VULNERABILITY AND ADAPTATION OF RURAL FARM HOUSEHOLDS TO DESERTIFICATION IN KATSINA STATE OF NIGERIA

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(97/66ME108)

Ph.D. (GEOGRAPHY) THESIS SUBMITTED TO THE UNIVERSITY OF ILORIN IN THE CANDIDATURE FOR THE DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL MANAGEMENT, FACULTY OF SOCIAL SCIENCES, UNIVERSITY OF ILORIN, ILORIN NIGERIA.

FEBRUARY, 2018

CERTIFICATION

This is to certify that this thesis is a product of original research conducted by Yahaya Olanrewaju Yusuf of the Department of Geography and Environmental Management under the supervision of Professor Adebisi Funsho Adedayo for the award of Doctor of Philosophy (Ph.D.) Degree in Geography in the Department of Geography and Environmental Management, Faculty of Social Sciences, University of Ilorin, Ilorin, Nigeria.

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Dedication

It is an honour to dedicate this thesis to Almighty Allah and my awesome family.

To my parents (Alhaji and Alhaja A.A.Yahaya) whose roles in my life cannot be quantified.

To my wife whose prayer, sacrifice and support are immense.

To my children whose witty ideas, comic display and disturbances helped in the course of this work.

Acknowledgement

I give all praises and glorifications to Almighty Allah (S.W.T) for sparing my life till this moment and seeing me through this work. My unquantifiable appreciation goes to my able supervisor, Professor Adebisi Funsho Adedayo for his fatherly role, constructive criticisms, advice, thorough readings and corrections, suggestions and above all his words of encouragement in making this work a reality. I pray to Almighty God not to cease His infinite mercy and blessings on him and his household.

I am grateful to all the staff in the Department of Geography and Environmental Management, University of Ilorin and those in the Department of Geography and Regional Planning, Federal University of Dutsinma, Katsina State for their meticulous support throughout this programme. I also appreciate the efforts of my students who served as research assistance during the field work. The support of my friend and colleague, Dr. Malik, Nurudeen Adesola right from the time we get to know each other as supervisees under Prof. A.F. Adedayo up to this moment is highly appreciated.

I will forever be indebted to my parents, Alhaji and Alhaja (Mrs.) AbdulRasheed Ajadi Yahaya for their incessant support in my life right from birth to this level. I pray Almighty Allah (S.W.T) to grant them long life and good health.

I am particularly grateful to my mentor and benevolent; Dr. Shehu Raheem Adaramaja for his advice, assistance, support and immense contribution towards my success. My gratitude also goes to the following family member and friends for their prayers: engineer Abdul-lateef Yahaya, Alhaji Sheu Yahaya, Mukadam Surajudeen Yahaya, Ibrahim Gafar, Abdul-ganeey Gafar, Ahmed Akeem Apo and Alhaji AbdulRashhed Oba Kajola (Ajia).

Finally, I owe my wife and children a lot of appreciations for their prayers and contributions. Your sacrifice and patience in this course of this work cannot be quantified.

Abstract

Desertification poses one of the greatest environmental challenges in Nigeria. It accounts for 73% of the estimated total cost of US$5.110 billion the country loses to environment degradation annually. More than 30 million people in the desertification frontline states including Katsina are estimated to be affected by the impact of desertification. The rural population that rely on dry lands ecosystem for farming are likely to be more vulnerable to the menace of desertification. This study therefore examined the vulnerability and adaptation of rural farm households to desertification in Katsina State of Nigeria. The specific objectives were to: (i) identify farm households' perception of the causes of desertification; (ii) assess the effects of desertification on farm households' livelihood; (iii) determine the degree of vulnerability of farm households to desertification; (iv) examine the factors influencing household's vulnerability to desertification; and (v) identify adaptation strategies for mitigating the effects of desertification among farm households.

Data were collected from both primary and secondary sources. A systematic random sampling technique was employed to select 633 respondents in 18 rural communities from the six local government areas selected for the study. Data were collected on the perception, exposure, effects, vulnerability and adaptation strategies of the sampled households to desertification. Vulnerability Index was used to classify households into less, moderate and highly vulnerable. Tobit Model was used to determine the factors influencing farm households' vulnerability to desertification.

The findings of the study were that:

i. climate change (73.5%), deforestation (71.7%), environmental mismanagement (64.3%), and act of God (65.2%) were the perceived causes of desertification among the farm households;
ii. decreased use of ground water (88.9%), low income from farm produce (66.7%), declining crop yields (63%), and extinction of flora and fauna species (59.3%) were the effects of desertification in the study area;
iii. vulnerability to desertification varied from one Local Government Area to the other. The vulnerability index showed that Jibia L.G.A was less vulnerable (1.228), Kaita L.G.A. (0.523), Mashi L.G.A. (0.756) and Mai'adua L.G.A. (0.685) were moderately vulnerable while Zango L.G.A. (-1.629) and Baure L.G.A. (-1.405) were highly vulnerable;
iv. age of household head, farming status, educational level, size of the household, access to credit facilities and access to non-farm income ($p < 0.05$) were the factors influencing vulnerability of farm households to desertification; and
v. planting of drought tolerant crops (95%), intercropping (94%), early planting (81%), liquidating accumulated assets (73%) and manure application (50.2%) were the major adaptive strategies employed by farm households.

The study concluded that most of the farm households of the study area were vulnerable to desertification. The study therefore recommended the need to encourage livelihood diversification and intensified efforts toward effective management of environmental resources by respective governmental agencies.

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CHAPTER ONE

INTRODUCTION

1.1: Background to the Study

Desertification has been widely recognized as an important and urgent environmental problem that constitutes a serious threat to the arid and semi-arid environments which are inhabited by more than one billion humans (United Nations Sudano-Sahelian Office to Combat Desertification and Drought, 1997). It has received and continues to receive much attention considering the disastrous effects on the lives and livelihoods of a considerable percentage of the world's population. According to United Nations Convention to Combat Desertification (UNCCD) statement, 250 million people are directly affected and the livelihood of one billion human populations is being threatened by desertification (UNCCD, 2007). The area threatened at least moderately by desertification was put at 3.97 billion hectares or 75.1% of the total dry lands, which is equal to one quarter of the total land area of the world (UNCOD, 1977; UNCCD, 1992). According to Thomas and Middleton (1994), desertification is a problem of global significance. This significance is clearly evident from the very important international events on desertification such as the call for a convention in 1944 by the United Nations to Combat Desertification (UNCCD) in those countries experiencing serious drought which entered into force in 1996. It also includes the 1977 United Nation Conference on Desertification (UNCOD) held in Nairobi and United Nations Conference on Environment and Development (UNCED) held in Rio de Jeneiro in 1992.

Desertification gained popularity following the severe drought that afflicted the Sahelian regions in Africa from the late 1960s to 1970s and again in the 1980s. During the period from 1958 to 1975, the mean annual rainfall diminished by nearly 50%, and the boundary between the Sahara and the Sahel shifted southward by nearly 100km (Lamprey, 1975). As part of the world's concern for desertification, the United Nations General

Assembly declared 2006 the international year of Deserts and Desertification to spread the awareness of the world's deserts and the problem of desertification. All countries were encouraged to undertake special initiatives to mark the year. The international film festivals entitled 'Desert Nights-Tales from the Deserts' in Rome in December, 2006 is an example of one such awareness raising initiative. Also, in commemoration of the United Nations Convention to Combat Desertification adopted on 17th June 1994, the "World Day to Combat Desertification and Drought" is observed every year on 17 June. The purpose of the world Day is to raise awareness of desertification and to encourage actions that would remedy some of the effects of desertification and prevent further degradation and loss of soil and water.

Nigeria is not exempted from the threats of this worldwide recognized environmental problem. The problem of desertification in Nigeria has a very long history. As early as 1930's when the British Colonial Government reports revealed that the Sahara was expanding and encroaching into Sudan Savannah at a rate that would only increase if the trend is not checked and that about 15% or 140,000 square kilometres of the total land cover of Nigeria is prone to desertification (FAO, WMO and UNESCO, 1977). Desertification frontline states in Nigeria include Adamawa, Borno, Bauchi, Gombe, Jigawa, Kano, Kebbi, Katsina, Sokoto, Yobe and Zamfara State (Figure 1.1). It has been estimated that between 50% and 75% of land area in the affected eleven northern states are under the threats of moderate to severe rate of desertification. These states, with a population of about 46.4 million people account for about 47.41% of the country's total land area (NPC, 2006; Nasiru, 2007; NBS, 2010). Desertification accounts for 73% of the estimated total cost of US$5.110 billion the country loses to environment degradation annually (UNCCD, 1999). Similarly, Nigeria is losing about 351,000km^2 of land to desertification per annum, which represents 38% of its total landmass and more than 30 million of her people are estimated to be affected by the impact of desertification (Ayuba and Dami, 2011). There is a general consensus in Nigeria that

desertification is by far the most pressing environmental problem in the dry land parts of the country. The visible sign of this phenomenon is the gradual shift in vegetation from grasses, bushes and occasional trees, to grass` and bushes, and in the final stage, expansive areas of desert-like sand. Entire villages and major access roads have been buried under sand dunes in the extreme northern parts of Katsina, Sokoto, Jigawa, Borno and Yobe States. The pressure of the migrating human and livestock population from these areas are absorbed by pressure point buffer states such as the Federal Capital Territory, Plateau, Taraba, Niger, and Kaduna States. It is reported that these buffer states have about 10-15% of their land area threatened by desertification (UNCCD, 1999).

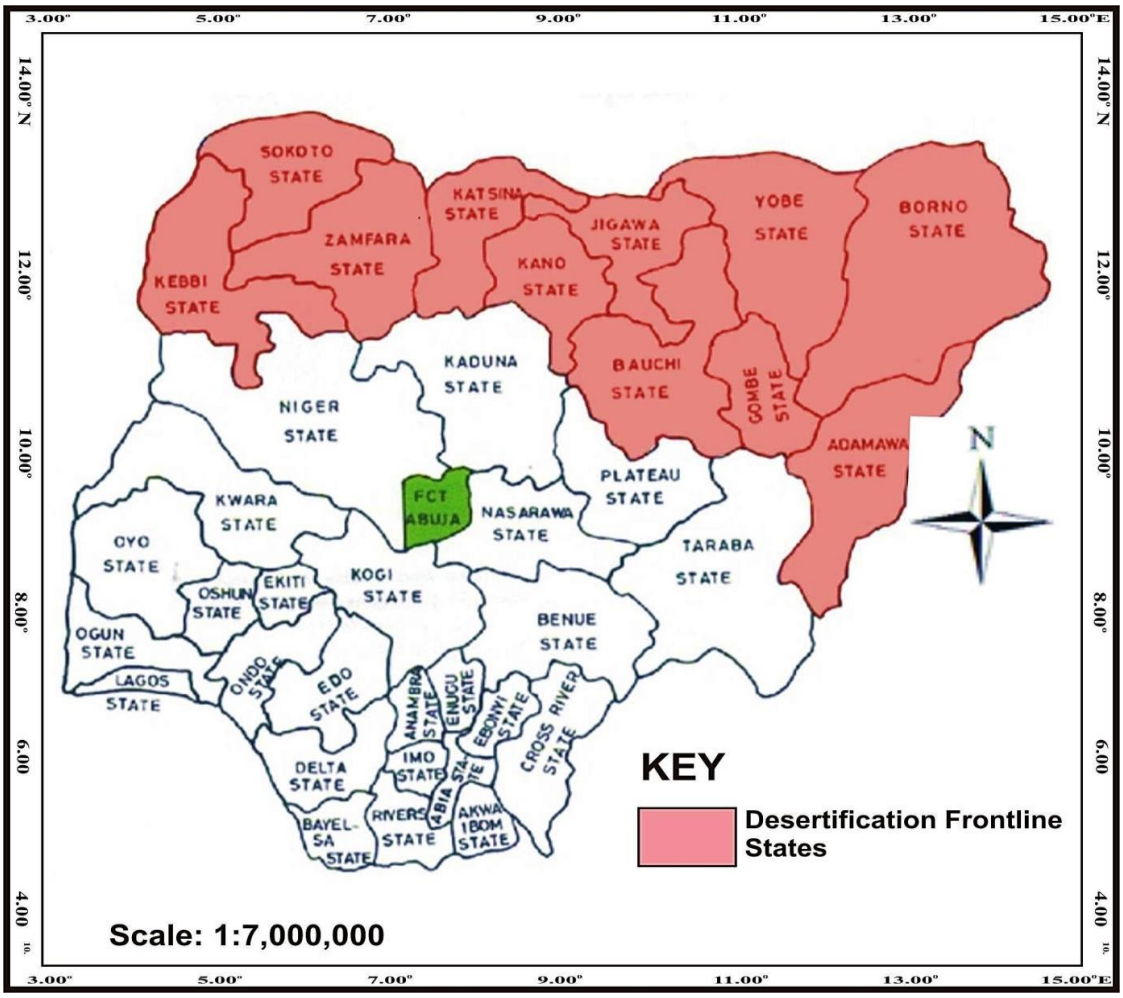

Figure 1.1: Desertification Frontline States in Nigeria.

Source: Modified from Olagunju, 2015.

Northern Nigeria is prone to desertification mainly because of its proximity to Sahara desert (Ayuba and Dami, 2011). Northern Nigeria is situated in the semi-arid areas bordering Sahara desert with average annual rainfall of less than 600 mm. This rainfall pattern has contributed to desertification encroachment in the affected northern states of Nigeria. Desertification is on the increase in Northern region of Nigeria with the desert advancing at a rate scientists consider alarming (Matazau, 2013). It is on record that Nigeria loses about 350,000 km^2 of its land mass to desert condition which is advancing southwards at an estimated rate of 0.6 kilometres per year (Federal Ministry of Environment 2001). With the rate of advancement of desertification in Nigeria, agricultural production and access to food is projected to be severely compromised.

Katisna is one of the eleven northern Nigeria states already affected by desertification as it falls within the semi-arid zone and constitutes the dry lands of Nigeria (NARP, 1994). The dry lands are by nature prone to recurrent and sometimes intense and persistent periods of drought. They are characterized by low rainfall that is irregular and unpredictable; soil that is low in organic matter and limited water for consumption (FAO, 1978). The characteristic of the dry lands that makes them specifically vulnerable is the slowness of ecosystem recovery. In the desertification prone areas, declining per capital cropland availability will lead to intensified use of already stressed ecosystem resources with humanity's need for food increase (Dregne and Chou, 1993). For example, human pressure resulting in over grazing and over exploitation of marginal lands particularly in the northern part of Katsina state has continued to take toll on the environment, resulting in desertification (Kastina State Ministry of Environment, 2002). Desertification is made very severe in the area by increasing human attempts to exploit the resources of the ecological zone in the face of persistent drought.

The rural population, in particular, is considered more vulnerable and mostly affected by desertification than the urban population. The vulnerability of farm households in rural

areas to desertification can therefore be explained from lack of or limited ability to manage natural resources, upon which their livelihood depends, particularly under changing climatic conditions. In view of this, a good approach towards helping to reduce the vulnerability of the rural small farm holders is a systematic assessment of their coping strategies in the face of increasing climate variability and human impacts. By so doing, strategic interventions that can increase the resilience of the rural small farm holders can be identified and used to develop a comprehensive approach to mitigating and adapting to desertification in the affected areas. This is the focus of this study, using specific vulnerable rural settlements in Katsina state.

1.2: Statement of the Research Problem

Studies have shown that desertification poses one of the greatest environmental challenges today and constitutes a major barrier to meeting basic human needs in the dry lands of Nigeria (UNCOD, 1977; Oladipo, 1993; Nasiru, 2007; Okoye and Ezeonyejiaku, 2010). A preliminary report by the consultative committee on Desert encroachment in northern Nigeria concluded that about 48% of the region was being seriously affected by desertification (Gadzama, 1991). The dry lands of Nigeria of which Katsina State is inclusive lie approximately within latitudes 10^0N and 14^0N and longitudes 4^oE and 14^oE and are by nature prone to recurrent and persistent periods of drought and as well faced with desertification problems (NARP, 1994). Oladipo (1993:243) and Bashir (2008) have acknowledged that historical records of droughts have occurred in this particular zone and its frequency in the past was due to high inter-annual variability of rainfall. Desertification is affecting agriculture in the dry lands part of Nigeria due to inadequate rainfall and increasing temperature leading to over dryness of the environment coupled with drought, increasing evaporation, wind erosion and low soil nutrients. Agriculture serves as the main economic stay of the majority of households in the study area and is a significant contributor to household income. The impact of desertification is intense because agriculture in Nigeria is

dependent on rainfall. Evidently, Abaje *et al.,* (2012) revealed that the trends and fluctuations of annual rainfall in northern Nigeria show a decrease of 220.20mm at the rate of 3.67 per annum in Katsina and its immediate environs. This implies that Katsina area has been experiencing a general decrease in the period of wet season yearly and an apparent increase in desertification process. This situation is a serious concern and worrisome for sustainability of human activities, especially as it relates to farming, the main economic activity of the rural people.

Consequently, the rural farmers depend seriously on ecosystem services for their growth, survival and development. It is a known fact that rural populations whose livelihoods depend mainly on natural resources are often described as the world's most vulnerable populations to desertification (Reynolds, 2001). Although most rural communities are predominantly homogenous, households within communities may have differing degree of vulnerability. Access to and control over the resources necessary for adaptation also varies within countries, communities and even households. Arif *et al.,* (2010) classify rural households into three broad categories: farm households, livestock households and non-agriculture households. While it is generally recognized that rural population is the most vulnerable to desertification, rural farm households are considered the most important household at risk among the natural resource-dependent categories vulnerable to desertification.

According to Burton et al. (2006), micro-level studies should form the inputs for formulating relevant policies at the national/macro level. Despite this, researches have shown that majority of the scientific literature on vulnerability over the last decades focused more on contributing to measurement of vulnerability and identifying resilience-building strategies that have national and regional planning implication (Brooks et al., 2005; Fussel, 2007; Hinkel, 2011). Moreover, studies on community vulnerability and adaptation that has been conducted

globally and specifically in Africa (Downing, 1992; Ribot, 1996; Nyong, 2003; Babagura, 2005; Ford 2011; Khan and Salman, 2012; Opiyo et al., 2013; Abaje et al., 2015), was conducted on climate change and vulnerability. This indicates that much remains unknown regarding macro-level vulnerabilities and adaptation to desertification in Africa and Nigeria in particular. The dearth of data and inadequate scholarly research on the local-level vulnerability and adaptation to desertification in Katsina, the study area constitutes the main crux of this investigation. Based on this, it is pertinent in this research to provide answers to the following basic questions:

i) How do farm households perceive desertification?
ii) What are the possible effects of desertification on farm household livelihood?
iii) What is the degree of exposure of farm households to the effects of desertification?
iv) What are the factors influencing households vulnerability to desertification?
v) What coping strategies are adopted by farm households to minimize the threats of desertification?

1.3: Aim and Objectives

The aim of this study is to examine vulnerability and adaptation strategies of rural farm households to desertification in Katsina State, Nigeria. The specific objectives set for the realization of this aim are to:

i) identify farm households' perception of the causes of desertification;
ii) assess the effects of desertification on farm households' livelihood;
iii) determine the degree of vulnerability of farm households to desertification;
iv) examine the factors influencing household's vulnerability to desertification; and
v) identify various coping strategies for mitigating the effects of desertification among farm households.

1.4: Justification for the Study

Vulnerability of rural farm households to desertification can be explained from the fact that their livelihoods depend principally on what the environment offers (ecosystem and natural resources). Based on Millennium Ecosystem Assessment (MEA) statement as cited in Adeel et al. (2005), desertification has led to a persistent reduction in the capacity of ecosystems to provide services such as water, food, and other necessities, thereby causing a major decline in the well-being of people living in the dry lands. When faced with land degradation, people often respond by making use of land that is even less productive, transforming pieces of rangeland into cultivated land, or moving towards areas with adequate environmental resources (Adedayo and Yusuf, 2012). This can lead to unsustainable agricultural practices, further land degradation, exacerbated urban sprawl, and socio-political problems.

Desertification is a gradual phenomenon operating on a time scale of several years or decades. It may not be readily apparent even to the local people if human intervention in the environment has not been drastic. In the same vein, people's sensitivity to desertification as well as their resource capability will determine their level of vulnerability. In general, the world's poorest people are also the most vulnerable to hazards. This is often because they have limited access to those resources that would facilitate adaptation. Since rural households are in many cases the managers of local resources, their activities are critical with regard to combating desertification. Similarly, Klein et al. (2007) observed that vulnerability analysis particularly in the arid and semi-arid areas of Africa should be conducted at the local level for policy makers to effectively tackle challenges associated with climate change. Farm household was however selected in this study as the main unit of analysis because Thomas (2008) asserted that major decisions about adaptation to climate-induced stresses and livelihood processes are taken at the household level. Although desertification, as a slow and insidious process of land degradation, can occur in any climatic regime, the consensus is that

the arid, semi-arid and sub-humid areas of the world that are characterized by variable climates are the most vulnerable (Oladipo, 1993). Katsina state constitutes one of the semi-arid areas of northern Nigeria, and therefore, forms the basis of our research about the desertification phenomenon. Also, effective planning for desertification adaptation measures require an analysis at the lower level in order to bridge the gap between community needs and priorities at the local level, and policy decisions at the national level. Measuring households' vulnerability to desertification impacts may be necessary to increase their resilience. Hence, the justification for this study is found in identifying a wider resilience-building programme that would assist the government in resources allocation and provide the people with investment opportunities that may likely reduce their vulnerability.

1.5: Significance of the Study

The relevance of this study is based on the fact that rural populations, especially the farm households of semi-arid regions including Katsina state depend largely on arable land for their survival. This arable land is being threatened by desertification despite the fact that only 35 percent of Nigeria's landmass is considered arable (NAP, 2000).

According to Brett (2009), the area suitable for agriculture, the length of growing seasons and yield potential, particularly along the margins of semi-arid and arid areas, are expected to decrease. Yields from rain-fed agriculture could be reduced by up to 50 percent by 2020 in some countries. If Brett's observations are valid for Katsina state, yields from rain-fed agriculture could be reduced by half in many areas of the state. Desertification can result in widespread poverty and persistent decline in agricultural production and hence food scarcity. Since desertification is known to cause decreasing productivity, one way to address the problem of food insecurity is by combating desertification by all means.

The study is meant to add to the growing international awareness for desertification and encourage actions that would remedy some of its consequences at all levels. It is hoped

that this study would encourage government to make sure that rural farm households whose lives are directly affected by desertification become part of the decision making process in the formulation and implementation of national and state specific programmes/projects to combat desertification.

The study will also deepen our understanding of farm household's sensitivity to impact of desertification as well as their control over resources that are necessary for adaptation. In order to achieve sustainable development of society, there is always the need to ensure that the perspectives of the local households are understood and incorporated into programmes aimed at achieving the goals of development. The findings of this study can therefore be useful for identifying interventions, resources allocations, and priority setting at the local-level. This study will most importantly enable proactive policy formulation that will enhance people driven intervention, and that will ameliorate the poverty plight associated with environmental problems. By so doing, sustainability of rural livelihood can be guaranteed in the affected areas and hence increased food production in the country at large.

1.6: The Study Area

1.6.1 Location and Land Area

Katsina State was carved out of the former Kaduna State and became existence on September 23, 1987. It lies between latitudes 11^0 $07^{/}$ N and 13^0 $22^{/}$ N of the equator and longitudes 6^0 $52^{/}$ E and 9^0 $20^{/}$ E of the Greenwich meridian. The state shares boundary with Kaduna State to the South, Niger Republic to the North, Kano and Jigawa State to the East, and Zamfara State to the West (Figure 1.2).

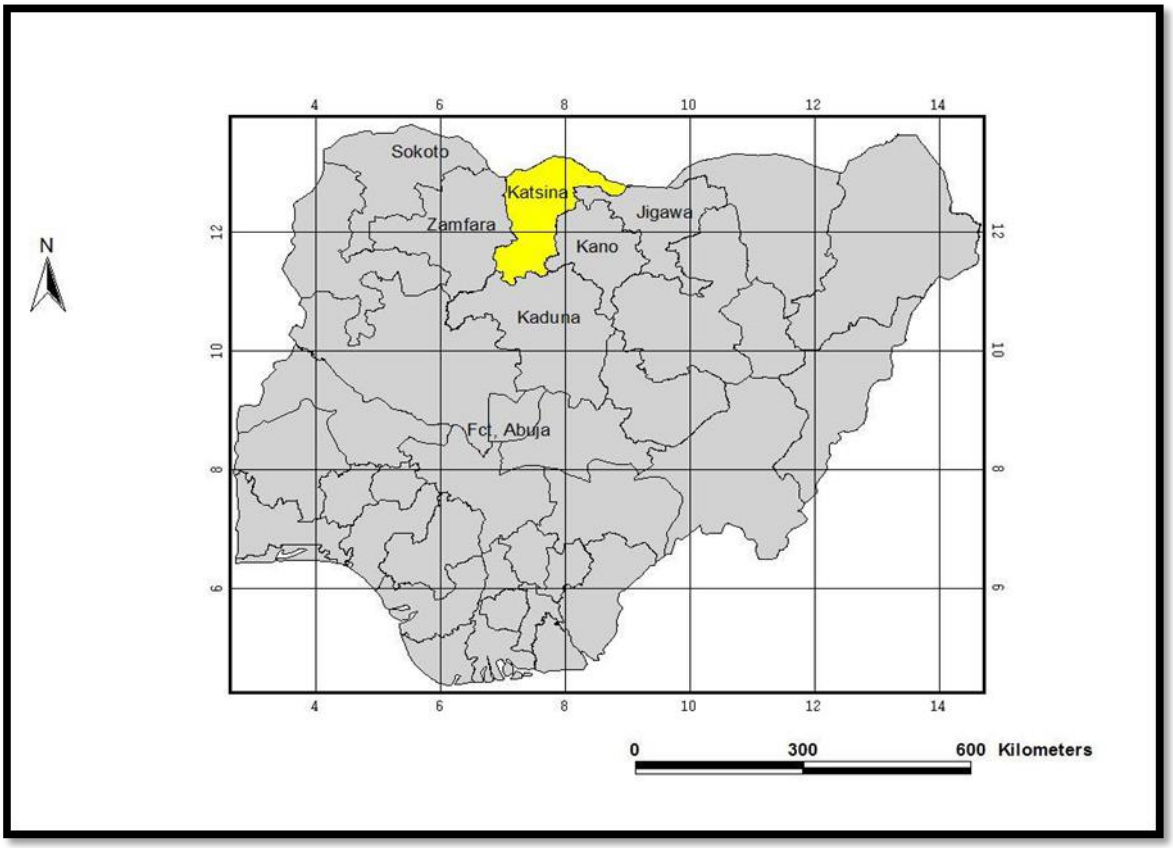

Figure 1.2: Location of Katsina State within Nigeria
Source: Adapted from Inkani, 2015.

Out of a total land mass of 24.192km^2 in the state, only 2,420km^2 (10%) are constituted into gazette forest estates, comprising 96 forest reserves, one grazing reserve, 244 communal forest areas of which 80% have been threatened with extinction by desertification, drought and human activities (Katsina State Ministry of Environment, 2002). Arable land in the area is classified into upland (gona) and bottom valley land (fadama). The upland is used mainly for rain fed agriculture while the valley bottom soils are cultivated mostly in the dry season (NARP, 1994).

This study focuses on rural farm households found in the local government areas situated in the north fringe of Katsina state. The study area lies between latitude 12.4^0 and 13.2^{0}N and longitude 6.5^0 and 9.2^0. These local government areas are Jibia, Kaita, Mashi, Mai'adua, Zango and Baure (Figure 1.3)

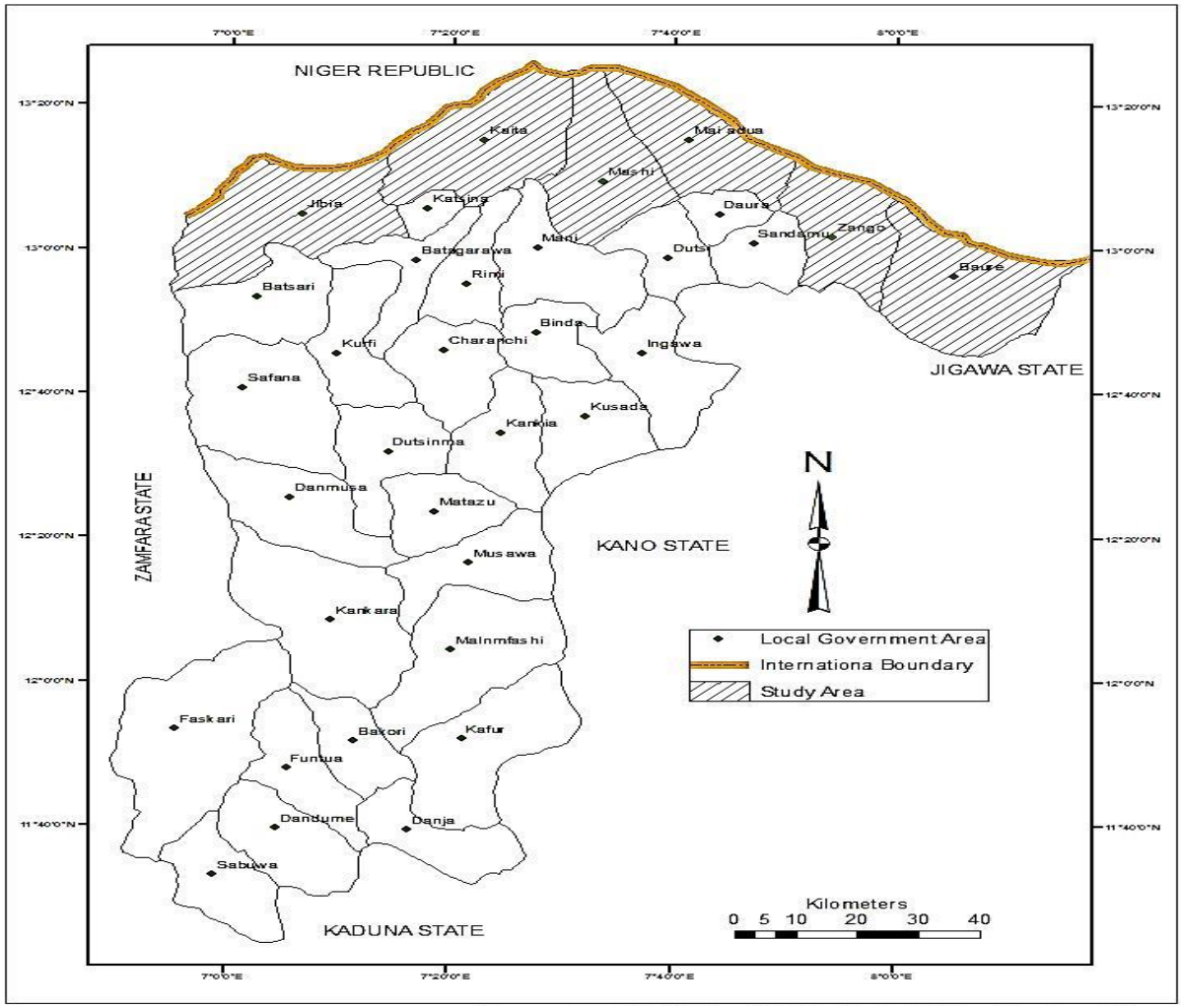

Figure 1.3: Location of Study Area within Katsina State.

Source: Created in FUDMA GIS Lab, 2016.

1.6.2: Climate

Katsina State enjoys two climatic zones which are tropical continental and semi-arid continental. According to Koppen's classification, the State falls within 'Aw' type of climate characterized by distinct wet and dry seasons. The southern part of the state (from around Funtua to DutsinMa) enjoys tropical continental climate with total annual rainfall figures ranging from 1000mm for Funtua and environs to over 800mm around DutsinMa. The north has semi-arid continental type of climate found around Kankia, Charanchi, Kurfi and Batsari areas down to the extreme north of the state around Daura, Baure, Zango, Kaita, Mai'adua,

Mashi, Jibia and Sandamu. This zone has total annual rainfall figures ranging from 600mm around the extreme north-east to 700mm around Kankia. The temperature of this zone is high especially at the peak of dry season when temperature reaches about 38^0C-40^0C and above some times. Generally the climate varies considerably accordingly to month and seasons. It consists of a cool dry harmattan season covering December to February; a hot dry season spreading from March to May; a warm wet season experience between June to September; and a less marked season after rains from October to November, characterized by decreasing rainfall and gradual reduction in temperature (Adamu, 2000). The rainfall zones in katsina are mainly classified into three – northern zone with less than 700mm annual total, central zone with of between 700 – 900mm and the southern zone has annual rainfall figure of about 1000mm (Figure 1.4)

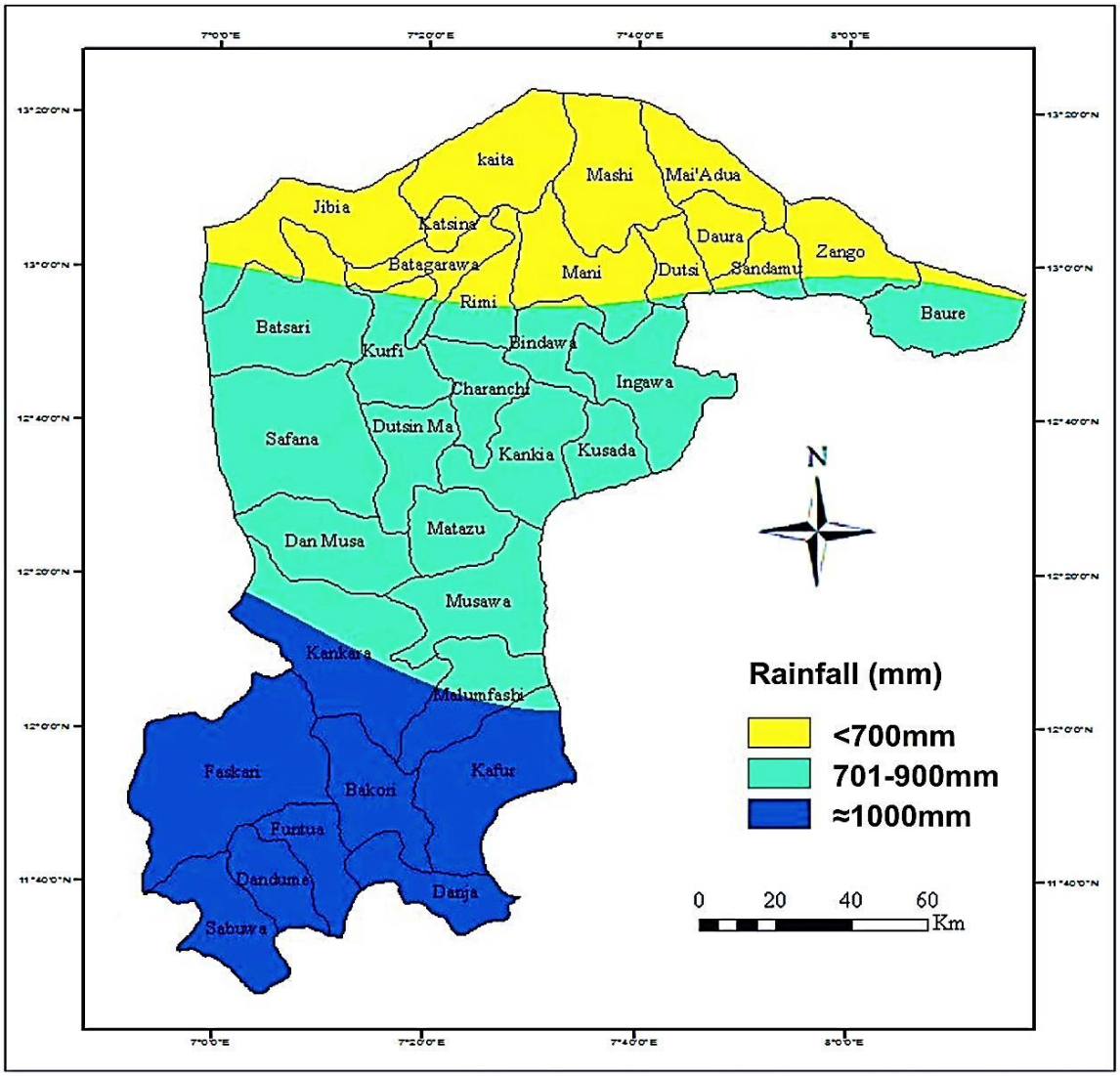

Figure 1.4: Rainfall zones of Katsina State.

Source: (Modified from Inkani, 2015).

1.6.3: Vegetation

The vegetation of Katsina State is generally typical Savannah type classified into three major categories - Northern Guinea, Sudan and Sahel (Figure 1.5). The climate of the zone supports mostly savanna vegetation. In the southern part of the state, Northern Guinea Savanna exists with tall tussocky grasses and broad-leaved trees of guinea affinities. The vegetation also consists of fine-leaved species of thorny tree with short and feathery grass cover. Examples of plant species found in the south include *Butyrospermum parkii, Parkia biglobosa, Entada africana, Prosopis africana and Andropogons gayanus*.

Sudan Savanna vegetation is found in some part of south down to northern part of the state. The trees in the Sudan savanna region are able to withstand the long dry season and bush fires because they have thick barks and grow deep tap roots. The grasses also have durable roots which remain underground after stalks are burnt. In the extreme northern part of the state, Sahel Savanna is found. Examples of plant species in northern and extreme northern parts include *Acacia Senegal, Acacia nilotica, Acacia ataxacantha, Parkia biglobosa, Combretum mole and Fiscus syscomorus, Feidherbia albida and Adansonia digitata* (Adamu, 2000).

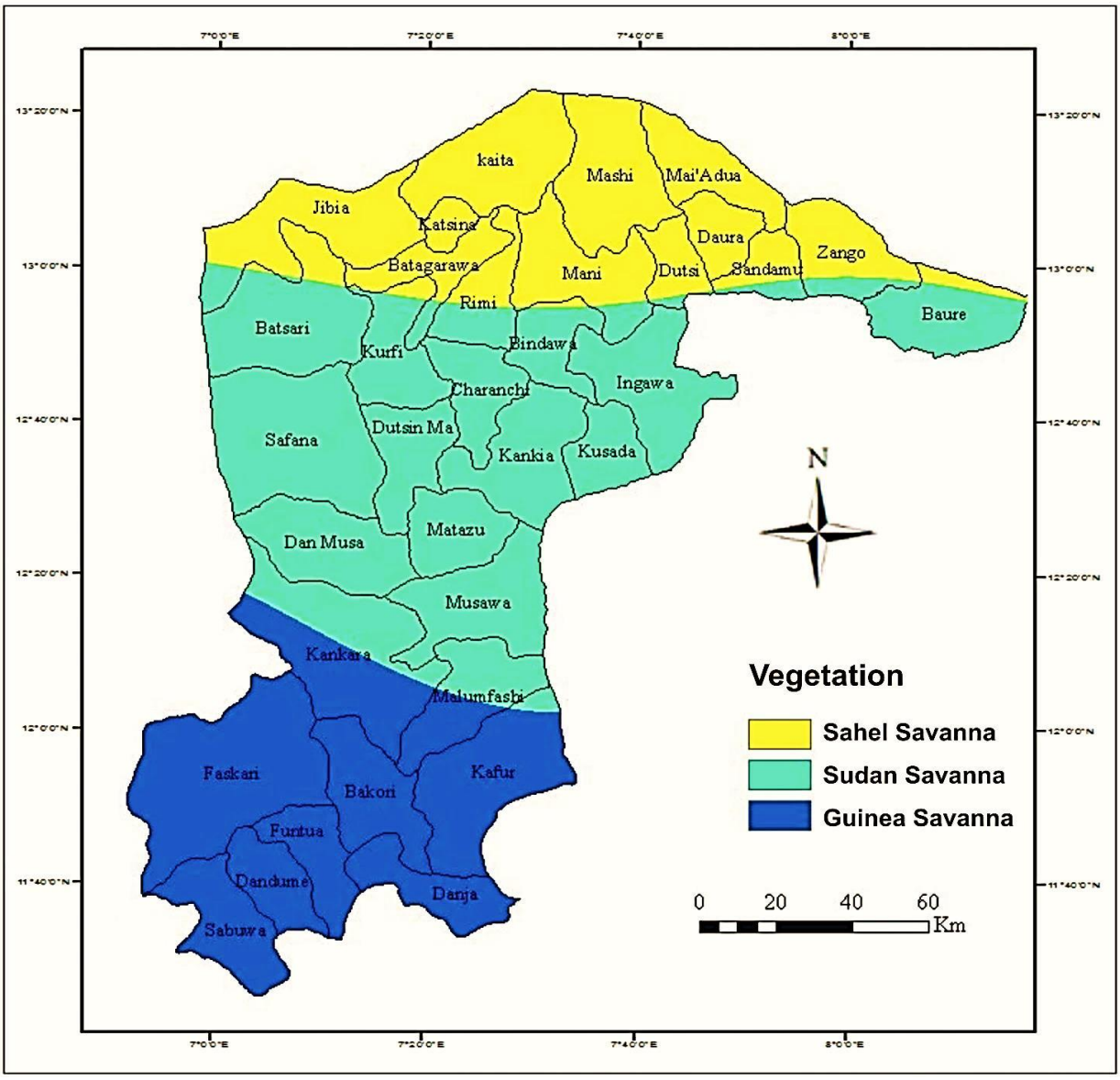

Figure 1.5: Vegetation zones of Katsina state.

Source: (Modified from Inkani, 2015)

1.6.4: Soil

The soil of Katsina State is generally sandy 'drift' deposits. It has two distinct soil types - clay and sandy. The soil of the southern part of the state is largely clayed of about 5 metres in depth with reddish black or dark-brown colour. It has a very fine texture although it becomes difficult to work, tending to become water-logged with heavy rains and during the dry season, it dry out and crack. The soil of the southern part is of medium fertility and suitable for the production of crops like maize, cotton, sorghum and guinea corn. The northern part of the state contains drift deposits are which are coarser, resulting in light sandy soils of buff or reddish colours of low fertility. Generally, planting is done on the flat with minimum tillage (Adamu, 2000). The soils of the northern part are marginal for efficient arable crop production. Millet and sorghum are the main food crops grown in the northern part while the predominant crop mixtures are sorghum/millet/cowpea or groundnut.

1.6.5: Ecological Problem

Katsina state is known for the persistent ecological problems of soil erosion, drought, and desertification especially in the northern part of the state. The state is highly desertified in the north, as evidenced by the prevalence of desert plants such as Acacia species. Desertification in the area is caused by drier climatic conditions and largely by human destruction of the vegetation. Drought is as a result of climatic change which has occurred conspicuously in the early 1970s because of the decline of mean annual rainfall witnessed in the northern-most states of Nigeria since 1965. It does not have adequate quantity and duration of rainfall. The rainfall variability in terms of time of on-set and cessation often leads to crop failure. Soil erosion is experienced mostly at the extreme northern parts which are under the threat of wind erosion resulting from desert encroachment. Very severe gully erosion of up to 11.8% of the state is also experienced. The state is heavily eroded by wind and water. The lack of adequate

rainfall has also caused increased erosion and flooding (Katsina State Ministry of Environment, 2000; Adamu, 2000).

1.6.6: Population, People and Economic Activities

The 2006 population census put the population of Katsina State at 5,792,578 and annual growth rate of 2.2%. Katsina state is predominantly inhabited by Hausa-Fulanis and most people speak only Hausa language. Majority of the people are settled cultivators and traders. Sizeable number of migrants from southern Nigeria, especially the Yorubas and Igbos, are found and dwell mostly in towns (Mortimore, 1989).

Agriculture is the main economic activity of the state. In Katsina as in other parts of the savanna, agriculture is largely rain-fed. About 95% of the population is into subsistence agriculture. Agricultural production follows the rhythm of the seasons with most of the farming activities occurring during the rainy season which last between 7 months in the southern part of the state to 4 months in the extreme north. The short rainy season limits crop production to only those crops that can grow and mature within a short time. These crops include millet, sorghum, ground nuts, maize, rice and hungry rice (acha) (Adamu, 2000). Livestock production is also widespread in the state. These include cattle, camel, donkeys, goats, horses, sheep, poultry and pigeons (Katsina State Ministry of Environment, 2002). Seasonal migration known as “cin rani” in Hausa language takes place in the area, especially of able bodied males in the dry season to the southern part of the state in search of part-time jobs and also the migratory move of the Fulani herdsman in search of pasture.

1.7 Scope of the Study

Desertification is a serious issue in the arid and semi-arid regions of the world. The process of desertification is a continuous one which integrates climatic elements with human activities in transforming productive land, into an ecological impoverished land generally

considered as land degradation. Desertification has direct or indirect impacts on all aspects of human life and the environment including the ecological, health, hydrological and socio-economic facets. It is however, important to examine the problem because it affects so many aspects in the society. The situation is a serious concern and worrisome for sustainability of human activities, especially as it relates to farming, the main economic drive of the rural people. Vulnerability and adaptation of the main natural resource-dependent communities at risk to desertification is hereby considered. Therefore, to measure the vulnerability and adaptation of the rural population, the point of focus in this study is the farm households in the six identified local government areas that are susceptible to desertification in northern part of Katsina.

1.8: Organization of the Study

The thesis is divided into seven chapters. Chapter one focuses on the introductory aspect of the study which include background to the study, statement of research problem, aim and objectives of the study. The chapter also addresses justification for the study and dwells on the main elements of the study area such as latitudinal and longitudinal location, physical background (climate, soil and vegetation), land area, population people and economic activities.

Chapter two contains the conceptual issues and the review of relevant literature. Some of the concepts discussed are desertification, land degradation, desertification assessment, vulnerability, and adaptation in the context of desertification. The literature review was discussed under these sub-themes: linkages between desertification, drought and climate change; causes and consequences of desertification particularly in northern Nigeria. Chapter three dealt with the research design and methods under which the nature of research

information, sampling procedure, sources of data and analytical method employed were discussed.

Chapters four, five and six focused on the analysis and interpretation of results. Chapter four examined the socio-economic characteristics of respondents (household survey) and households' perception of desertification while chapter five focused on the vulnerability of households to desertification. In chapter six, the adaptation strategies employed by respondents to combat desertification were examined and the government strategic interventions to mitigating the effects of desertification were equally discussed.

Chapter seven is the last chapter which deals with summary of findings, implications of study, conclusion and recommendations.

CHAPTER TWO

CONCEPTUAL FRAMEWORK, THEORETICAL ISSUES AND LITERATURE REVIEW

2.1: Conceptual Framework

This section deals with definitions and clarification of some basic concepts used in this study, the theoretical issues as well as review of related literatures. The basic concepts defined here include desertification, land degradation, vulnerability and adaptation.

2.1.1: Concept of Desertification

The word "desertification" was introduced by the French scientist Aubreville (1949), in his report on climate, forest and desertification in Tropical Africa. He used the term desertification to mean the spreading of deserts or desert-like conditions. At first, the general perception of desertification was that of expanding deserts, mainly in the Sahel region, and this is still the common public understanding of the term. The symptoms of the phenomena were often related to sand movement and encroachment into oasis and desert margins.

The concept of desertification has acquired a number of contradictory definitions and often had a progressive evolution over time since it was first used by Aubreville (1949). Due to the controversy involved in defining desertification and its essential, the term can be viewed in two ways: as a process of change (verb) and as the end stage (noun). In terms of process, desertification is a negative change from productive land to a less productive state of land, or a transfer of the unproductive characteristic of one area (such as desert) to another (Mortimore, 1989). Desertification is a process of continuous and gradual ecosystem degradation, during which plants, animals, and geological resources such as water and soil, are stressed beyond their ability to adjust to changing conditions. On the other hand as a noun, desertification is defined as "the diminution or destruction of biological potentials of land, and

can lead to desert like condition" (UNEP 1977). Around 100 formal definitions on desertification were in existence by the early 1980s and several more had appeared since then covering many spatial and temporal scales and representing different viewpoints (Glantz and Orlovsky, 1983; Mainguet 1994; Thomas, 1997; Reynolds and Stafford-Smith, 2002).

According to United Nations Conference on Desertification and United Nations Environment Programme, desertification is conceptualized as "the diminution or destruction of the biological potential of land that can lead ultimately to desert-like conditions" (UNCOD & UNEP, 1977) and term it an aspect of the widespread deterioration of ecosystems under the combined pressure of fluctuating climatic condition and excessive exploitation of environmental resource (Grainger, 1990). Several definitions were presented in the United Nations Conference on Desertification (UNCOD) documentation which was summarized and implicitly understood that desertification leads to long lasting and possibly irreversible desert-like conditions (Hellden, 1991; Mainguet, 1991; Thomas and Middleton, 1994). However, they noted that the 1977 UNEP's concept of desertification encountered serious ctiticism by groups of scientists during the 1980s and at the beginning of the 1990s. The criticism probably contributed to a UNEP initiative to modify the prevailing concept of desertification in 1990. The early 1990 UNEP definition conceptualized desertification as land degradation in arid, semi-arid and dry sub-humid areas resulting mainly from adverse human impact. It specified the environments in which land degradation was to be termed desertification (Dregne et al., 1991). The new definition introduces the idea that desertification does not need to lead to the development of deserts or desert-like conditions. It simply refers to all types of land degradation in the dry lands of the world. Human adverse impact on the environment is considered to be the only cause of desertification (Rozanou 1990; UNEP, 1991). The human impact was expressed in terms of bad management of the natural resources including over cutting of wood resources, over grazing, over cultivation and misuse of water.

Other definitions include - (i) “the sum of geological, climate, biological and human factors which leads to the degradation of the physical, chemical and biological potential of lands in arid and semi-arid zones, and endanger biodiversity and the survival of human communities” (FAO,1993). (ii) a process of sustained land degradation (loss of primary production) that results in the inability of the environment to sustain the demands being made upon it by socio-economic systems at existing levels of technology and economic development and under prevailing climatic conditions, especially recurrent drought (Oladipo, 1993) and (iii) land degradation in arid, semi arid and dry sub-humid areas, resulting from various factors including climatic variations and human activities (UNCED, 1992). The last definition recognizes that not only human impact but also various factors including climatic variations are important causes of land degradation in the dry lands. Climate variability means the fluctuation between the normally experienced climate conditions and a different, but recurrent set of the climate conditions over a given region of the world (IPCC, 1998).

The most accepted definition up to date states that desertification is land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities (UN, 1994; Reynolds and Stafford Smith, 2002). Arid, semi-arid and sub-humid areas are referred to as dry lands and are defined by Food and Agricultural Organization (FAO) on the basis of length of the growing season, as zones which fall between 1-74 and 75-199 growing days to represent the arid and semi-arid areas respectively (FAO, 1978). They are also characterized by low, erratic and highly inconsistent rainfall levels, receiving between 100-600mm rainfalls annually.

No matter the different opinions on the conceptualization of desertification, it is generally considered a serious threat to the environment, and human welfare (Williams and Balling, 1996; Stafford Smith, 2002). Also, independently of the exact definition of

desertification as discussed in this study, three aspects of the problem are greatly emphasized. This can be summarized as follows:

(a) Decreasing productivity" is a key process included implicitly or explicitly in most definitions.

(b) Vulnerability of the arid, semi-arid and dry sub-humid regions.

(c) Both climate and human activity are considered essential causal elements.

However, Jagdish and Paul (2000) were of the opinion that the definition of desertification should include reference to:

- The causative element as human action
- The driving process as land degradation
- The indicator as decline in economic productivity of biota beneficial to man and his animal support system. However, the decline in productivity must be incessant and applicable to a land use or a production system. The threshold limit to mark the beginning of significant effects of land degradation is suggested as a 15% fall in potential productivity.
- The modifiers of the loss in potential productivity and restorative management as climatic variability (including short-term and long-term incidence of drought).
- The areas of prime concern for global initiatives as arid, semi arid and sub-humid environments. The designated areas susceptible to desertification as per UNEP (1992), are territories with P/ETP (the ratio of precipitation to potential evapotranspiration) ranging between 0.05 and 0.65.

Desertification in northern Nigeria is the result of two main factors. The first factor being poor physical conditions in terms of soils, vegetation, topography and inherent extreme

variability of climate as manifested in frequent droughts. The second factor is the destruction in ecological system caused by poor land use and ever-increasing demand being made upon the available land resources by the expanding population and socio-economic systems of the affected areas (Oladipo, 1993). Thus, desertification is as a result of complex inter-relationships between social and natural systems. The interplay among the two systems leading to desertification and the consequences is shown in figure 2.1.

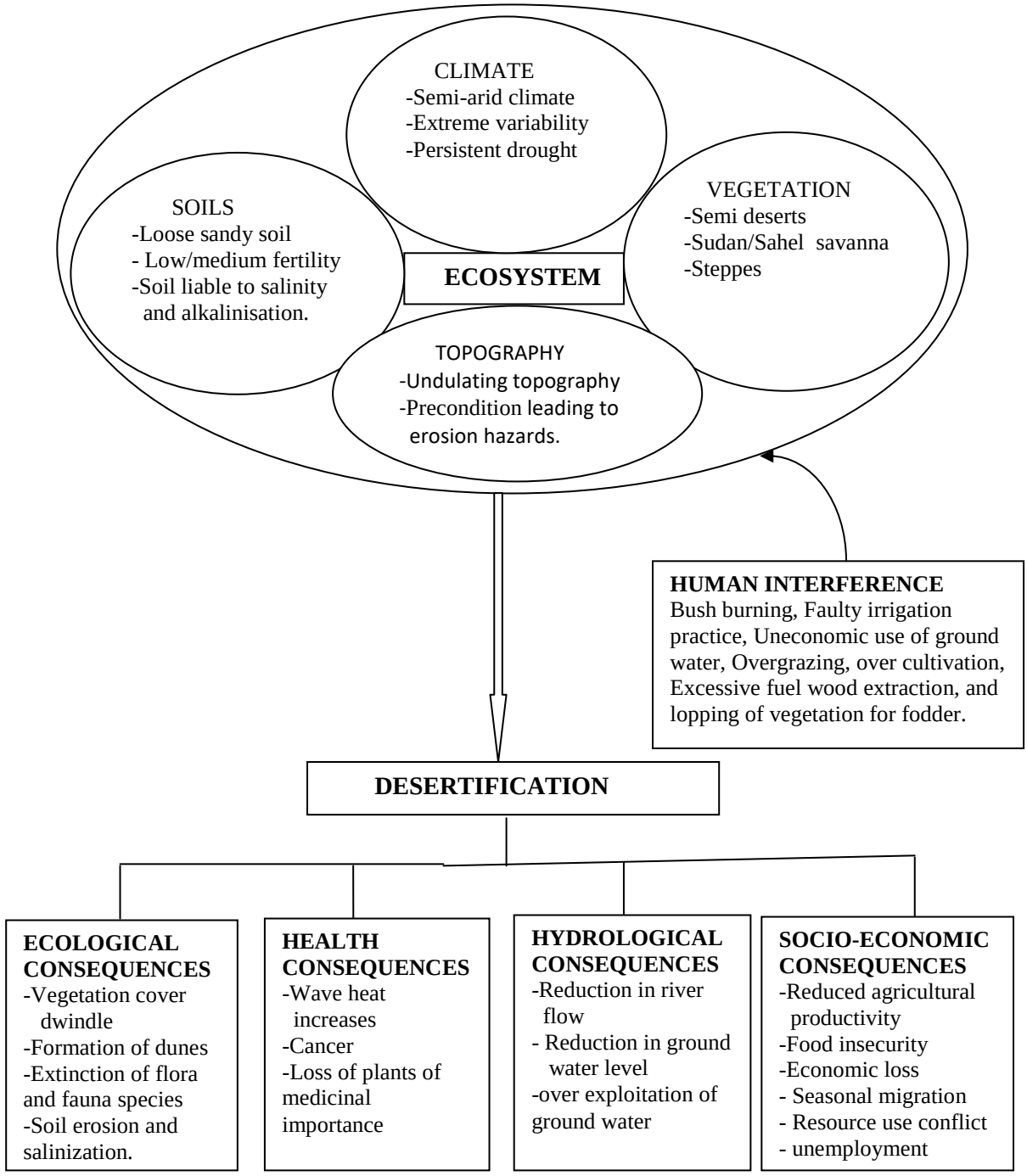

Figure 2.1: Model of Desertification Process in Northern Nigeria.

Source: (Modified from Oladipo, 1993; Nasiru, 2007)

Northern Nigeria is characterized by loose sandy soil of low fertility; semi-arid climate of extreme variability in annual rainfall amount and persistent drought; semi-desert vegetation of mainly savanna and steppes; and the undulating topography that acts as a precondition for

erosion hazards. These poor physical conditions of the area coupled with human interference on the ecosystem which include bush burning, faulty irrigation practice, overgrazing, uneconomic use of ground water and excessive fuel wood extraction combined to aggravate the process of desertification. The consequences of the whole process of desertification are manifested in the ecological, health, hydrological and socio-economic consequences as shown in figure 2.1.

2.1.2: Land Degradation

There are various definitions of land degradation which have appeared in literature. They include that of United Nation Environment Programme (UNEP, 1982 and 1984) which states that land degradation is the diminution of the soil's current and/or potential capability to produce quantitative or qualitative goods or services as a result of one or more degradative processes. Lal and Okigbo (1990) define it as the decline in soil quality caused through misuse by humans and results in deterioration of soil's life support processes and decline in its capacity to produce food, feed, fibre and fuel. Land Degradation occurs when the land's use by man is incongruent with the land's attributes (FAO, 1976). Land degradation also implies a reduction of the resources potential by one or a combination of processes acting on the land, including water and wind erosion, sedimentation and siltation, long-term reduction in the level of diversity in natural vegetation, crop yields, and soil salinization (Hellden, 1991). Following Scores and Toulmin (1999: 63), degradation is defined as an effectively permanent decline in the rate at which land yields products useful to local livelihoods within a reasonable time frame. This links to the UNEP (1977) usage of the definition as "diminution or destruction of biological potential of land". According to a Global Environment Facility (GEF) news release, land degradation, which includes desertification, can be defined as loss of biodiversity, reduced subterranean carbon sequestration, and pollution of international waters (GEF, 2003).

Various forms of land degradation exist which can be light, moderate, severe or extreme. Light degradation occur when good soils begin to show sign of productivity loss which include nutrient decline and increased salinity on top soil which can be restored through standard conservation practices such as crop rotation, minimum tillage and other on-farm practices. Decline in nutrient and soil compaction as well as loss of top soil from water and wind erosion, all of which contribute to loss of potential productivity are regarded as moderate degradation. Soil conservation practices and major structural interventions such as contour ridging and bands, drainage for water logging or salinity are restoration measures to reverse moderate type of degradation. Severe degradation is the one that involves serious nutrient depletion and deeper and more frequent gullies and hollows. For severe degradation to be restored, measures required include terracing, physical structures, reseeding, and mechanised deep ploughing. Lastly, extreme degradation occurs when there is serious loss of potential productivity of land making the soil to be extremely poor and restoration becomes impossible (Oldeman et al., 1990; WRI, 1992).

No matter how degradation may be conceptualised or classified, land degradation denotes negative connotations that refer to decrease in potential capability within the environmental-economic system. The decrease may be related to loss of land value for agriculture, the environment as host to naturally-occurring species of fauna flora and or to the environment as a place for human activities such as human habitation, mining, and waste assimilation (Gretton and Salma, 1997). Land degradation is primarily measured by decline in productivity which occurs through the loss in quality of water, soil, and vegetation, the three ecologically and economically important attributes of land. The process leading to land degradation through the loss of sustainable use of water, soil, and vegetation is presented in figure 2.2.

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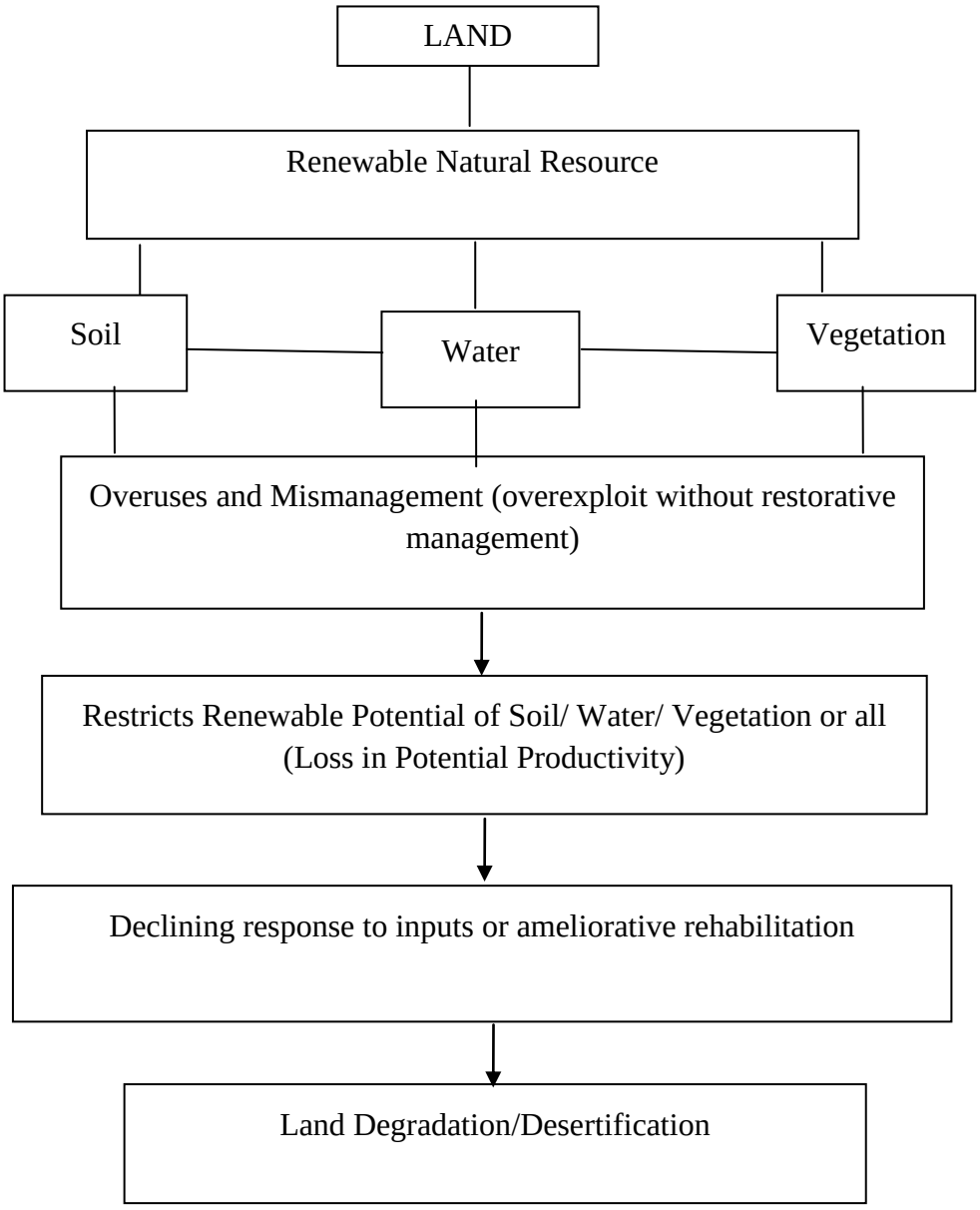

Figure 2.2: Process of Land Degradation.

Source: Jagdish and Paul (2000)

2.1.3: Understanding Vulnerability

Vulnerability is an important part of hazard and risk research. The scientific use of the term 'vulnerability' has its root in geography and natural hazards research, although it is now a central concept in a variety of research contexts such as disaster risk management, ecology, public health, poverty and development, secure livelihoods, food security, sustainability

sciences, global environmental change, and climate change impacts and adaptation (Fussel and Klein, 2006; Fussel, 2005 & 2010). Vulnerability refers to the susceptibility of people, communities, and regions to natural, human made, or technological hazards (Kumpulainen, 2006).

Vulnerability is defined by Blaikie et al. (2004) as the characteristics of a person or group in terms of their capacity to anticipate, cope with, resist and recover from the impact of a natural hazard. They argue that vulnerability is a measure of a person or groups exposure to the effects of natural hazards including the degree to which they can recover from the impact of that event. According to Cutter et al. (2009), vulnerability is defined as the susceptibility of a given population, system, or place to harm from exposure to the hazard and directly affects the ability to prepare for, respond to, and recover from hazards and disasters. According to Holling 1986, and Kasperson et al. (1995), vulnerability is based on:

- The degree to which a system is exposed to a perturbation;
- Its sensitivity to that perturbation (i.e. the degree of system change associated with a given degree of perturbation;
- Its adaptive capacity (the ability - often measure in the time it takes – for a system to change its structure to support basic system functions in response to perturbation; and
- Its resilience (the rate at which a system regains structure and function following a perturbation). Resilience is seen as the ability to self-organize, learn and adapt to risk hazards (Carpenter et al. 2001; Turner et al. 2003).

According to United Nations International Strategy for Disaster Reduction (UNISDR, 2009), resilience refers to the transformative process of a household or community exposed to hazards to resist, absorb, accommodate and recover from hazards in a timely and efficient manner.

Researches has shown that vulnerability has been analysed as a composite of adaptive capacity, sensitivity and exposure to hazards (Kelly and Adger, 2000; IPCC, 2001; Adger 2006; Yuga et al. 2010). Adaptive capacity is seen as the ability of people to cope with or adjust to the changing context and is explained by socio economic indicators. Sensitivity refers to the ability of a system to be affected while exposure is the incidences of events that are encountered (Kasperson et al. 1995; Adger 2006; Paavola 2008). Vulnerability therefore comprised of risks or a chain of risky events that households confront in pursuit of their livelihoods, the sensitivity of livelihood to these risks, the response or options that households have for managing these risks and finally the outcomes that describe the loss in wellbeing (Turner et al. 2003).

Vulnerability has three components based on IPCC (2007) definition. These are exposure, sensitivity and adaptive capacity. It follows that a system will be vulnerable if it is exposed and sensitive to the impacts of environmental hazards and at the same time has only limited capacity to adapt, whereas, a system will be less vulnerable if it is less exposed, less sensitive and/or has a strong adaptive capacity (Smit et al. 2000; Smit and Wandel, 2006; Fellmann, 2012). For example, a farm household that is highly sensitive to desertification but whose ability to adapt is severely constrained will become highly vulnerable. Blaikie et al (2004) also argued that households that have access to resources and social networks are less vulnerable. Although they may experience greater losses (in absolute terms) than the poor, it can be argued that resource rich households are more resilient in that they recover more quickly from a stress/stimulus.

Vulnerability as used in this study refers to the likelihood of farm households in rural communities of semi-arid region of Katsina State to suffer from desertification adverse impacts on their livelihood and their inability to respond to stresses resulting from the impacts. Farm households are vulnerable because they majorly depend on ecosystem which is

prone to the effects of desertification. This is as a result of the combined effects of over dryness of the environment, increasing temperature, drought, increasing evaporation, low soil nutrients, inadequate pasture combined with wind erosion that are common in desertification prone areas of the world.

2.14: Vulnerability Assessment Approach

Vulnerability assessment of an individual or groups, regions and household levels can be carried out using three main approaches. These are socio-economic, biophysical and integrated approaches.

The concern of socio-economic approach is on the socio-economic and political status of individuals or groups. This approach sees individuals in a community to vary in terms of gender, education, health status, wealth, access to credit, information and technology, formal and informal capital and political power, which are responsible for variations in vulnerability levels (Füssel 2007; Deressa et al. 2008). For instance, Blaikie et al. (2004) argued that households that have access to resources and social networks are less vulnerable. For example, Opiyo et al. (2014) affirmed that the vulnerability level of households to the frequently occurring climate-induced stresses in pastoral rangeland of Kenya is largely determined by gender and education level of the household head. Their findings show that more than 80% of the studied households had no basic primary education which in turn reduces their ability to understand climatic and early warning information and hence makes them highly vulnerable. They also asserted that gender discrimination with respect to resources, rights, income and economic opportunities faced by female-headed households makes them more likely to be vulnerable than male-headed households. In this regard, vulnerability is shaped by society as a result of institutional and socio-political status of individual or groups. One main limitation of this approach is that it focuses only on variations within society, but in reality, societies vary not only due to socio-political factors but also

because of environmental or biophysical factors (Deressa et al. 2008). For example, areas with easily accessible underground water can better cope with drought by utilizing this resource, compared to areas without it.

Biophysical approach attempts to assess the level of damage that a given environmental stress causes on both social and biological systems. It is sometimes known as an impact assessment approach. The emphasis here is on the degradation of biophysical conditions (Liverman 1990). The environmental or biophysical factors such as climate, soil and vegetation of an area can determine the variation in vulnerability level of communities or regions. For example, Molua (2003) carried out a research on climate variability, vulnerability and effectiveness of farm level adaptation on food security in southwestern Cameroon. It was argued that the risks associated with increasing climate variability pose technological and economic challenges to societies which are dependent on agriculture for their livelihood. Similarly, according to the report of the project executed by Centre for Environmental Economic and Policy in Africa on climate change and agriculture in Africa , it was argued that agro-ecological systems are the most vulnerable sectors. Agriculture in low latitude developing countries is expected to be especially vulnerable because climate of many of these countries is already too hot (Hassan, 2002). According to Hewitt (1995), biophysical approach is an approach mostly employed in studies of vulnerability to natural hazards and climate variability and change. The limitation of this approach is that it neglects both human agency and structural factors in producing vulnerability and in coping or adapting to it. Also, this approach according to Liverman (1990), Hewitt (1995), and Pulwarty and Riebsame (1997) overemphasize extreme events while neglecting root causes and everyday social processes that influence differential vulnerability.

The third approach is the integrated which unites the first two approaches, both socio-economic and biophysical factors. This approach combines all the socio-economic and

political status of an individual or groups as well as the environmental or biophysical factors to determine vulnerability. For example, the African continent has been highlighted as particularly vulnerable in the future, primarily due to its low adaptive capacity and its sensitivity to many of the projected changes (IPCC, 2007b; Callaway, 2004). Additionally, climatic changes are taking place in the context of other developmental stresses, notably poverty, fluctuating oil prices, and food insecurity (FAO, 2006), as well as in combination with environmental change, drought and land degradation (Thomas et al, 2008). This approach therefore includes all the internal state of vulnerability and the external situation.

2.1.5: Understanding Adaptation

Adaptation is a process of deliberate change, often in response to multiple pressures and changes that affect people's lives. Smit et al. (2000) suggest adaptation to be the adjustments made in ecological–social–economic systems in response to actual or expected climate stimuli, their effects or impacts. Burton et al. (2002) consider adaptation to mean the ability of social and environmental systems to adjust to change in order to cope with the consequences of change. According to Inter-Governmental Panel on Climate Change (IPCC), adaptations are adjustments or interventions, which take place in order to manage the losses or take advantage of the opportunities presented by a changing climate (IPCC 2001). Adaptation is the process of improving society's ability to cope with changes in climatic conditions across time scales, from short term (e.g. seasonal to annual) to the long term (e.g. decades to centuries). The goal of an adaptation measure should be to increase the capacity of a system to survive external shocks or change. Adaptation is therefore a process of deliberate change in anticipation of or in reaction to external stimuli and stresses (Nelson et al. 2007).

Adaptation has the potential to significantly contribute to reductions in negative impacts from changes in climatic conditions as well as other changing socio-economic conditions, such as volatile short-term changes in local and international markets (IFPRI,

2007). Adaptation was seen as a viable option in reducing vulnerability associated with anticipated negative impacts of climate change (Jones, 2010). Adaptation is certainly an essential component of any policy response to desertification. Adaptation will likely play a key role in reducing vulnerability and give room for multiple opportunities to be realized.

Farm household adaptation to desertification as used in this research work refers to "a process of deliberate change in response to or in order to cope with desertification-induced stresses that affect farm household's livelihood". While these changes can be environmentally, climatically or economically driven, Adger et al (2005) noted that identifying the precise drivers of these changes is extremely difficult. They further stressed that adaptation may reduce risk at one (short) time scale yet cause an increase in exposure to risk in the long term. Successful adaptation may therefore be viewed as those actions that decrease vulnerability and increase resilience overall, in response to a range of immediate needs, risk and aspirations (Van Aalst et al., 2008). For dry land populations, whose livelihoods are often tied to subsistence agriculture and the natural resource base, successful adaptations build resilience and decrease vulnerability to multiple threats of dry land hazards such as desertification, drought etc. Households that had full access and total control over resources necessary for adaptation tends to be less vulnerable and vice-versa.

2.1.6: Adaptation in the context of Desertification.

Rainfall variability and uncertainty surrounding its annual reliability have prompted dry land communities to adapt to dynamic climatic environmental and weather conditions throughout history. However, approaches to adaptation tend to be either actor-oriented or resilience-based. Actor-oriented approach focuses on the agency of social actors or institutions to respond to specific environmental stimuli while on the other hand, resilience-based approach focuses on systems that see adaptive capacity as a core feature of social-ecological systems (Nelson et al., 2007).

In the same vein, actor-oriented approach is regarded as managed, policy-driven adaptations (for example, through drought early warning systems) and resilience-based approach is considered autonomous, locally-driven adaptations (such as a change to the dominant livelihood activity). Conventionally, local level adaptations are thought of as reactive, while policy-driven adaptations tend to be planned (Smit et al., 1996; Burton et al, 2002). To enhance our understanding of policy-driven adaptation, parties to the United Nations Convention to Combat Desertification (UNCCD) that declare themselves affected by desertification are required to develop National Action Programmes (NAPs). The need for NAPs is embodied in the UNCCD (1994) text, which states that affected parties should highlight the key challenges they face in relation to desertification and drought, and present a strategy through which these challenges will be addressed. Community participation in the development and implementation of NAPs is also considered vital.

While the understanding of adaptation as a process of deliberate change is now widespread in climate change circles, the notion of adaptive capacity built on understandings about resilience has a broader application, encompassing deliberate changes in response to or anticipation of environmental changes including drought and desertification. While adaptation is critical in dealing with the unavoidable impacts of desertification, it should be approach from a site-specific perspective. For what may be effective adaptation for one community may undermine the ability of others to adapt through spatial spill-over and negative externalities. (Osbahr et al., in review) For example, land use shifts towards the cultivation of new species in one area may alter the dominant biodiversity, undermining the provision of ecosystem services such as pollination in other areas (e.g. Olschewski et al., 2006). Evidence abounds in literature that people in the dry lands communities have been adapting to desertification through early planting, crop rotation, intercropping, planting tolerant crop varieties, changing crop varieties, fertiliser application and livelihood diversification among

others. (Adger et al, 2005; Nelson et al, 2007; Smit et al, 2000 and Stringer et al ; 2009). Adaptation may also involve blending scientific practices with local/traditional knowledge. In northern Nigeria to be precise, people's responses to the hazards of drought and desertification have been noted. The adaptive strategies include among others: minimum tillage of the lightly sandy soils of the Sahel; cross-ridging to conserve water; dry planting in which seeds are planted while waiting for the rain in order to make maximum use of moisture from the very unpredictable, but usually heavy, first rains; planting of early-maturing and drought resistance crop varieties; intercropping; alternative employment; liquidating accumulated assets, such as livestock during drought; mobilizing social networks by which wealth is distributed from the relatively rich to the common people; and migration into the cities and neighbouring countries (Gashua, 1991; Mortimore, 1989, NEST, 1991 and Oladipo, 1993).

2.2: Theoretical Issues on Desertification/Land Degradation

2.2.1. Introduction

The theoretical framework for this study is anchored on the human use of environmental resources leading to land degradation/desertification. This is so because the causes of desertification are principally human in nature. Although, some attributed desertification to climatic variations, most analysts accept that the natural processes causing land degradation have been exacerbated by human factors (Blaikie, 1987). Land degradation is defined as the change in productivity and the provision of ecosystem services as well as human benefits derived from them. The term land degradation and desertification are used interchangeably in the literature; however, the latter is strictly defined as land degradation in the dry lands.

The theoretical issues on land degradation focus on explaining how man's use of environmental resources may results into land degradation in the dry lands, otherwise known

as desertification. Three theories are considered appropriate in this study to explain land degradation in relation to desertification, all of which are closely related to the concept of externality. The theories share similar belief that externalities are responsible for land degradation. They are social cost, collective goods and the property rights theory.

2.2.2: Theory of Social Cost

The theory of social cost can be traced back to Pigou (1920) and his recognition of the relationship between private and social cost (Watcher, 1992). According to this theory of land degradation, the private interest of the impoverished and the social interest of the broader society diverge. The interests of the local people in using land and water resources are intense, immediate, and focussed. They will, often unknowingly, incur almost any social cost to permit the immediate exploitation of these environmental resources to sustain their livelihood. The interest of loggers, commercial farmers, builders and others who exploit the forests, rangeland, grassland and water resources are equally intense, but driven more by immediate profit consideration rather than the need to survive. On the other hand, society, as a whole, has traditionally not placed a monetary value on the benefits derived from these resources. Rather, they are naturally occurring systems, on which the economic wellbeing of societies at local, national and international levels depends. When society has recognised these resources as having value, it has assigned a diffused, nonspecific value that has not been translated into financial incentives for preservation or disincentives for destruction of these resources. Thus, intense, focussed private interests are permitted to discount the value of environmental resources, and thereby sacrifice the longer-term benefits of the society (Onoja and Idoko, 2012).

The argument here is based on the fact that if users of environmental resources known as economic agents do not bear the full social costs of their actions (if there are externalities), factors of production will not be optimally allocated and the assumption is that the

environment cannot cope with the externality problem by itself (Wachter, 1992). Externalities are impacts inflicted on individual or people who are not party to the action or transactions that produce that impacts. Externalities introduce a distortion between the private and the social perspectives, and can explain why privately rational individuals may produce socially disastrous results. It is when the rate of degradation is off the social welfare maximizing path that land degradation is excessive and constitutes an economic problem. However, analysts have concluded that the socially and privately optimal rates of land degradation are largely the same (McComell, 1983), or that privately rational individuals may be forced to degrade land on a tragical path to self-extinction (Perrings, 1989).

The theory of social cost explains land degradation as the result of farmers' use of practices for which they do not bear the full social costs (Wachter, 1992). For example, fertiliser application can accelerate the natural process of soil acidification as nitrates and phosphates leach into the soil profile, while irrigation can raise the table water and lead to soil salinization (LaFrance, 1992). The application of more intensive tillage techniques will break up the soil and allow it to be more easily washed away. Repeated tillage and the ploughing up and down the slope instead of along the contour are other examples. Furthermore, extending the crop season and increasing the farm area under cultivation may accelerate the processes of land degradation. Cultivation of land with greater slope and the ploughing of all grass ways to increase short-term output will also imply a higher soil loss rate, thus reducing the future productivity of land (McConnell, 1983). Also, bush burning when done too frequently can permanently reduce the nutrient content of the land. The dangers of unsustainable land cultivation customs are exacerbated by high population growth rates in dry lands. For example, 2004 global population growth rate was 1.14%, but in Africa, the rate was 2.4%. This places additional strains on already delicate physical systems as vegetation and natural forest cover – earth's natural defence against land degradation – are eliminated in an effort to

sustain the population. This, however, contributes to land degradation in the long run.

2.2.3: Theory of Collective Goods

The theory of collective goods sees environmental resources as a public good. Public goods are goods that are jointly consumed by individual in a society such that exclusion of would-be users or consumers is impossible. On the other hand, if more than one individual has access to the particular resource, these investments are characterised as public goods, i.e. the returns from the investment of one user may be cashed by others. This kind of ownership provides incentives for free-riding, resulting in over utilisation of the natural resources. These effects have been exemplified by Warming (1911) on fishing grounds and perhaps more famously by Hardin (1968) on grazing pastures. A pure collective good has three properties according to Wachter (1992). First is non-excludability, meaning that nobody can be excluded from consuming it. Second is non-rivalry in consumption which connotes that one person's consumption does not impair that of another and the third is externalities which represent the possibility of free-riding because of non-excludability. The theory of collective good is closely related to the theory of social cost since externalities are a constituent part of collective goods (Wachter, 1992). Externality arises wherever some user A, (which may be either an individual or a firm), takes an action which has an impact on some other user B who is not a party to the action taken by A (Hodge, 1995). Numerous environmental goods have collective properties of non-excludability and externalities and as such most environmental problems arise when non-rivalry no longer applies in the consumption of those goods (Wachter, 1992).

According to this theory, certain environmental problem such as land degradation may occur when users exploit this environmental resource without contributing anything to its conservation or maintenance (Wachter, 1992). Some environmental services to some degree have at least certain characteristics of public goods. The most important of these

characteristics is non-excludability. It is perhaps difficult to exclude those who are unwilling to pay or and unwilling to conserve them from the use of these resources. Historically, dry lands livelihoods have been based on a mixture of hunting, gathering, cropping, and animal husbandry, all of which depend on the use of ecosystem services. The harsh and unpredictable climate combined with changing socioeconomic and political factors has forced dry land inhabitants to be flexible in land use (MEA, 2005). In addition, the two main land users: herders and farmers see the land as a collective good which must be enjoyed by all. In some cases, this led to intercultural conflicts and desertification as herders and farmers claim access to and use of the same land. In most cases, two main land users exploit the scarce environmental resources (pastoral rangeland and cultivated land use) without any recourse to the negative effects on one another and even without contributing to the maintenance or conservation of these resources. No one has an incentive to conserve the land because the benefits of conservation are dissipated among all users (Wachter, 1992).

One school of thought maintains that the poor, who heavily depend on the land, lack the required capacity needed to prevent or mitigate land degradation. (Perrings, 1989; Larson and Bromley, 1990). In what Reardon and Vosti (1995) termed investment poverty, poor land users lack the capital required to invest in land improvement. Neither labour nor capital resources are available to invest in land conservation measures, such as green manuring or soil conservation structures (FAO 1994). Because farmers cannot afford inputs such as fertilizer, pesticide, or irrigation equipment, the productivity of the land declines. The low productivity puts pressure on marginal lands, which are cultivated to add to the family income. Poor farmers tend to be associated with marginal lands and low yields (Rockstrom, Barron, and Fox 2003), which is manifested in their lack of financial means, poor health status, and outmigration by men. This process is describe as a downward spiral of low

productivity and land degradation in which poverty is not only a result of desertification but a cause of it (Safriel and Adeel, 2005).

2.2.4: Property Right Theory

Property rights theory tries to explain the concept of property rights in relation to the use of natural resources, and the operationalisation of the concept in land degradation theory. It has long been recognised that the ownership of a resource to a large extent influences the way that the resource is used and managed for future use. The basic idea is that when an individual owns a resource and can expect to own and profit from the resource in the future as well, the individual has incentive to invest in the resource in the form of protective measures, restrained use and careful management (Warming, 1911). The property rights theory shares with the first two theories, the belief that externalities cause land degradation. In the use of environmental resources, there is possibility that the actions of an actor affect the welfare of others. If the actor does not take into account the effects visited upon others, an externality is said to occur. However, property rights theorists argue that the main problem is not externalities but rather absent or poorly defined property rights to environmental goods (Wachter, 1992).

Property right according to Bromley (1991) is defined as a set of actions and behaviours that the possessor may not be prevented from undertaking in relation to a benefit (or income) stream. When an individual possesses property rights, other individuals have a duty to refrain from taking actions that interfere with the rights holder's exercise of those rights. Property rights have always been categories into four different property rights regimes, namely- private property, common property, state property and open access (Bromley, 1991). All elements of a property right are vested with an individual under a private property rights regime such that other members of the community can be excluded from using these resources without the consent of those who hold the rights. In a common property rights

regime, all property rights are assigned to a group of individuals collectively such that every member of the group does not possess the rights individually but jointly with other member of the group. State property rights regime is vested in the hand of the state or some authority in the public sector. Access to resources under state property rights can only be granted by the government. Open access property rights regime did not assign specific rights to anyone and no one can be excluded from using the property. With this, there is no property rights defined. This is precisely the mechanism linking property rights with the decisions of how natural or environmental resources are used. As pointed out by Hardin (1968), when nobody owns a resource, i.e. under open access, resources users have no incentives to limit their use of the resources, because that would simply mean that other users increased their use. It is natural that without secured property rights; farmers do not feel emotional attachment to the land they cultivate, do not invest in land development and will not use inputs efficiently. For example, regarding the application of manure, evidence from farmers using own land and borrowed land for cultivation show that manure application ins more frequently applied on the former than on the latter (Gavian and Fafchamps, 1996), which underlines the importance of long-term incentives for single users, who are not necessarily dependant on the system as a whole.

One of the main topics of discussion between property rights theorist has been the identification of the most appropriate property rights regime in any given situation. Traditionally, the literature has favoured private property rights in the mid 1960s to 1970 (Demsetz, 1967; Cheung, 1970), but in last two decades the merits of common property rights have been demonstrated as well in a number of case studies (Ostrum, 1990; Stevenson, 1991; Ostrum et al., 1994). However, the institutional context within which the resources use take place is a major determinant of the effectiveness of the property rights structure. A well developed institutional framework ensures state enforcement of formal property rights. Ostrum (1990) is of the opinion that to a certain degree, when formal institutions exist to

support enforcement of property rights, private property rights may be more effective. But, when these institutions are lacking, common property rights may be superior to private property. Property rights consist of two components: the rule and its enforcement mechanism. While the rule may derive from state law, user group rules, and other frameworks, it is the responsibility of the state to enforce statutory law. For instance, if excessive utilization of fertilizers by a farmer imposes externalities (burden) on fishermen in a nearby river, the state could appropriate the right to use of fertilizer on the farmers field within the conditions set by the state such that the fishermen will not be affected. If same thing applies to cutting down of trees, grazing of animals, uneconomic use of ground water, pollution or erosion and all sorts of unsustainable use of environmental resources, socially optimal usage of land resources may be guaranteed and hence externalities causing land degradation will be curtailed.

If land rights are unclear, unspecified, disputed, or nonexistent, then land users are less likely to be interested in conserving resources or in making investments that improve long-term productivity of resources; that is, the land resources users would have no incentives to take care of their land resources and use them in a socially optimal way (Wachter, 1992; Hazell and Lutz, 1999). According to Ahmad (2000), degradation is an outcome of policy and institutional failures, which include a lack of well-defined, secure, tradable property rights. However, by establishing appropriate property rights, users will consider the maintenance, conservation and long-term sustainability of environmental resources and thus transformation of degradable land in most cases will be reversible.

2.3: Review of Related Literature

This section covers a review of related literature on linkages between desertification, drought and climate change as they are closely interlinked, and most acutely experienced by rural population. It also includes a review of related literature on desertification assessment as well as causes and consequences of desertification.

2.3.1: Linkages between Desertification, Drought and Climate Change

The impacts of desertification, drought and climate change are closely interlinked, and most acutely experienced by populations whose livelihoods depend principally on natural resources.

The United Nations Framework on Climate Change defines climate change as a change of climate which is attributed directly or indirectly to human activities that alter the composition of the global atmosphere and which is, in addition to natural climate variability, observed over comparable time period (Aliyu, 2008; Akeyeton and Ogundele, 2008; Anyadike, 2009 cited in Onokala, 2011).Climate Change is also defined as long-term change in the statistical distribution of weather patterns over periods ranging from decades to millions of years regardless of cause (Oladipo, 2013). Climate change results from the effect of human- induced increase in the concentration of greenhouse gases in the atmosphere, enhancing the natural greenhouse effect. As the concentration of these gases increase, so does the radioactive forcing, and global mean surface temperature. The magnitude of the human – induced effect is not fully resolved, but surface temperature observation indicate that there has been a global mean warming of 0.3 to 0.6 degrees centigrade over the past one hundred years, a very rapid rate of change compared to past changes in climate (Zinyowera et al; 1998). Climate change is responsible for uncertainty in the rainfall pattern, especially the timing and amount of rainfall and these affect agricultural activities. Many places in Nigeria are experiencing late onset of rains, early ending of rainy season, and reduced annual amount of rainfalls, especially in the northern parts of the country due to climate change (Adejuwon, 2006; Adefolalu, 2007).

Drought according to WMO (1975) is defined as “a deficit of rainfall with respect to the long-term mean, affecting a large area for one or several seasons or years, which drastically reduce primary production in natural ecosystems and rain-fed agriculture”. The

encyclopaedia of climate and weather (Schneider, 1996) defines drought as “an extended period – a season, a year, or several years of deficient rainfall relative to the statistical multiyear mean for a region”. Drought may also be defined as a climatic event involving a shortage of rainfall sufficient to affect adversely water supplies and crop and livestock production, causing much disruption of economic activities and producing some temporary ecological changes in the affected areas (Oladipo, 1993). A drought is primarily a natural climatic event with a subtle beginning and insidious progress, but its consequences can be significantly altered by man.

Nelson (1988) states that desertification is a process of sustained land (soil and vegetation) degradation in arid, semi-arid and dry sub-humid areas, caused at least partly by man. It reduces productive potential to an extent which can neither be readily reversed by removing the cause nor easily reclaimed without substantial investment. Desertification relates to both the processes and the end state of dry land degradation, involving soil erosion, soil degradation, deforestation and degradation of the land (Swift, 1996). The term desertification has been associated with a number of physical manifestations, such as sand dunes, that have conjured up images of deserts expanding uncontrollably, fuelled by population growth and inappropriate resource use technologies (Mortimore 1998).

Drought and desertification are intertwined so that they tend to be confused with each other and used interchangeably but the two phenomena, are however, not identical. According to Hare (1987), drought resembles mononucleosis: you get it, but you get over it. Desertification is like a chronic wasting disease (AIDS): you get it, but you don’t get over it. It slowly worsens.

There are several possible links between the physical processes of climate change and desertification. The links between these two issues become particularly strong, however, when the local – level social context of natural resources management is taken into account.

The first link between climate change and desertification concerns the suggestion that removal of vegetation, or dry land degradation, may affect climate. The perception that desertification is a man-made process suggest that removal of vegetation cover affects the rainfall producing convection circulation in West Africa, leading to a decline in rainfall over the Sahel. Once there is rainfall inadequacy, aridity sets in, and land degradation in arid area denotes desertification. Model studies of the interaction between land cover and climate, such as Franchito and Rao (1992) and varejao– Silva et al. (1998) indicate that the climate is sensitive to vegetation changes. (Kutzbach et al. 1996), though the extent of the effect is uncertain, and the scale of change very regional (chase et al; 2000)

A second link between desertification and deforestation and the global climate system is the emission of CO_2 into the atmosphere. Defries et al. (1999) estimate that land use change has contributed at least one third of the total carbon released into the atmosphere from human activities. Deforestation also leads to a transient increase in atmospheric CO_2 release by burning or decomposition of the forest biomass. Hulme and Kelly (1993) point out that desertification reduces a potential carbon sink, in terms of carbon stored in vegetation. Though important for regional not carbon budgets, however, they suggest that land conversion in dry land areas is a less important contributing factor than tropical deforestation to carbon emissions.

The third link suggests that global climate changes exert a stronger effect on local climate patterns and desertification. Natural climatic variability as well as global mean warming may be driving forces in desertification (Hulme and Kelly, 1993). Sea surface

temperature may be a dominant factor influencing rainfall variability in general and the Sahelian climate in particular (Rowell et al. 1992). Much of the variability of the Sahara's areal extent can be explained by rainfall variability. Change in rainfall patterns alters the extent of arid, semi-arid and dry sub-humid areas. Savannas, a common dry land vegetation type in Africa, are likely to be particularly affected by global climate change as their water balance and vegetation are quite sensitive to water balance changes induced by temperature and precipitation changes (Yang and Prince, 2000).

Drought and desertification are closely related phenomena. In fact, drought and desertification have been related so intimately that the former is often associated with the incidence of desertification (UNEP–UNCOD, 1978). Although evidence is not adequate to link drought to the onset of land degradation, the consequences of land degradation/desertification are most pronounced under drought conditions (Dregne, 1978; Hare, 1985, Mainguet, 1994). During the last 30 years or so, decreasing rainfall with increasing abnormally trends have been observed in Africa (Hulme 1992 and Zeng et al; 1999). For instance, studies have indicated that the Sudano-Sahelian Ecological Zone (SSEZ) of Nigeria has suffered decrease in rainfall in the range of about 3-4% per decade since the beginning of the 19th century (FRN, 2003). As a result of the large inter-annual variability of rainfall in the SSEZ, it is therefore subject to frequent drought. Because of the consistency, these trends suggest a change in climate and hence the role of desertification becomes certain. For example, the arid and semi-arid areas of Nigeria are, by nature prone to recurrent and sometimes intense and persistence period of drought separated by period of wet years. Drought may result in the depletion of soil and shallow ground water resources and are capable of disrupting even if temporarily, the low level of resilience of the natural ecosystem of these regions. Protracted drought as experience in northern Nigeria in the 20th century (from 1903 up to 1985) has a more serious impact. During such extended dry period, the land

is under increased stress from both humans and livestock, and these may be severe enough to cause extensive damage to the environment once the precarious equilibrium of the plant communities could not adopt to characteristics variables of climate and this leads to prolong drought, and complete recovery may be impossible, even when the rains return (Oladipo, l989).

While desertification is a natural phenomenon, whose impacts can be exacerbated by human activities that are not adapted to the local climate, land degradation is the process of turning fertile land into less or non- productive land. In extreme cases in dry lands, this is called desertification. Land degradation and desertification are complex phenomena driven by un-adapted human activity in combination with land and climatic constraints. Inappropriate land use, such as monocultures, and unsustainable land management practices, such as deforestation, unsuitable agricultural practices and overexploitation of water resources, can cause land degradation that can be further aggravated by drought. Climate change is expected to increase frequency, duration and severity of droughts in many parts of the world. Such changing conditions add to already stressing land use globally and especially in the world's fragile dry lands. This may lead to an accelerated rate of land degradation and desertification which, in turn, is likely to increase poverty (Oladipo, l989).

In regions susceptible to desertification, co-efficient of variation of annual precipitation frequently exceeds 30%. Fifty percent of the rainfall often falls in less than 10% of the rainy days associated with intensive storm events. In addition, the total annual evapotranspiration far exceeds total annual precipitation. Studies have shown that the inter-annual variability of rainfall in the desertification prone areas of northern Nigeria is between 15 and 20% and the total annual evapotranspiration in these areas far exceeds total annual precipitation (Oladipo, 1993 and Bashir, 2008). It's this high variability that makes dry land regions climatically unstable and particular prone to drought. However, neither the role of

prevailing climatic variations in intensifying land degradation, nor the influence of global warming on land degradation, should be ignored when designing strategies for combating it. This therefore establishes a relationship that links land degradation directly to human actions and indirectly to climatic variations.

2.3.2: Desertification Assessment

Given the potential relevance of desertification as a serious threat to arid and semi-arid environment, it is surprising that there is no consensus on the proper way to assess the desertification status of a piece of land. Since the concept was first used by a French scientist, Aubreville in 1949, conflicting definition have produced both different assessment methodologies and divergent estimates. Some studies provided catastrophic perspectives on both the rate of advance of desert lines and the area affected by desertification (Lamprey, 1975; UNEP 1984). Others, in contrast, questioned the methodology employed by previous, studies and found no evidence for extensive desertification (e.g. Hellden, 1988, 1991; Tucker et al., 1991; Nicholson et al., 1998; prince et al; 1998). The affirmation of desertification assessment being controversial is evidence from the United Nations Convention to combat desertification statement as at year 2000 that although a great deal of data on land resources are available, it has not been possible to get a clear picture of the status of land degradation at regional or national levels (UNCCD, 2000).

The lack of precise, agreed estimates of the extent of desertification opens the door to misusing the advances and limitations of desertification status. For instance, a review of most important foreign and Nigerian newspaper headlines (Table 2.1&2.2) showed the radical treatment that the issue of desertification was given in the popular press.

Table 2.1: Display of Desertification Assessment in Foreign Popular Press

Headline	Source	Date
World's Desert Grow by 14 million Acres	New York Time	Aug,28, 1977
Plan for 'Green Belt' Near Sahara Revived	New York Time	Sep. 7, 1977
Man and Environment-An Unending Battle	The Washington Post	Sep. 9, 1977
Greedy Sahara Devours Land Along its Border	New York Time	Sep. 15, 1980
Droughts, Desert and Death	Nassau Guardian	May 13, 1985
Spread of Deserts Seen as Catastrophe Underlying Famine	New York Time	Jan. 8, 1985
Continuing Threat: Senegalese President Makes Drought Plea Staff Writer	Washington Post	Oct. 26, 1985
Desert Encroachment is Predicted in China	New York Time	Sep. 15, 1985
The Ebb and flow of the Sahara	New York Time	July 23, 1991
Sahara Discovered to be in Retreat	The Washington Post	July 21, 1991
Threat of Encroaching Deserts may be more myth than fact	New York Time	Jan. 18, 1994
Man-made Desert	National Geographic	May 1998
Sahara Jumps Mediterranean into Europe	Guardian of London	Dec. 20, 2000
The Arid expansion	Guardian of London	Jan. 11, 2001
China's Growing Deserts are Suffocating Korea	New York Time	April14, 2002

Source: Reynolds and Stafford-Smith (2002) and Veron et al. (2006)

Table 2.2: Display of Desertification Assessment in Nigerian Popular Press

Headline	Source	Date
Sahara Desert over running Nigeria before our watchful eye	Sahara reporters	May 31, 2009
Special Report on Desertification in Nigeria: The Sun eats our land	Vanguard	May 3, 2010
Desert Encroachment in Nigeria	Nigeria Pilot	Aug. 3, 2011
Desertification is a threat to Economic Growth and Food Sufficiency	Royal Times	Nov. 19, 2012
Jonathan Approves ₦10bn to Fight Desertification in Nigeria	Nigerian Tribune	May 10, 2013
Nigeria: How Yobe Varsity Plans to tackle Desertification	Daily Trust	Feb. 28, 2013
Great Green Wall Project to check Desertification	Daily Trust	Jun. 26, 2013
43.3% of Land Area prone to Desertification in Nigeria	Vanguard	July 9, 2013
Desertification, Most Processing Environmental Challenge facing Nigeria	Daily Trust	July 17, 2013
Nigeria sets up Monitoring Team to Fight Desertification	Premium Times	Oct. 18, 2013
Government raises unit on Desertification	The Guardian	Jan. 7, 2014
How Katsina lost 15 Economic and Medicinal Trees to Desertification	Daily Trust	May 30, 2016

Source: Author's Compilation, 2016.

Traditionally, the issue of desertification assessment has been approached from a site-specific perspective (e.g. Prince et al; 1998; Diouf and Lambin, 2001; Collado et.al, 2002; Holm et al., 2002; Wessels et al; 2004). However, the estimates of the spatial extent of desertification would only be meaningful if they are circumscribed to a particular method to measure its magnitude. For instance, Veron et al., (2006) believe that much of the confusion

surrounding the spatial extent of desertification would be reduced if estimates were interpreted according to the conceptual and methodological framework under which they are produced. They further opine that a methodology to assess desertification impact should quantify its effects independently of other issues.

The assessment will be based on the biophysical aspects of desertification. This is because the land can hardly be said to be desertified until the symptoms appear in the biophysical system (Prince, 2002). Thus, desertification assessment methods as discussed here include- Desert-edge displacement, Field-data matrix and Rain use efficiency.

2.3.2.1: Desert–edge Displacement

In an attempt to determine the extent of desertification, Lamprey (1975) applied desert – edge displacement paradigm. He conducted aerial and terrestrial surveys in 1975 to quantify the rate of advance of the Sahara by comparing the location of the southern margin at two different times (1958 and 1975), according to a vegetation map produced by Harrison and Jackson (1958) (Figure 2.3). During this 17 year period, he observed a 90– 100km displacement, thus concluding that desert edges was encroaching at 5.5km per year. Desertification was regarded as the creation of deserts by humans. It was assumed as a state, characterised by physiognomic features typical of deserts (e.g. sand dunes, scarce open thorny vegetation, etc.), rather than a process. It was believed to spread from desert cores by means of sand invasions and in general, these changes were considered irreversible. Interestingly, this perception of desertification remained almost unchanged until Lamprey's years (Mainguet, 1994). Lamprey's work was later criticised for ignoring the fundamental role of climate variability. He received criticism from the work of Hellden (1991) and Tucker et.al (1991) who were able to showed through a combination of field work and satellite remote sensing that desert boundaries were very dynamic, their locations being tightly linked to annual rainfall. Lamprey's assessment subjected to detailed rainfall analysis actually showed

that it was a comparison between a wet year (1958) proceeded by a series of wet years and a dry year (1975) preceded by a series of dry years. However, Lamprey's approximation represented the application of the prevailing paradigm of desertification during that period.

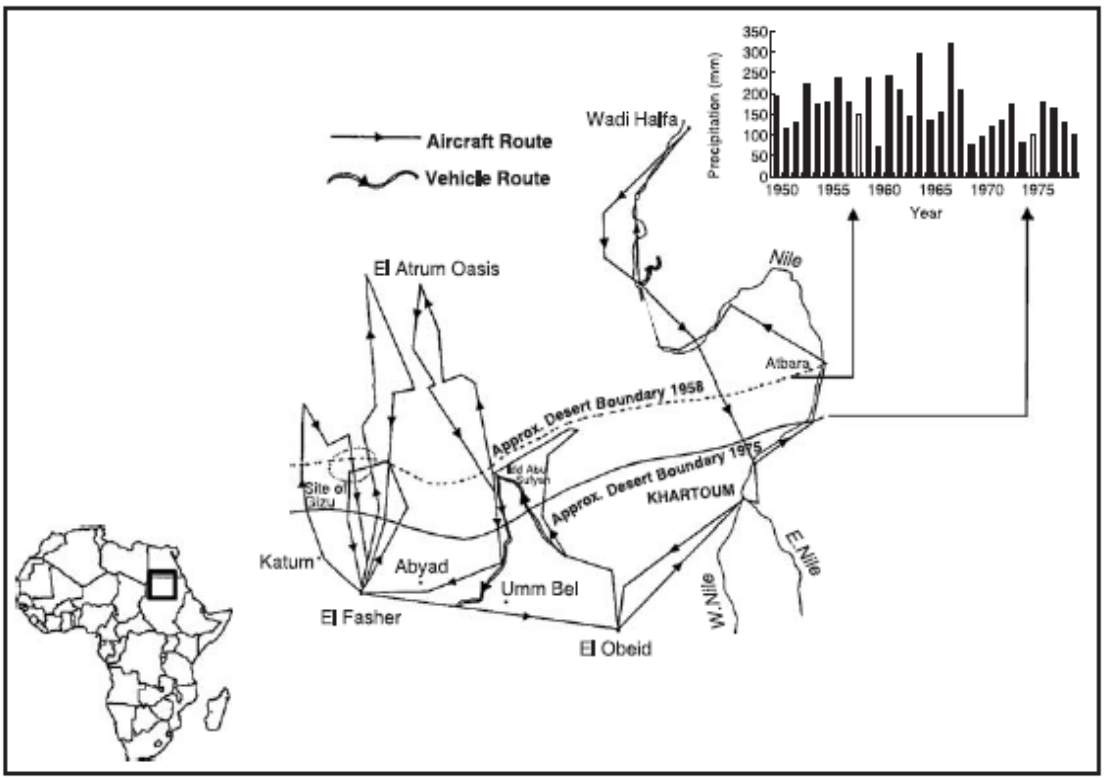

Figure 2.3: The survey route taken by aircraft and vehicle in 1975 by Lamprey
Source: Lamprey (1975) and FAO/UN (2000)
Dotted and plain horizontal lines indicate the position of the desert boundary in 1958 and 1975, respectively. Upper right inset: Khartoum annual precipitation (in mm) from 1950 to 1980. Precipitation from years 1958 and 1975 appear in white.

2.3.2.2: Field Data Matrix

Field data matrix represents another methodology aimed at assessing desertification. It came to be recognized following the conceptual ambiguity of the 1980s surrounding the state nature of desertification, its reversibility, and the relative importance of human versus climatic causes. Glantz and Orlovsky's (1983) popular review of more than 100 definitions of desertification speaks by itself of the vagueness and uncertainty that reigned during the 1980s.

This conceptual ambiguity was translated into assessment attempts that yield multidimensional methodologies which are based on a number of field data on vegetation and soil. International institutions like FAO or UNEP promoted the monitoring of desertification with these methodologies. For example, the FAO/UNEP (1984) method was summarized by a 16x4 matrix whose rows (16) were quantitative and qualitative variables of vegetation and soil, and the columns (4) were classes of degree of desertification (slight, moderate severe and very severe) (Table 2.3). Individual sites whose desertification status needed to be determined were visited and actual values (quantitative) or descriptions (quantitative) were recorded. The elements of the matrix were then integrated into a single index that summarized the desertification status of a site into one out of four classes: slight, moderate, severe and very severe as shown in Table 2.3

TABLE 2.3: FAO's Matrix of the Criteria for the Evaluation of Desertification Status Proposed by FAO/UNEP (1984)

Variable	Class limits			
	Slight	**Moderate**	**Severe**	**Very severe**
Plant cover				
Perennial plant cover	> 50	50-20	8-05 20-5	< 5
Grassland condition (%)	> 75	50- 75	08-08 20-50	< 25
Actual productivity (% potentate)	85- 100	65- 85	28- 05 25- 65	< 25
Water erosion				
Surface status (% area)	Gravel and Stones < 10	Stones and boulders 10-25	Boulders and rocks 25- 50	Boulders and rock outcrops >50
Type of erosion [a]				
Exposed subsoil (% area)	< 10	10-25	25-50	> 50
Gully area (%)	< 10	10-25	25-50	> 50
Soil thickness (cm)	< 90	90-50	25-10	< 10
Soil loss (%)				
Original soil depth < lm	25	25 -50	50-75	> 75
Original soil depth > lm	30	30-60	60-90	< 90
Actual productivity (% potential)	85-100	65-85	25-65	< 25
Wind erosion [b]				
Area covered by hummocks (%)	< 5	5-15	15- 30	> 30
Surface gravel percent cover	< 15	15-30	30- 50	> 50
Sanitization				
Morphology[c]				
Soil electrical conductivity (mmhos/cm)	< 4	4-8	8-16	>16
Exchangeable sodium (%)	< 5	5-20	20-45	> 45
Crop yield (% potential)	85-100	65-85	20-65	> 45
Affected areas (%)	<5	5- 20	20-50	> 50

Source: FAO/UNEP, 1984

[a]Slight: slight to moderate in sheets and rills. Moderate to severe in sheet and rills. Severe: severe in sheet, rill and gully. Very severe: very severe in sheets, rills and gully. [b]It includes a number of same characteristics used for water erosion. [c]Slight: no salts. Moderate: salt spots. Severe: salt spots and philaments. Very severe: crystalline efflorescence and salt crusts.

The most well-known result by this approach was the estimation that 70% of all dry lands were affected by desertification (UNEP, 1992). FAO and UNEP's approach received several criticisms for having logical and practical problems. As pointed out by Agnew and Warren (1993), a major avenue of criticism has been the subjective nature of their data as

most variables were not measured but estimated by informed opinion.. Regarding the practical problems, the methodology was labour-intensive, which posed serious limitations to the frequency and/or the extent of assessments. Overall, the methodology served to institutionalize desertification as a fact, downplaying the intense debate that was still taking place within scientific circles (veron et al; 2006).

2.3.2.3: Rain Use Efficiency

The need to develop a practical, objective methodology based on indicators which were applicable and readily interpretable across different regions was an important lesson from the 1980s and early 1990s attempts. Prince el al. (1998) and Nicholson et al. (1998) tried to fulfil this requirement, and assessed the desertification status of the Sahel region by means of the Rain Use Efficiency (RUE).

The RUE, the ratio between annual aboveground primary production (the rate of aerial biomass accumulation by plants, ANPP) and annual precipitation, was first suggested as a useful indicator of ecosystem productivity by Le Houerou in 1984. Le Houerou's (1984) underlying assumption was that different plant traits, favoured by natural selection, and community structure (e.g. Soil cover, plant biomass) account for the spatial variation in soils or climate leading to a convergence in the limiting resources use efficiency. Departures from the average RUE would, thus, constitute the result of human management.

The application of the RUE concept to the assessment of desertification was not investigated until many years later when Prince et al. (1998) sharpened its rationale. These authors argued that desertification decreased the proportion of precipitation that was diverted to infiltration and transpiration largely due to increases in run-off or evaporation. Prince el al. (1998) and Nicholson et al. (1998) articles concluded that there was not enough evidence to indicate extensive Sahelian desertification as neither ANPP nor RUE decreased with time.

One important advantage of RUE-based approaches over other methodologies is that it offered an attractive solution to the problem of desertification assessment. The availability of both rainfall data and remotely sensed estimates of ANPP at adequate temporal and spatial scales ensured its applicability to regional assessments. In addition, by considering RUE instead of soil variables, this methodology had more chances to provide anticipatory value as it allowed remedial actions to be taken before severe soil degradation occurs. Finally, the use of RUE was consistent with the most authoritative definition of desertification (Reynolds and Stafford Smith, 2002) as land degradation in arid, semi-arid areas resulting from various factors, including climate variations and human activities (UN, 1994) and as ANPP has been proved to be a good estimator of ecosystem functioning (McNaughton et al., 1989), and, thus, of land degradation.

Their results were extensively reported in scientific and popular media with provocative titles such as “The Sahara is not marching southward” (Kerr, 1998), and the methodology they used was afterwards applied in Australia (Holm et al., 2003), South Africa (O’Connor et al., 2001), and Senegal (Diouf and Lambin, 2001). Additionally, they incorporated remote sensing data into the analysis allowing for a complete coverage of large areas.

2.3.3: Causes and Consequences of Desertification

2.3.3.1: Causes of Desertification

General views, through review or book chapters have dealt with the concepts, definition, causes, consequences and processes involved in the phenomenon of desertification (Graetz, 1991; Le Houerou, 1996, 2002; Williams and Ballin1996; Reynolds and Stafford smith, 2002). The causes and consequences of desertification cannot be generalized on a global, continental, regional or even national level, although, two major factors are generally involved in desertification, first being the periodic stress of climate, and the second is man’s misuse of the sensible and vulnerable dry land ecosystem. They are however, site specific

(Hellden, 2003). Every site and case needs its own diagnosis, based on integrated and systematic research approach. In general, the natural vegetation of the desertification prone areas of the world is sparse or scanty due primarily to lack of sufficient precipitation. Nonetheless, however scanty the vegetation in these regions may be, it protects and to a large extent stabilizes ground surface. Accordingly, where vegetation is not completely degraded, there is always, in arid zone, a diffuse cover of at least 20-40% perennial species, such as shrubs, under shrub and grasses, which are capable of protecting soil surface from erosion. Wind erosion in these conditions is compensated by sand deposits behind obstacle that perennial plants constitute. When, as a result of climatic stress and man's intervention, the species become scattered (for example distance between two perennial species is equal to or greater than five times the size of their height), wind erosion is no longer compensated by particles deposited behind the obstacles that perennial species constitute and deflation may increase up to the point where patches of land surface are covered by pebbles after the removal of movable materials (Le Houerou, 1977).

For the purpose of this research, much emphasis will be placed on the causes and consequences of desertification, particularly in Nigeria. The causes and consequences of desertification and land degradation in Nigeria have been noted (Oladipo, 1993; NAP, 2000; Narisu, 2007; Majid and Choji, 2008; Ayuba and Dami, 2011; Audu, 2013). Desertification in northern Nigeria is the result of two main factors. The first factor being poor physical conditions in terms of soils, vegetation, topography and inherent extreme variability of climate as manifested in frequent droughts. The second factor is the destruction in ecological system caused by poor land use and ever-increasing demand being made upon the available land resources by the expanding population and socio-economic systems of the affected areas (Oladipo, 1993).

Natural cause of desertification is perhaps attributed to climatic variation in the arid and semi-arid regions of the world. Climatic fluctuations with changes in the temporal and spatial distribution of rainfall may result in the lengthening of aridity phases, higher temperatures and winds of greater intensity. Among the natural forces are wind and water erosion of soil, long-term changes in rainfall patterns, and other changes in climatic conditions. The role of drought is variable and related in part to its duration. A prolonged drought accompanied by poor land management may be devastating, while a shorter drought might not have lasting consequences. As such, drought thus stresses the ecosystem without necessarily degrading it permanently. Rainfall similarly plays a variable role that depends on its duration, the seasonal pattern of its occurrence, and its spatial distribution. Because of the erratic nature and high inter annual variability of rainfall, the arid semi-arid regions of the world are consequently prone to recurrent and sometimes intense and persistent drought. An analysis of the spatially-averaged rainfall series in four main sub-Saharan zones since 1900 shows the high degree variability and trends in the seasonal rainfall of an arid environment (Nicholson, 1989).

According to Barrow (1991) and Lal (1997a), a range of natural factor endemic to territories susceptible to desertification is believed to influence the progress of land degradation. For instance, climatic variations will have consequences for the availability of water resources, frequency of pest and diseases, and soil quality, leading to significant changes in the condition for agriculture and livestock production. Year-round aridity limits bio-productivity and slows down the processes of soil development, resulting in poor quality soils (Stewart et al., 1991). For example, the history of the severe and prolonged drought events that afflicted the Sudano- Sahelian zone of Nigeria speaks by itself of the influence of climatic variation in the process of desertification. The zone started the 20th century with a prolonged drought of 1903 culminating in that of 1911-1914. Other droughts included those

of 1991; 1924; 1935 and 1951-1954. Also, 1983-1985 was regarded as the driest period in this zone as the lake fell to its lowest level and shrank to its smallest area (Nasiru, 2007).

Along with climatic factors, a range of anthropogenic factors help in the process of desertification. The list of human or cultural influences on desertification includes vegetation loss by overgrazing, depletion of groundwater, surface runoff of rainwater, frequent burning, deforestation, the influence of invasive non-native species, physical compaction of the soil by livestock and vehicles, and damage by strip-mining. Desertification caused by human influences has a long historical record. There is evidence of such damage caused around the Tigris and Euphrates rivers in ancient Mesopotamia. In addition, several processes may operate simultaneously, feeding back into the system, intensifying the degradation of the quality of the resource base and the dec1ine of biological productivity (Feedback Mechanism). Similarly, increasing human pressure on the cultivated area beyond borders where man-environment equilibrium can be maintained is one of the main causes of desertification. Such human pressure normally includes the extension of irrigated areas, extensive use of the trees for firewood and overgrazing of livestock. Such pressures result in increased water and wind erosion of soil salinization and degradation of the plant cover by wind, man and livestock (Oladipo, 1989). For example, climatic cause of desertification in Nigeria is being intensified by the country's large population (about 140 million by 2006 national census) and increasing population growth. The land is fixed while the population keeps on growing. The increasing demand for land could be over-stressing the natural resources especially of northern Nigeria (where desertification is prominent) and make human activity a determining factor at all stages of desertification.

The causes of desertification were seen primarily as over-exploitation by humans exceeding the carrying capacity (human or livestock) of the relevant area (UNEP, 1977). This perception that desertification is a man-made process is partly based on studies, such as

Charney (1975). In Nigeria, human pressure on the land particularly in the marginal areas has continued to take its toll on the environment, resulting in desertification. Desertification is made very severe in the dry lands of the country by increasing human attempts to exploit the resources of the ecological zone in the face of persistent drought (Nasiru, 2007). More specifically there are four primary causes, notably over-exploitation, over grazing, deforestation and poor irrigation practices. For instance, cultivation of marginal climatic areas, especially, increase of cultivated area in rainfall years, is among the causes of land degradation. The extension of agricultural activities to the erstwhile marginally productive regions to the negligence of agronomic boundary would result in a heavy impact on to a highly sensitive ecosystem. The year1y repetition of clearing, planting, and harvesting leads to the inevitable destruction of the natural vegetation cover and increase erosion of the top soil. Over cultivation of crops and excessive tilling of the land leads to exhaustion of the soil nutrients. Crops harvested in dry lands are often grown in soils already depleted in nutrients. The pressure to exploit the land in this way can be brought about by increase food demand due to an increasing population, and monetary pressures such as the development of a cash-crop economy. Soils especially those of sandy nature exploited in this way can become prone to wind erosion, whilst over cultivation of clay soil may well cause water erosion leading to land degradation. Expansion of agricultural land to meet up with the food requirements of the increasing population has led to the degradation of land in Northern Nigeria. New lands are cleared of trees and other vegetations to establish agricultural croplands in the dry land, many of such lands are unable of recuperation, and hence desertification sets in (Oladipo, 1989).

In Nigeria, overgrazing and over-cultivation have been reported to be responsible for the conversion of 351,000 hectares of land into desert each year. For example, from 1978 to 1992, in Katsina state, the area of land used for intensive agriculture increased from 36.8% to 69% and forest decreased approximately from 1.1% to 0.1%. Livestock densities are high, the

majority owned by nomadic Fulani, who retained large herds for security. Soils in the region are ferruginous tropical soils, generally of poor structure and low fertility. The hot and dry climate causes bare, un-vegetated soil to easily heat up, especially during the dry season, resulting in soil baking. Coupled with high evaporation rate, the soil becomes powdery and easily blown away by the wind. Thus, in the absence of vegetation, wind and water erosion in exposed soil have had extremely detrimental effect, limiting plant growth and productivity. In the far northern areas, increasing sand dune formation is evident (UNEP, 1998).

Deforestation is another cause of desertification especially in developing countries. Logging, expansion of agricultural croplands, urbanization, fuel wood collection, mining and resources extraction, fire-hunting and slash and burn practices have been identified as the key drivers of deforestation. Non-commercial sources of energy such as fuel wood, dung, and crop residues constitute about 40% of the energy for cooking in developing countries. That percentage increases beyond 80% in small towns and hamlets (Lele et al; 1994). For instance, the use of fuel wood in Nigeria is put at 92% which is more in rural area than urban because of its cheapness, availability, tradition as well as near absence or scarcity of other sources of domestic energy (Audu, 2013). The demand for fuel wood causes the removal of trees, shrubs, herbaceous plants and grass cover from the fragile land, thereby accelerating the degradation of the soil to desert-like conditions (FAO, 2006). In Nigeria, more than 70% of the nation's population depends on fuel wood. Katsina alone, a northern state, has its over 90% energy from fuel wood (Mohammed et al., 2013). In Kano City, 75,000 tonnes of fuel wood are brought in by lorry and donkey within a radius of 20 km, which leads to denuding of the woodland. Due to socio-economic status of the people living in Nigeria dry land, felling of tree for fuel wood will continue to increase if alternative sources of energy in the sudano-sahelian zone are not provided. The effect of this continuous and increasing harvesting of fuel wood is the increasing desertification (Ayuba and Dami, 2011).

Nigeria is considered among the world's highest deforested country and has lost about 55.7% of its primary forest. From 1990 to 2010, Nigeria nearly halved its amount of primary forest cover with an annual deforestation rate of 3.67% between 2000 and 2010. The situation appears alarming that the Food and Agricultural Organization states that the forest in Nigeria will disappear by 2020 if the current rate of forest depletion continues unabated. In addition, the production forest area in western and central Africa has declined after 2000 as Nigeria is among those reported to have a substantial decrease in production of forest area (FAO, 2010).

Over grazing constitutes another paramount cause of rangeland degradation because natural re-growth is not able to keep pace with the grazing pressure (Kassas, 1995). Over grazing, deforestation, and unregulated fires, or combination thereof is the primary cause of vegetation (Dregne and Chou, 1992). The dry lands of Nigeria is said to support much of the country's livestock economy, hosting about 90% of the cattle population, two-thirds of the goats and sheep and almost all donkeys, camels and horses. In the Sudan and Sahel zones of the country, which carry most of the livestock population, nomadic herdsman graze their livestock throughout the area and are constantly in search of suitable pastures. Additional pressure is also put on pasture resources by livestock from neighbouring countries, notably Cameroon, Chad and Niger (Nasiru, 2007). Except for some chaotic natural phenomena, degradation is mainly due to interaction of land with its users or community of user organism.

2.3.3.2: Consequences of Desertification

The consequences of desertification are far-reaching and diverse. All aspects of human lives are either directly or indirectly affected wherever the phenomenon exists. It ranges from ecological consequences (loss of vegetation cover, formation of dunes and soil erosion); health consequences (increase in wave heat, cancer occurrence and loss of plants of medicinal value); hydrological consequences (reduction in river flow and ground water level) to socio-economic consequences (food insecurity, economic loss, political unrest, poverty and

unemployment). A statement credited to Millennium Ecosystem Assessment states that because of desertification, incessant reductions in the capacity of ecosystems to provide services such as water, food, and other necessities, are leading to a major decline in the well-being of people living in dry lands (Adeel et al., 2005). In Africa alone, a total of more than 650 million people are dependent on rain-fed agriculture in environments that are already affected by water scarcity and land degradation, which will be further exacerbated by climate change. If this trend continues, two – third of the region's arable land could be lost by 2025, and the livelihood of millions of small farmers along with it (FAO, 2009). In another report according to Brett (2009), "the area suitable for agriculture, the length of growing seasons and yield potential, particularly along the margins of semi – arid and arid areas, are expected to decrease. In some countries yields from rain – fed agriculture could be reduced by up to 50% by 2020."

Nasiru (2007) in his analysis of the consequences of desertification in the dry lands of Nigeria identified loss of land and water resources, resources use conflicts as well as destruction of habitat and loss of bio-diversity. Many species are prone to be endangered due to desertification. Nigeria dry lands contain a large number of species of plants and animals that are important to humankind as a whole, but which are threatened as a result of desertification process occurring in the area. NAP (2000) revealed that some important animal species such as the Sitodunga antelope, Cheetah, Giraffe, Lion and Elephants in the northern states of Nigeria have become endangered and indigenous plant species especially those with medicinal values e.g. Mitrogina spp (known as Giyaya in the area) are now difficult to locate. Another major consequence of desertification is migration causing separation of families as men usually abandon the women and children to seek for employment in the urban centres due to unproductive agricultural practice at the rural areas. For example in Nigeria, people living in dry lands usually the herdsmen of the north migrate into towns and villages down

south and neighbouring countries that are wetter (NEST, 1991). More so, migration could enhance disease transmission from an epidemic area to another area. Migration also implies the destruction of family patterns. Men often leave their villages in search of income-producing labour, leaving the burden of the agricultural activities on the shoulders of the poor women, children and the elderly. Immigrants to the cities also add to the destabilizing effects of rapid urbanization in the affected areas (Oladipo, 1993).

Desertification equally leads to economic loss and reduced economic growth. Short fall in earned tax receipts occurs due to low productivity, and has consequences on the capacity of government to reimburse their foreign debt and develop national socio-economic programmes. The persistence of desertification reduces national food production and furthers the need to rely on foreign imported products. Also, government expends so much revenue which could have been used for other developmental projects on ameliorating the effects of desertification. For example, it is estimated that Nigeria loses about $5.1 billion every year owing to rapid encroachment of drought and desert in most parts of the north (Vanguard News Paper, 2010). Increased soil erosion is another consequence of desertification. Impoverishment of soil's natural vegetation cover has been a primary cause of soil erosion. When land is deforested, the soil anchorage provided by trees and other plants is lost and the soil is rapidly eroded. Because of the nature of desertification prone area, soil erosion by wind occurs most, but erosion by water is more disastrous during the unusual heavy rainfall. Gully erosion, that hitherto was not a major threat in Nigeria has increased, threatening about 18, 400 km2 compared to only about 122 km2 in 1976 and 1978. A survey conducted in Katsina State revealed that 30% of agricultural land has been severely damaged and lost from further productive use due to erosion which has resulted to decline in crop yield by 30 to 60% (Olagunju, 2015b). Formation and remobilization of sand dunes represent part of the ecological consequences of desertification which has produce extensive wasteland in many

part of northern Nigeria. For examples, communities such as Bukarti, Bula Tura, Kaska, Toshua, Tubtulowa, and Yunusari in Borno State are said have either been completely surrounded by crescent-shaped sand dunes or about to be buried by them. In Gidan Kaura, a village 90km north west of Sokoto, sand dunes have been reported to have levelled up vast areas of farmlands and swept a whole village of nearly 300 houses out of existence. Also, in the extreme northern part of Borno State, a post-primary school established by the government could not be put to proper use because moving sands make access to it difficult. The sand dunes are now reported to have reached many parts of Borno, Yobe and Katsina State and they are already jeopardizing agricultural and other economic activities in these areas (NEST, 1991; Oladipo, 1993).

Desertification has also lead to resource use conflicts especially among the people of northern Nigeria. Conflicts over land resources are focused on areas of high productivity, especially those that provide seasonally critical resource. These critically limited resources have competitive uses amongst the various rural land users; notably farmers, herders, fishermen and hunters. For example, Maitatsine riots in Gombe, Kaduna, Kano, Maiduguri, and Yola between 1980 and 1985 is a form of socio-economic and political consequences of ecological degradation of northern Nigeria during the droughts of the 1970s and 1980s when there was an increase in competition for the scarce social and economic resources (Oladipo, 1993). In addition, northern part of the country has witnessed a dense occurrence of conflicts resulting from the effects of desertification especially in the seasons when rainfall is very low and the graze lands are unable to sustain the population of livestock in the zone. The herdsmen (especially the popularly known Fulani herdsmen) geared their livestock to farmland area in the zone or down south in the country, a situation which has caused brutal fight between the herdsmen and farmers. For instance, as natural pastoral rangeland become more scarce, the relationship between the Fulani pastoralist and Hausa cultivators, as reported

in the media, is now frequently that of conflict, especially along the movement routes of the pastoralists and their cattle, resulting from invasion of the crop farms by desperate cattle. A conflict in Barkin ladi Shendam in North Central (Plateau State) in June to July 2002 between indigenous tribes and the nomad Fulani; between Ngamo and Maitatsine over farm lands and grazing areas in Yobe State; Agatu people and Fulanis in Benue State and many others are good examples.

Agriculture in semi-arid areas of Nigeria suffer from desertification because of over dryness of the environment, inadequate rainfall resulting in persistent drought, increasing temperature, increasing evaporation, low soil nutrients, inadequate pasture, reduction in transpiration, and erosion. Agriculture is a significant sector of Nigeria's economy and the economic mainstay of majority of its households especially in rural areas. Factors that affect soil quality affect agricultural productivity also and indirectly on food supply. Loss of soil structure and cohesion, soil crusting, soil compaction and soil erosion especially in arable lands has been enumerated as consequences of desertification which also reduce agricultural output, hence food insecurity. This therefore is contributing to food shortage, increasing conflicts between farmers and herdsmen, unemployment, shortage of both surface and underground water especially in dry season as well as the migration of domestic animals, birds, jungle animals and people in search of means of survival (Audu, 2013). With the nature of desertification process in Nigeria, agricultural production and access to food is projected to be severely compromised.

CHAPTER THREE

RESEARCH METHODS

3.1: Introduction

The validity of the outcomes of research conducted is hinged on the appropriateness of the methodology employed. The research methodology therefore entails basic processes that are followed in realization of the aim and objectives of the study. The methodology for this study encompasses a range of systematic procedures such as the types of data required, sources of data, method of data collection, sampling procedure and the techniques of data analysis.

3.2: Data Required for the Study.

Data required for this study were collected based on the stated objectives in chapter one. In this regard, the following data are required:

Data were collected on the socio-economic characteristics of farm households in order to have their general background information. Data needed include the age, sex, marital status and level of educational attainment of farm households. Data were also required on the farming status, cropping pattern, size of farm land, household size of respondents as well as the type of crops grown.

In order to examine farm households awareness and perceived causes of desertification, data required include farm households awareness to desertification occurrence, years of experience in desertification phenomenon, perceived causes of desertification among which are deforestation, environmental mismanagement, over grazing, climate change (fluctuation in rainfall amount and intensity), over cultivation of marginal land, and natural occurrence. These data were collected through qualitative research.

Data on vulnerability of farm households to desertification was required in order to determine their degree of vulnerability. Data needed include farm households sensitivity to the impact of desertification; exposure of farm households to the effects of desertification; number of years of such exposure; spatio-temporal extent of decreasing productivity; extent of decreasing productivity on food availability for farm households and local consumption. Data was also required on the effects of desertification on farm households' livelihood. Data needed include reduced crop yields, low income from farm produce, declining soil fertility, conflicts between farmers and pastoralists, loss of livestock, inadequate water for irrigation, as well as extinction of flora and fauna.

To identify the adaptation strategies adopted by farm households to combat desertification, data were needed on various coping measures which include intercropping, early planting, application of manure/fertilizer, seasonal migration to cities, livelihood diversification (off-farm activities and income producing labour in cities), changing of crop varieties, planting of drought tolerant crops, soil conservation techniques, increase use of irrigation, liquidating accumulated assets, mulching and afforestation measures as well as traditional/local coping strategies employed by farm households in the study area. Data on these were gathered through questionnaire and interview.

Data were also required on government efforts at combating desertification in the study area. Various data needed include sectoral programmes and projects initiated by the State and Federal governments such as the Green Belt Project, Shelter Belt Projects, Forestry Programmes (e.g Arid Zone Afforestation Project, AZAP), as well as the National Policy on Environment all of which are meant to combat desertification.

3.3: Sources of Data

The various data required for this study were basically gathered from the primary and the secondary sources.

3.3.1: Primary Sources of Data

The primary sources were raw data collected directly by the researcher from the field. In other words, data from the primary sources are information that are derived originally from the respondents and have not been previously analysed. These data are collected from field survey based on the objectives of the study using research questionnaire, focus group discussion and interview. The process began with a reconnaissance survey which was conducted to familiarize the researcher with the study area. This was done to identify the study communities, the major farm households in the area, and eventually a participatory reconnaissance survey was conducted with the farm households in those communities. Based on this, the researcher was able to design an appropriate questionnaire that captured the aim and objectives of the study. Data from primary sources were gathered through the following research instruments.

3.3.1.1: Questionnaire Administration: - A well-structured questionnaire consisting of both open and close-ended questions was designed (see Appendix I). The questions were formulated to provide the information needed to achieve the aim and objectives stated for this study. The close ended questions offer the respondents a list of possible options or answers from which the respondents must choose based on researcher informed opinion. The open ended questions on the other hand permit free responses that are recorded in respondent's own words. The respondents were not given any possible answers to choose from and this provides them the opportunity of expressing their views satisfactorily and thereby providing more valid answers.

3.3.1.2: Focus Group Discussion (FGD): - Focus group discussion was employed to obtain in-depth information on concepts, perceptions, ideas, and vulnerability as well as adaptation to desertification among a small non-representative sample of farm households who share one or more characteristics that are of interest to the researcher. Discussions were held with various groups of relevant stakeholders who had the knowledge of various occurrences in the community. The groups consist of 11 people drawn from different socio-economic strata and ideological views such as farmers, nomads, civil servants engaged in white collar jobs, community opinion leaders, and settlers of various ethnic groups. The selection of people was purposive and based more on suitability and availability. The focus group discussion was done to gathered people from similar background, experiences and knowledge in order to discuss the research topic to get their own perspectives. This was meant to seek detailed information from households' members that were not covered with questionnaire. A facilitator led the discussion in a lively manner under a relaxed atmosphere, with the participation of all members who were encouraged to speak and keep the discussion points in focus.

3.3.1.3: Semi - Structured Interview: - Interview sessions were held with key members of the community such as chairmen of community based organizations and village heads in the selected communities. Officials in the State Ministries such as the Directors of Drought and Desertification Control in the Ministry of Environment, Arid Zone Programme, Katsina State Afforestation Project Unit (KTAPU), and Katsina State Agricultural and Rural Development Authority (KTARDA) were also interviewed. This complemented the focus group discussion held in order to have a comprehensive knowledge of the vulnerability and adaptation of farm households to desertification in the study area.

3.3.2: Secondary Sources of Data

Secondary data were gathered to complement the various sources of primary data stated above. Secondary data on desertification control activities of State and Federal Government in Katsina, afforestation programmes, shelterbelts and windbreaks established, causes and consequences of desertification, and the physical characteristics of the study area were sourced from government agencies and parastatals which include Katsina State Ministry of Environment, State Forestry Department, Drought and Desertification Control Unit and Arid Zone Afforestation Unit and as well from textbooks, magazines, journals, seminar papers, proceedings of conferences, unpublished dissertation/thesis, classified documents, library as well as the internet.

3.4: Sampling Procedure

A multi-stage sampling procedure was adopted in this study. The first stage involves identifying the areas that are susceptible to desertification in Katsina state. According to Adamu (2000), the areas that were prone to desertification problems are those that are located in northern Katsina which fall within the semi-arid zones of northern Nigeria and enjoy semi - arid continental type of climate. Following Adamu (2000) assertion, the local government areas that are considered more prone to desertification are found in the extreme northern part of Katsina state and they formed the basis of analysis for this study. Using the map of Katsina state (see figure 1), the local government areas that fall in the extreme northern Katsina were identified and they are Jibia, Kaita, Mashi, Mai'adua, Zango and Baure.

The second stage involves selection of the specific local government of study. In order to ensure complete representativeness of the sample selected, this study covers all six local government areas (Jibia, Kaita, Mashi, Mai'adua, Zango and Baure) that are considered susceptible to desertification in the extreme north of Katsina state.

In the third stage, a systematic purposive sampling was used to select three (3) rural communities where farming is the predominant livelihood from each of the six local government areas concerned. Therefore, a total number of eighteen (18) rural communities were selected in all (Figure 3.1). A structured questionnaire was used to gather the necessary information from the farm households in each of the selected communities. The household was selected as the main unit of analysis because major decisions about adaptation to livelihood processes are taken at that level as observed by Thomas (2008). The reason for chosen the heads of households was that they were decision maker in resource allocation and use. They are considered more concerned and conscious about decision taking at the household level and therefore more informed about vulnerability and adaptation of their household to desertification in particular and the community at large.

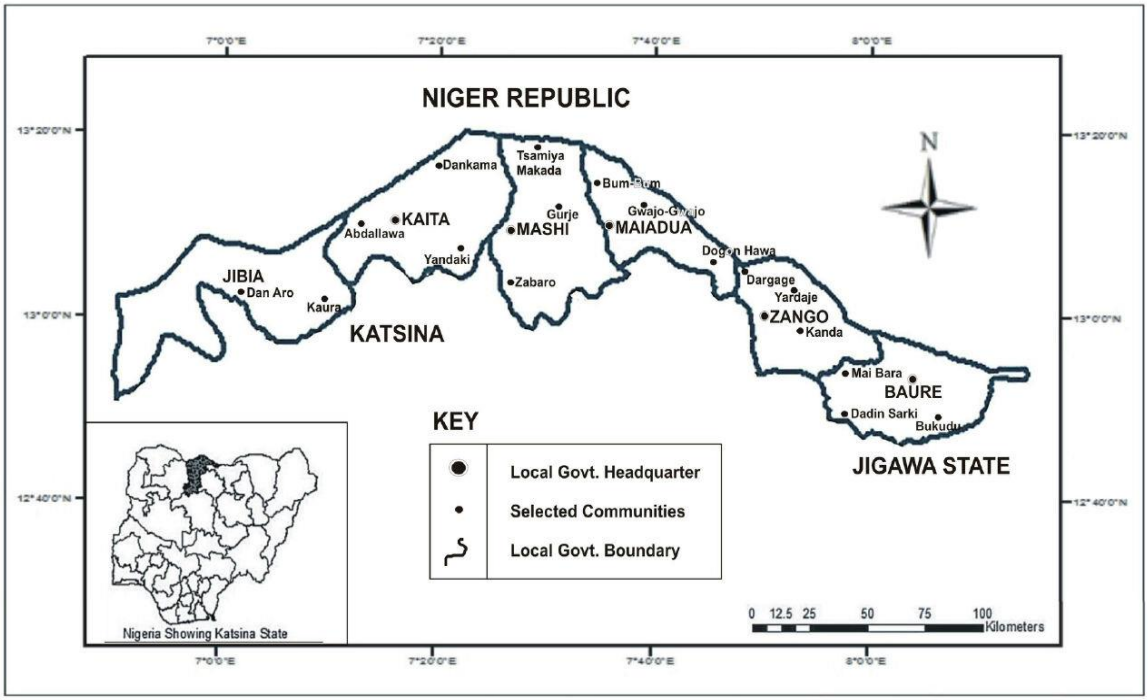

Figure 3.1: Map of selected Communities across the L.G.As of Study

To select the respondents, it is on record that Katsina state has a total number of 88,300 farmer's families (KTARDA, 2009). Out of this total, an estimated 7,450 farm households are found in the six LGAs considered for this study. The sample households were

therefore selected randomly in proportion to population size of each community. Ten (10) percent of households from each of the eighteen (18) selected communities were randomly sampled to come up with a total of six hundred and thirty-three (633) respondents for this study. This is presented in Table 3.1

Table 3.1: Distribution of Respondents in Selected Communities of the Study Area

S/N	L.G.A	Selected Communities	Number of respondents
1	JIBIA	Dan Aro	33
		Madachi	36
		Kaura	32
2	ZANGO	Yardaje	38
		Kanda	37
		Dargage	35
3	KAITA	Dankama	34
		Abdallawa	32
		Yandaki	36
4	MASHI	Gurje	36
		Tsamiya Makada	37
		Zabaro	34
5	BAURE	Mai Bara	32
		Dadin Sarki	36
		Bukudu	34
6	MAI' ADUA	Bum- Bum	38
		Gwajo- Gwajo	37
		Dogon Hawa	36
TOTAL		**18**	**633**

Source: Author's compilation, 2016

3.5: Techniques of Data Analysis

Descriptive and inferential analytical techniques were used to analyze the data collected from the field. The descriptive techniques include use of frequency counts, tables, and simple percentages to summarize and organize the data collected on the general background information as well as farm household's awareness/knowledge of desertification, perception about desertification and the consequences among others. The inferential statistics methods that were employed include Principal Component Analysis (PCA), Household Vulnerability Index (HVI) and Tobit Regression Model.

Principal Component Analysis (PCA) was used to develop factor scores for different variables of measurement of vulnerability (exposure, sensitivity and adaptive capacity). PCA was used to reduce the large number of variables down to smaller numbers that are considered important for the analysis. Factor scores were generated for each of the variable of measurement in order to determine their functional relationship to vulnerability (either positive or negative). This was then used to produce a household vulnerability index (HVI) so as to categorise households according to their level of vulnerability. The variables of measurement of vulnerability were derived from the three components of vulnerability (exposure, sensitivity and adaptive capacity) as defined by IPCC (2001, 2007) and adopted by Wisner et al. (2004), Barocca et al. (2006) and Abaje et al. (2015). The list of variables for measuring household vulnerability to desertification is presented in Table 3.2

Table 3.2: Variables of Measurement of Vulnerability

`Variable No.	Definition of Variables
X1	Change in annual Rainfall (from 1985-2015)
X2	Change in Temperature (from 1985-2015)
X3	Frequency of Drought (drought events from 1985-2015)
X4	Wind occurrence (intensity of occurrence from 1985-2015)
X5	Sex of household (percentage of male-headed households)
X6	Age of household (percentage of household heads above 45 years)
X7	Farming status (percentage of full-time farmers)
X8	Educational level (percentage of farmers with no primary education)
X9	Farm holding size in hectares
X10	Household size (numbers of dependants)
X11	Value of crop produced per hectare in tons
X12	Percentage of household with access to early warning information
X13	Household years of experiences in desertification in the area
X14	Percentage of household with access to fertilizer supply
X15	Percentage of household having livelihood diversification (off-farm employments)
X16	Percentage of household involved in early planting
X17	Percentage of household with access to insecticide/pesticide
X18	Percentage of household involved in migration to cities
X19	Percentage of household with access to credit facilities
X20	Percentage of household with access to improved seed supply
X21	Percentage of household with accumulated assets

Source: Author's compilation, 2016

It should be noted that variables X1 - X4 are components of exposure, X5 – X13 are that of sensitivity and X14- X21 are those of adaptive capacity.

The model specification for calculating the household vulnerability index is given as thus:

$Vi = (A_1X_1j + A_2X_2j + \ldots\ldots + A_{2n}X_nj) - (A_{n+1}Y_{1j} + A_{n+2}Y_2j + \ldots.. + A_{n+n}X_nj)$.

Where Vi is the vulnerability index,

Xs are elements of adaptive capacity represented by variables 14 - 21

Ys are elements of exposure and sensitivity represented by variables 1 – 4 and 5 – 13 respectively.

The Tobit Regression Model was used to determine the factors influencing households' vulnerability to desertification. The Tobit Model was used because it has the advantages of measuring both the probability of use of indicators of vulnerability and the intensity of use of such indicators. The Tobit Model was used in several studies such as Bamire et al., 2002, Ojiako, et al., 2007 and Idrisa et al., 2012.

The Tobit model is expressed in its simplest form as:

$\mu_i = \beta_{Xi} + \mu$ …… (Equation 1)

The Tobit model is explicitly expressed for the ith household as:

$\mu_i = \beta_0 + \beta_1X_1 + \ldots\ldots\ldots\ldots.. \beta nXn, \quad i = 1\ldots\ldots..N$ (Equation 2)

where,

μ_i is the observed dependent variable i.e. vulnerability to desertification

β_0 is the intercept

$\beta_1\ldots..\beta n$ are the coefficient of the independent variables

$X_{1\ldots..}Xn$ are the independent variables/ explanatory variables (socio-economic characteristics of households and adaptation strategies

CHAPTER FOUR

AWARENESS OF FARM HOUSEHOLDS TO DESERTIFICATION

4.1: Introduction

This chapter is aimed at discussing the socio-economic characteristics of the respondents and their awareness of the causes and consequences of desertification. This include age, sex, marital status, size of household, educational qualification, farming status, cropping pattern, farm size in hectares, types of crops grown as well as awareness and perception about desertification was equally examined.

4.2: General Background Information of Farm Households.

The analysis of the age distribution of respondents is shown as contained in Table 4.1.

Table 4.1: Age Distribution of Respondents

Age	Frequency	Percentage	Cumulative %
18- 26	32	5.1	5.1
26- 35	148	23.4	28.5
36-45	275	43.4	71.8
46-65	142	22.5	94.3
Above 65	36	5.7	100
Total	**633**	**100**	**100**

Source: Author's Field Work, 2016.

The age distribution of respondents as shown in Table 4.1 reveals that about 5.1% of the respondents fall within the age bracket of 18- 25 years while only 5.7% were above 65 years of age. Furthermore, about 23.4% of the respondents were between the age bracket of 36-45 years and 22.5% fall within the age of 46-65 years. The age distribution shows that majority of the respondents were grown-up adults within the age bracket of 36-45 years. This implies that agile and able-bodied men were actively involved in crop production in the study area. This is an indication that the very active and productive working population are majorly involved in farming. By implication, grown-up adults within the age bracket of 36-45 years must have gathered better experience in managing or coping with environmental problems associated with crop production and farming activities compared to the younger ones. It also

helps the researcher in getting a better response from the respondents as regards vulnerability and adaptation to desertification in the study area.

Table 4.2: Sex Distribution of Respondents

Sex	Frequency	Percentage	Cumulative %
Male	589	93	93
Female	44	7	100
Total	**633**	**100**	**100**

Source: Author's Field Work, 2016.

The sex distribution of respondents as shown in Table 4.2 revealed that 589 of the respondents were males while 44 were females. With this, majority of the respondents (93.0%) were males while only 7% happens to be females. This indicates the dominance of males in farming activities over the females. The dominancy of male heads of households could be attributed to the fact that Katsina State is predominantly a conservative Hausa-Muslim society in which it is very uncommon for females to become head of household unless the male died. This indicates that farming is done mostly by men in the study area while women participate majorly in off- farm activities.

Table 4.3 contains the analysis of the marital status of the respondents. It is reveals from the table that 88.9% were married. The remaining 2.5% and 8.5% were divorced and widowed respectively. This indicates that majority of the respondents were male heads of households who shoulder the responsibility of taking care of their families.

Table 4.3: Marital Status of Respondents

Sex	Frequency	Percentage	Cumulative %
Married	563	88.9	88.9
Divorced	16	2.5	91.5
Widowed	54	8.5	100
Total	**633**	**100**	**100**

Source: Author's Field Work, 2016.

Table 4.4 presents the farming status of the respondents. As shown in Table 4.4, 461 of the respondents representing 72.8% of the total sample population operates on a full time basis while 27.2% partake in crop production on a part- time basis. This indicates that

majority are full time farmers. The finding of this study corresponds to that of Watts (2010) which states that people of Hausa land of northern Nigeria are known to be actively involved in farming. He further stressed that the cereal crops and livestock produced in the region accounts for over 75 percent of national food supplies. This is an indication that farming is the main source of livelihood of the people of this area. This implies the over dependency of rural people of Katsina on the environment for survival and hence any small change in the environmental condition has greater impact on farming upon which their livelihood depend.

Table 4.4: Farming Status of Respondents

Status	**Frequency**	**Percentage**	**Cumulative %**
Full time	461	72.8	72.8
Part-time	172	27.2	100
Total	**633**	**100**	**100**

Source: Author's Field Work, 2016.

The educational attainment of the respondents as shown in Table 4.5 reveals that 122 (19.2%) of the respondents have not attended any form of educational institution. About 285 (45%) of them had Quranic/Islamic education. Others categories of education attained by the respondents were primary (13.6%), secondary (13%), and only a few (9.2%) had tertiary education. This is an indication that majority of respondents had Islamic education. This implies that more than 80% of the respondents were not having basic primary education. By implication, low level of education especially western education could influence respondents' perceived causes of desertification and hence may cause impromptu attitude to addressing the issue of desertification as it affects their livelihood. The resultant effect may be a reduction in household's ability to comprehend climatic information, adopt appropriate strategies and access early warning information.

Table 4.5: Educational Attainment of Respondents

Category	Frequency	Percentage	Cumulative %
No education	122	19.2	19.2
Quranic	285	45	64.2
Primary	86	13.6	77.8
Secondary	82	13	90.8
Tertiary	58	9.2	100
Total	**633**	**100**	**100**

Source: Author's Field Work, 2016.

The analysis shown in Table 4.6 contains the cropping pattern of respondents. The Table reveals that 90.5% of the respondents partake in mixed cropping while 9.5% engage in sole cropping.

Table 4.6: Cropping Pattern of Respondents

Type	Frequency	Percentage	Cumulative %
Mixed	573	90.5	90.5
Sole	60	9.5	100
Total	**633**	**100**	**100**

Source: Author's Field Work, 2016.

It is evident from Table 4.6 that majority of the respondents preferred mixed cropping than sole cropping. They tend to combine cropping of more than one crop on the same farm. This is an indication that the most prominent cropping pattern in the area is mixed cropping. The most common crop combinations are Millet/sorghum, Millet/sorghum/cowpea and Millet/sorghum/groundnut.

The size of farm holding of respondents is also considered as shown in Table 4.7.

Table 4.7: Farm Size of Respondents

Farm size in hectares	Frequency	Percentage	Cumulative %
Less than 1	148	23.4	23.4
1 - 3	299	47.2	70.6
3 - 5	160	25.3	95.9
Above 5	26	4.1	100
Total	**633**	**100**	**100**

Source: Author's Field Work, 2016.

Table 4.7 reveals that 148 (23.4%) of the respondents operates on less than one hectare of land. It further revealed that a very few percentage of 4.1 operates on farm size above 5

hectares. Also, while 25.3% of the respondents operate between 3- 5 hectares, 47.2% operates between 1-3 hectares of farmland. This indicates that majority of the farmer operate on farm land of between 1-3 hectares. This implies that the average farm holdings were found to be 2 hectares and hence the predominance of small scale farming system using traditional techniques of production. One would have expected the respondents to have relatively larger farm size since they are fully involved in farming as their primary activity. They are however incapacitated by the continued loss of the productive capacity of land to desertification process coupled with inadequate access to farm inputs.

Table 4.8: Household Size of Respondents

Size	**Frequency**	**Percentage**	**Cumulative %**
1 – 5	217	34.2	34.2
6 - 10	280	44.3	78.5
11 – 15	106	16.8	95.3
16 - 20	16	2.5	97.8
Above 20	14	2.2	100
Total	**633**	**100**	**100**

Source: Author's Field Work, 2016.

From Table 4.8, while 44.3% of the respondents representing the majority had household members of 6-10; the least percentage (2.2%) represents households having above 20 persons as family member. Others include 34.2% representing respondents with 1-5 members of household, 16.8% represents those having 11- 15 members and 2.5% represents those having 16-20 members of household. Going by the conduct of this research, household members are those currently living with the heads of household by the time the research was conducted.

Table 4.9: Types of Crops Grown by Respondents

Crop types	Frequency	Percentage
Millet	605	95.6
Wheat	10	1.6
Sorghum	433	68.4
Groundnut	317	50.1
Maize	15	2.4
Rice	0	0
Cowpea	407	64.3

Source: Author's Field Work, 2016.

The type of crops grown by the respondents is shown as contained in Table 4.9. The distribution shows that 95.6% of the respondents are involved in millet production, 68.4% are into sorghum production, 64.3% are engaged in cowpea production and 50.1% get involved in the production of groundnut. Other crops produced are maize (2.4%), and wheat (1.6%). None of the respondents is involved in rice production in the area. While millet, sorghum, cowpea and groundnut are grown by more than half of the respondents, wheat and maize are least produced and are grown in Jibia L.G.A using Jibia dam irrigation scheme. Maize is however largely produced in southern part of katsina (such as Funtua, Charanchi, Faskari, Malunfashi, and Danja L.G.As). This shows that the land use for the cultivation of millet, sorghum, cowpea and groundnut are higher than other crops grown in the area. This is in line with the Katsina State Community and Social Development Project (KSCSDP, 2012) report which affirmed that in the northern part of katsina where this study is conducted, the cultivation of millet has the highest land usage in hectares followed by sorghum, beans and groundnut respectively. The finding reveals that grains are majorly grown by farmers in the study area and that millet is grown by almost every household which makes it becomes the most cultivated crop in the study area. This is in conformity with the findings of Inkani (2015) which affirmed that millet is the most consumed staple foods in northern Katsina. The outcome of the key informant discussion with some of the respondents provided an important basis for understanding why millet is grown by almost every household in the study area. According to them, millet is a drought resistant crop that requires less water, little nutrients

and gets matured within 3-4 months. They further stressed that millet known as 'Gero' in Hausa land is a multi-purpose food crop consumed as 'kunu/kunu zaki' (gruel or pap), 'fura', 'tuwo', 'danbu' and 'burabusko'. All these are varieties of foods in Hausa land.

4.3: Households Awareness/ Knowledge of Desertification.

To combat desertification and succeed with the mitigation measures and actions implies a full knowledge of the general awareness about the phenomenon. In order to know whether the respondents had knowledge of desertification occurrence in the study area and for how long they have been experiencing it, questions relating to these were asked. The result is as presented in Table 4.10 and 4.11.

Table 4.10: Respondents Awareness on Desertification

Status	Frequency	Percentage	Cumulative %
Yes	591	93.4	93.4
No	42	6.6	100
Total	**633**	**100**	**100**

Source: Author's Field Work, 2016.

Table 4.10 reveals that 591 respondents claimed to have knowledge of desertification incidence in the study area while only 42 of them claimed ignorant. It shows that 93.4% representing the majority are quite aware of desertification phenomenon. This is an indication that desertification process is well noticed in the study area.

Table 4.11 is a presentation of the years the respondents have been experiencing desertification in the area.

Table 4.11: Respondents Years of Experiencing Desertification

Years	Frequency	Percentage	Cumulative %
Less than 10	120	19	19
11 - 20	319	50.4	69.4
21 – 30	62	9.8	79.2
Above 40	4	0.6	79.8
No Idea	128	20.2	100
Total	**633**	**100**	**100**

Source: Author's Field Work, 2016.

Table 4.11 reveals that 50.4% of the respondents claimed to have been experiencing desertification for the past 11- 20 years while 0.6% claimed it was above 40 years. Furthermore, 19% claimed it had been occurring in less than 10 years and 9.8% went for 21-30 years of occurrence. About 20.2% of the respondents can't say precisely when desertification had been occurring in the area. From the analysis, half of the respondents (50.4%) had 11-20 years of experience indicating that the average time of desertification occurrence was found to be 15 years. This implies that desertification has come to stay in the area and the farmers must have suffered from its effects and at the same time must have developed adaptation strategies over time.

4.4: Perception of Farm Households about Desertification

The perception of the farm households toward desertification could expose the urgency with which the problem needs to be understood and help in developing effective strategies. Also, the types of policies to be formulated and the potentials for their effective implementation could be derived from the perception of the vulnerable households towards 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 view of this, respondents perceived causes of desertification were also sought in this study. The result is as presented in Table 4.12.

Table 4.12: Respondents' Perceived causes of Desertification

Perceived causes	Frequency	Percentage	Rank
Deforestation	454	71.7	2
Environmental mismanagement	407	64.3	4
Over grazing	157	24.8	6
Climate change	465	73.5	1
Over cultivation	313	49.4	5
An act of God	413	65.2	3

Source: Author's Field Work, 2016.

*** Multiple responses resulted in a total percentage > 100%**

From Table 4.12, it was revealed that 73.5% of the respondents perceived climate change resulting in reduced annual precipitation over the years as the most pronounced cause of desertification in the area. Respondents' perception about climate change being one of the prominent causes of desertification in the study area concurs with previous studies (Oladipo, 1993; Odjugo and Ikhuoria, 2003; Nasiru, 2007) in northern Nigeria. For instance, Oladipo (1993) affirmed that desertification in northern Nigeria is partly a result of inherent extreme variability of climate as manifested in frequent droughts coupled with the poor physical conditions in terms of soils, vegetation and topography. Odjugo and Ikhuoria, (2003) similarly revealed that climate change has started impacting on desertification in Nigeria, and the negative impact on plant species composition in the north-eastern Nigeria is observed by Ayuba et al. (2007). Nasiru (2007) equally asserts that climate variation is perhaps the most important natural cause of drought and desertification in the dry lands of Nigeria. He further stressed that the history of the Sudano-Sahelian zone of Nigeria is replete with severe and prolonged droughts events, some lasting several years. According to the findings in Table 4.12, climate change is rank as the first and most important cause of desertification in the study area. This is however in contrast to United Nations Conference on Desertification (UNCOD, 1977) documentation summarised by Thomas and Middleton (1994) in which man's occupation and use of the dry lands was playing the major role. Human adverse impact on the environment (over cutting, over grazing, over cultivation and misuse of water) is considered to be the only cause of desertification (Rozanov, 1990 and UNEP, 1991). Nevertheless, the active role of climate was acknowledged among the factors that trigger desertification process in the study area in particular and similar ecosystem in general.

In addition to climate change, 71.7% of the respondents perceived deforestation as another factor that causes desertification. Deforestation is rank second (see Table 4.12) and it happens to be the most second major perceived factor causing desertification in the study

area. Respondents' perception about deforestation as another main cause of desertification attests to previous findings in Nigeria. For example, the African Institute for Applied Economics (AIAE) had estimated that in 2005, Nigeria had lost about ₦180 billion to deforestation. The AIAE hinged the destructive trend to crop land expansion and the felling of trees for fuel. Real wood fuel prices had doubled in the last two decades in the country due to woodland destruction resulting in an estimated loss of between ₦60 billion annually. According to Mohammed et al (2013) Katsina state, the study area has its over 90% energy from fuel wood. Consequently, the demand for fuel wood causes the removal of trees, shrubs, herbaceous plants and grass cover from the fragile land, thereby accelerating the degradation of the soil to desert-like conditions (FAO, 2006).

About 65% of the respondents perceived desertification as an act of God which had been destined to affect their land. This option is rank third and was perceived by more than half of the respondents as a cause of desertification. This shows that it is a significant factor attributed to the occurrence of desertification in the study area. This can however be attributed to the fact that majority of respondents had Islamic/Quranic education. Their religious ideology could have influence them to believe that desertification couldn't have happened if not destined by God and not by the relative role of climate, droughts and human impacts.

Environmental mismanagement (bush burning, faulty irrigation practice, uneconomic agricultural practices etc) was perceived by 64.3% of the respondents as a factor leading to desertification process and is seen as the fourth most important factor causing desertification in the study area. This finding is in line with Oladipo (1993) assertion that desertification in northern Nigeria was partly because of the disruption in the ecological system caused by poor land use and the ever-increasing demand being made upon the available resources by the expanding population and socio-economic systems of the affected areas. Among the main causes of desertification are poor land management and environmental pressure. Dry land

soils, because of their inherently low fertility, are particularly susceptible to erosion, especially when their vegetative cover has been removed or degraded. Increased population and livestock pressure on marginal lands have accelerated desertification.

Other causes of desertification are over cultivation and over grazing which were perceived by 49.4% and 24.8% of the respondents as shown in Table 4.12. Over grazing was least perceived by the respondents and is rank the last factor causing desertification. Although, Katsina state had a large livestock population but the nomadic herdsmen normally move their animals to the southern part of the state with guinea savannah vegetation type in search of suitable pastures. It can be deduced from the analysis that climate change, environmental mismanagement, and deforestation were perceived to be the main cause of desertification in the study area. This finding is consistent with the most recognised assertion that desertification is as a result of human activities and climatic variations (UNCED, 1992; UN, 1994; Reynolds and Stafford-Smith, 2002). Similarly, the results corroborates Oladipo's (1993) assertion that desertification in northern Nigeria is a result of complex inter-relationship between social and natural systems.

CHAPTER FIVE

VULNERABILITY OF FARM HOUSEHOLDS TO DESERTIFICATION

5.1: Introduction

This chapter examined households' exposure to the effect of desertification in the study area. To achieve this, the analyses include households' perception of desertification as a threat to livelihood, households' view on decreasing yield per hectare, time of decreasing productivity, households' food availability status, effects/consequences of desertification, measurement of the degree of farm household vulnerability as well as factors influencing households' vulnerability to desertification.

5.2: Farm Households' Exposure to Desertification

The perception of the respondents was sought regarding whether they consider desertification a threat to their environment and farming activity or not. The analysis as contained in Table 5.1 shows that 75% of the respondents considered desertification as a threat to environmental resources and their livelihood options. This indicates that majority of the respondents believed in the propensity to be adversely affected by desertification.

Table 5.1: Respondents' Perception of Desertification as a threat to Livelihood

Responses	Frequency	Percentage	Cumulative %
Yes	475	75	75
No	158	25	100
Total	**633**	**100**	**100**

Source: Author's Field Work, 2016.

The analysis as shown in Table 5.2 concerns declining yields per hectare as reported by the respondent. The Table reveals that 66% of the respondents reported declining yields per hectare on their farm while the other 34% claimed not to have experienced decline in their yields. The result implies that desertification in the area had devastating impact on crop yields with its resultant effect on household level food availability which may escalates food insecurity.

Table 5.2: Respondents' View on Declining Yields per Hectare

Responses	Frequency	Percentage	Cumulative %
Yes	418	66	66
No	215	34	100
Total	**633**	**100**	**100**

Source: Author's Field Work, 2016.

In order to know the time period over which the respondents had been experiencing declining yields, the result is presented in Table 5.3.

Table 5.3: Respondents' View on Time of Decreasing Productivity

Years	Frequency	Percentage	Cumulative %
Less than 10	191	30.2	30.2
10 - 20	352	55.6	85.8
20 – 30	68	10.7	96.5
Above 30	22	3.5	100
Total	**633**	**100**	**100**

Source: Author's Field Work, 2016.

Table 5.3 shows that 30.2% of respondents had been experiencing decreasing productivity in less than 10 years, 55.6% mentioning 11-20 years and 10.7% citing 21-30 years as the time they have been experiencing decrease in productivity. The result indicates that more than half of the respondents have been experiencing devastating impact of desertification on their productivity over the past two decades, with 10.7% of them for over three decades. This implies that desertification have taken toll on food availability for quite a long time in the area and farm households largely bear the consequences of negative impact of desertification-induced stresses which include loss of farmland, food insecurity and poverty. This may explain why majority of people in northern Nigeria live below the poverty line. According to National Bureau of Statistics (NBS, 2012) report, Katsina is one of the poorest states in Nigeria with poverty rate of about 74.5%. The increasingly unpredictable weather of the area triggered by climate variability and change added to the burden of the people who are already poor and are struggling to cope with the situation. Evidence shows that communities in rural areas of Katsina State experience variation in total annual rainfall received as one move from

southern to northern margin. The areas in the northern margin received rainfall of less than 700mm annually (El-tantawi, 2012). Previous studies (Mortimore, 1989; Ekpoh, 1996b; Mortimore and Adams, 2001) in the region in line with the findings of this study confirmed that the effect of climate variability and change on agriculture ranges from pronounced seasonality of rainfall to repeated crop failures and declining yields which have led to falling farm incomes and the associated problems of food shortage, malnutrition and general impoverishment of local inhabitants.

Table 5.4: Food Availability Status of Respondents.

Class	Frequency	Percentage	Cumulative %
Adequate	221	34.9	34.9
Moderate	298	47.1	82
Inadequate	114	18	100
Total	633	100	100

Source: Author's Field Work, 2016.

In terms of household food availability of respondents, three different categories was recognised and used to describe their status. These are: adequate, moderate and inadequate. 'Adequate' is used to denote households that have enough staple food to feed their family and still have excess to sell out. 'Moderate' is used to denote household who can only feed their family with their annual productivity but cannot sell out while 'Inadequate' is used to represent those households whose produce are not enough for immediate family consumption.

The findings as contained in Table 5.4 shows that 34.9% of the respondents were having adequate household food availability, with 47.1% of the respondents having moderate food availability and 18% belongs to the inadequate household food availability class. This indicates that while majority of the respondents (adequate, 34.9 + moderate, 47.1 = 82%) can sufficiently feed their family with their annual produce, 18% of the respondents cannot cater for their immediate family consumption and will have to resort to buying more at the local markets. The findings also imply that the respondent of the study area contribute about 34.9% to the National food supplies from the northern region of the country. This finding

corroborates Watts (2010) assertion that the cereal crops and livestock produced in northern Nigeria accounts for over 75% of National food supplies.

5.3: Consequences of Desertification

The effects of desertification on the respondent are summarised in Table 5.3

Table 5.5: Percentage of Respondents reporting the effect of Desertification

Effects of Desertification	Yes (%)	No (%)	Total (%)
Reduced crop yields	63	37	100
Declining soil productivity/ fertility	60.5	39.5	100
Low income from farm produce	66.7	33.3	100
Conflicts between farmers and pastoralist	23.5	76.5	100
Destruction of crops and loss of livestock	19.1	80.9	100
Decreased use of irrigation/ ground water	88.9	11.1	100
Extinction of flora and fauna species	59.3	39.5	100

Source: Author's Field Work, 2016.

Table 5.5 reveals that 63% of the respondents experienced reduction in crop yields, 60.5% of the respondents reported declining soil productivity, 66.7% experienced low income from farm produce and 23.5% cited conflicts between farmers and pastoralists as a resultant effect of desertification. Others were destruction of crops and loss of livestock which was reported by 19.1% of the respondents, decreasing use of irrigation/ground water got 88.9% of responses and 59.3% of the respondents cited extinction of flora and fauna species as noticeable effects of desertification in the study area. The reduction in crop yields could be attributed to declining annual rainfall amount and loss of soil cover due to harsh winds, sand storms, extreme temperature and decline in soil fertility. Researchers have shown that rainfall amount in Katsina area is characterized by high inter-annual variability and decreasing annual total. The pattern of rainfall is characterized by unpredictability and unreliability. Both the amount and area of the secondary rainfall maximum in the region has decline with time (Oladipo, 1993; Adefolalu 2007; Odjugo, 2010). Declining soil productivity was as a result of population pressure of the area on scarce forest resources leading to over-cultivation of marginal land without adequate soil fertility restoration measure and soil management

techniques. Respondents also suffered low income from farm produce due to increased drying up of crops as a result of low rainfall and high temperature in the study area occasioned by climatic variation which had contributed to the process of desertification. Recent study by Abaje et al (2014) reveals that climate change is having severe impacts on the local people's livelihoods in Katsina resulting in water shortage and decline in crop yields. Decreasing use of irrigation and ground water can be attributed to recurrent drought in the area which has exacerbated desertification process. Evidence has shown that in the past decade, incessant widespread drought events were witnessed in northern Nigeria in 1903, 1911-1914, 1991, 1924, 1935, and 1983-1985. The 1983-1985 was regarded as the driest period in the zone as the lake fell to its lowest level and shrank to its smallest area (Nasiru, 2007). Destruction of crops and livestock are consequences of face-off between farmers and pastoralists competing for land use. The results imply that the most felt consequences of desertification in the study area were reduction in crop yields, declining soil productivity, low income from farm produce, decreasing use of irrigation/ground water and extinction of flora and fauna, all of which were experienced by more than half (50%) of the respondents. It is also clear that conflicts between farmers and pastoralists as well as destruction of crops and loss of livestock were the least experienced effects of desertification by the respondents. The results concur with studies by Oladipo (1993), Katsina State Ministry of Environment (2002) and Nasiru (2007) which similarly observed some of these factors to be the main effects or consequences of desertification in the study area in particular and northern Nigeria in general.

Apart from the aforementioned consequences of desertification, respondents also revealed others effects to include conversion of productive land to marginal land, households' farm lost to desertification, and extensive waste farmland which have become useless for crop production (see Plate 5.1, 5.2, 5.3 and 5.4). Many economic and medicinal trees were also lost to desertification.

Plate 5.1: Farmland lost to Desertification in Bukudu Settlement of Baure L.G.A.

Plate 5.2: Marginal land caused by Desertification in Dankama settlement of Kaita L.G.A

Plate5.3: Unproductive farmland caused by Desertification on Bum-Bum Community in Mai'adua L.G.A.

Plate 5.4 :Extensive waste farmland Resulting from Desertification in Yardaje Village in Zango L.G.A

Focus group discussion and interview session held with the respondents equally revealed that sand dunes have levelled up vast areas of farmlands thereby rendering them unproductive for crop production (see Plate 5.5, 5.6, 5.7 and 5.8). In some places, the sand dunes have appeared in a crescent form (see Plate 5.10) which have already jeopardised agricultural production and other economic activities of the people.

Desertification has also resulted in soil desiccation (see Plate 5.9). Because of the dry spells and inadequate rainfall of the area, soil compaction occur forming soil parch that becomes difficult to till for crop production. Soil desiccation is regarded among the consequences of desertification which has reduced agricultural output.

Plate 5.5: Extensive Waste land in Yandaki Settlement of Kaita L.G.A due to Sand Dunes

Plate 5.6: Farm land levelled by Sand Dunes in Zango L.G.A.

Plate 5.7: Marginal Farmland along Baure-Zango Road due to Formation of Sand Dunes

Plate 5.8: Sand Dunes rendering vast areas of farmland unproductive in Gwajo-Gwajo Community of Mai'adua LGA.

Plate 5.9: Soil desiccation/soil parches preventing land tillage for crop production.

Plate 5.10: A crescent shaped Sand Dunes in Baure LGA

5.4: Computation of Households Vulnerability Index (HVI)

There are three factors that describe vulnerability. These are exposure, sensitivity and adaptive capacity. While exposure represents the incidences of events that confront individual in the environment sensitivity is the likelihood of a system to be affected by hazards and adaptive capacity is the ability of people to cope with or adjust to the changing context which can be explained by socio-economic indicators. Vulnerability is therefore comprised of risks or a chain of risky events that confront individual in pursuit of their livelihoods, the sensitivity of individual to these risks, and the response or measures that individual have for managing these risks and finally the outcomes that describe the decline in wellbeing.

Vulnerability index is a measure of the exposure of a population to some hazards. It is used in this study to assess the degree of exposure of farm households to desertification. The vulnerability index is as developed by the Intergovernmental Panel on Climate Change IPCC (2012) indicates that vulnerability is the net effect of adaptive capacity (which represents socio-economic variables) and sensitivity/exposure (i.e. biophysical variables):

Vulnerability = (Adaptive capacity) – (Sensitivity + Exposure) …… (1)

It follows that when the adaptive capacity of a household is more than that of its sensitivity and exposure, then the household becomes less vulnerable to hazards and vice-versa.

The study of vulnerability of an individual or group in a 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). Following Wisner et al. (2004) and Barocca

et al. (2006) vulnerability index approach method, the main determinant and the associated indicators/ components that were used to provide the basis of understanding farm households' vulnerability to desertification in this study were presented in table 5.6.

Table 5.6: Components of Vulnerability, the Variables and Functional Relationship

Component of vulnerability	Variables	Description of the variables	Influence on vulnerability
Exposure (biophysical)	Rainfall	Change in annual rainfall	+
	Temperature	Experiencing increase	+
	Drought	Frequency of drought	+
	Wind	Noticed unusual change	+
Sensitivity (socio-economic)	Sex of household	Male – headed	-
	Age of household	45+ years	-
	Farming status	% of full time farmers	+
	Educational level	% of no primary education	+
	Farm holding size	Average farm size	-
	Household size	Number of dependents	+
	Crop production	Total value of crop produced	-
	Early warning information	no access to information	+
	Experiences in the area	Years of experience, 10+	+
Adaptive capacity	Fertilizer supply	Access to fertilizer use	-
	Livelihood diversification	Non- farm income	+
	Early planting	Engage in early planting	-
	Insecticide/pesticide	% of population with access	-
	Migration	Movement to cities	-
	Credit access	% of population having access	-
	Improved seed varieties	% of population having access	-
	Accumulated assets	Ownership of assets	-

Note: positive sign (+) indicates increasing vulnerability (positive relationship with vulnerability), while negative sign (-) means declining vulnerability (negative relationship to vulnerability).

Source: Author's compilation, 2016.

To measure vulnerability index (VI) of rural farm households in the study area, the integrated vulnerability approach as proposed by Madu (2012) and adopted by Tesso et al. (2012) and Opiyo et al. (2014) was used. The integrated assessment approach is a combination of both other two approaches (socio-economic and biophysical approach) to determine vulnerability. A set of 21 variables for the three components of vulnerability

(exposure, sensitivity and adaptive capacity) was selected for the households of the study area (see Table 5.6)

The formula for calculating vulnerability index (VI) is given as:

$VI = (A_1X_1j + A_2X_2j + \ldots\ldots + A_{2n} X_nj) - (A_{n+1} Y_{1j} + A_{n+2} Y_2j + \ldots\ldots + A_{n+n} X_nj)$........ (2)

There are two types of functional relationship. When the observed values are related positively to the vulnerability, the normalization is achieved by employing this formula:

$$pij = \frac{Xij - \underset{i}{Min}(Xij)}{\underset{i}{Max}(Xij) - \underset{i}{Min}(Xij)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

On the other way, when the observed values are related negatively to the vulnerability, the normalized score is computed using this formula:

$$Nij = \frac{\underset{i}{Max}(Xij) - Xij}{\underset{i}{Max}(Xij) - Min(Xij)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

Where,

Max = Maximum value of variable

Min = Minimum value of variable

X*ij* = values of variable j corresponding to household *i*

P*ij* = normalized score for observed values that are positively related to vulnerability

N*ij* = normalized score for observed values that are negatively related to vulnerability

The values of X and Y are obtained by normalization using their mean and standard errors. For instance, $X_{1j} = (X_{1j*} - X_{1*}) / S_{1*}$

Where X_{1j*} is the mean of X_{1j} across the different households,

S_{1*} is its standard deviation, and

X_1 is the principal component result of factors.

In this regard, the first principal component of a set of variables comprises the linear index of all the variables that represents the highest information common to all the variables.

Factor score for the 21 variables of measurement of vulnerability for the result of the principal component analysis is shown in Table 5.7.

Table 5.7: Principal Component Analysis Factor Score

S/N	Variables	Factor score
1	Rainfall	0.24986
2	Temperature	0.07215
3	Drought	0.16234
4	Wind	0.01247
5	Sex of household	0.23816
6	Age of household	-0.24704
7	Farming status	0.09417
8	Educational level	0.03468
9	Farm holding size	-0.32488
10	Household size	-0.28361
11	Crop production	-0.05248
12	Early warning information	0.19413
13	Experiences in the area	-0.02746
14	Fertilizer supply	0.10240
15	Livelihood diversification	-0.34270
16	Early planting	0.03840
17	Insecticide/pesticide	0.04732
18	Migration	-0.14815
19	Credit access	0.17743
20	Improved seed varieties	-0.42600
21	Accumulated assets	0.18986

Source: Computer output of Author's computation, 2016.

The variables having positive factor score are those that are positively associated with the first principal component analysis while those with negative factor score are negatively associated with the first principal component analysis.

Indicators of adaptive capacity, which show positive relationship with the first principal component factor score, and indicators of sensitivity and exposure, which are negatively associated with the principal component analysis were used to compute the vulnerability index using Equation 2 (see Table 5.7). Variables of adaptive capacity with positive factor score were considered while all the variables for exposure and sensitivity having both positive and negative score were used. The reason being that adaptive capacity is considered as positively contributing to the reduction of vulnerability, while exposure and

sensitivity are negatively contributing to vulnerability reduction. The higher the factor score, the more important is the variable and its contribution to the household's vulnerability.

In order to classify the farm households according to their degree of exposure to desertification (vulnerability), and to be able to produce the vulnerability map of the study area, vulnerability level is categorised into three as shown in Table 5.8 and Figure 5.1.

Table 5.8: Household' Vulnerability Classification Level

Vulnerability category	Vulnerability index value
Less vulnerable	1.1 to 3.0
Moderately vulnerable	-1.0 to 1.0
Highly vulnerable	-1.1 to -3.0

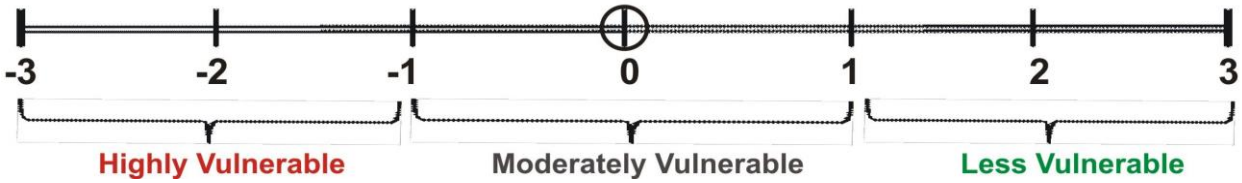

Figure 5.1: Vulnerability Index Scale.

The vulnerability index value ranges from -3.0 to +3.0, where the negative index of -3.0 indicates highly vulnerable and the positive index of +3.0 indicates less vulnerable (Table 5.8 and Figure 5.1). Households that fall within an index of 1.1 to 3.0 are the less vulnerable who happen to be in a vulnerable situation but can still cope; households that fall within an index of -1.0 to +1.0 are the moderately vulnerable who need necessary support and assistance to recover; and households that fall within an index of -1.1 to -3.0 are the highly vulnerable (emergency level households) who are almost at a point of no return.

The computed results of the 21 variables that were included in the vulnerability analysis are presented in Table 5.9.

Table 5.9: Vulnerability Index by Local Governments in the Study Area.

Components	Variables of Measurement	Local Government Areas					
		Jibia	**Zango**	**Kaita**	**Mashi**	**Baure**	**Mai'adua**
Exposure	Rainfall	-0.302	-2.651	-0.902	-0.744	-1.532	-1.714
	Temperature	1.843	-2.756	-1.743	-1.314	-2.114	-2.143
	Drought	-0.210	-1.945	-1.034	-1.142	-2.325	-1.314
	Wind	1.632	-2.638	-2.413	-1.232	-2.748	-1.134
Sensitivity	Sex of household	1.664	1.041	1.041	1.758	1.103	1.831
	Age of household	2.632	-2.845	1.841	1.833	-2.133	1.062
	Farming status	-0.641	-2.795	-2.614	-0.721	-2.100	-0.714
	Educational level	-1.361	-2.885	-0.721	-1.704	-1.632	1.751
	Farm holding size	2.147	-2.678	1.622	2.102	-2.014	1.632
	Household size	1.743	-2.883	2.101	1.643	-2.438	2.002
	Crop production	2.854	-2.748	1.000	1.843	-1.432	1.342
	Early warning information	-2.869	-2.869	1.732	-0.914	-2.476	1.000
	Experiences in the area	-0.101	1.231	-0.742	1.003	-2.810	-0.912
Adaptive capacity	Fertilizer supply	1.000	-2.387	1.000	2.105	-2.678	-0.731
	Livelihood diversification	2.841	-0.976	1.321	1.162	-1.943	1.542
	Early planting	2.476	0.156	1.742	1.124	1.212	2.005
	Insecticide/pesticide	2.621	-2.973	2.312	1.943	-2.114	2.315
	Migration	2.517	0.132	0.991	2.345	0.041	1.934
	Credit access	1.730	1.043	0.932	0.931	2.131	2.741
	Improved seed varieties	-0.470	1.103	2.641	0.972	1.079	0.918
	Accumulated assets	2.602	-2.896	0.875	2.815	-2.594	0.975
Vulnerability index		**1.228**	**-1.629**	**0.523**	**0.756**	**-1.405**	**0.685**

The results of the variables of measurement of vulnerability in the six local government areas considered for this study were presented in Table 5.9. The results show the vulnerability indices of all the variables for each local government as well as the overall vulnerability index for the local government areas. This is meant to determine the contribution of each variable to the degree of exposure of farm households to desertification and the resultant level of vulnerability at the local government level in particular and the state at large. The result of the analysis revealed that rainfall has a vulnerability index ranging from -0.302 to -2.651 across the six local government areas. This shows that rainfall has a high vulnerability index and hence makes the people to be more vulnerable. It is assumed that the higher the variation in rainfall amount, the higher the vulnerability. Agricultural production in Katsina as in many parts of northern Nigeria is largely rain fed. Due to the heavy dependency

on rainfall for agricultural production, any significant variability in the annual amount of rainfall could have an equally significant effect on agricultural production. Evidently, researches have shown that northern Nigeria is characterized by high inter-annual variability of rainfall and declining annual rainfall total. Both the amount and area of the secondary rainfall maximum at Sudano-Sahelian region in Nigeria has decline with time (Oladipo, 1993; Adefolalu 2007; Odjugo, 2010). Figure 5.2 depicts the variability in annual rainfall of the study area. The trends and fluctuations of annual rainfall as shown in the figure reveal a decrease of 220.20mm at the rate of 3.67 per annum in Katsina and its immediate environ (Abaje *et al.*, 2012). This implies that the study area has been experiencing a general decrease in the period of wet season yearly and an apparent increase in desertification process.

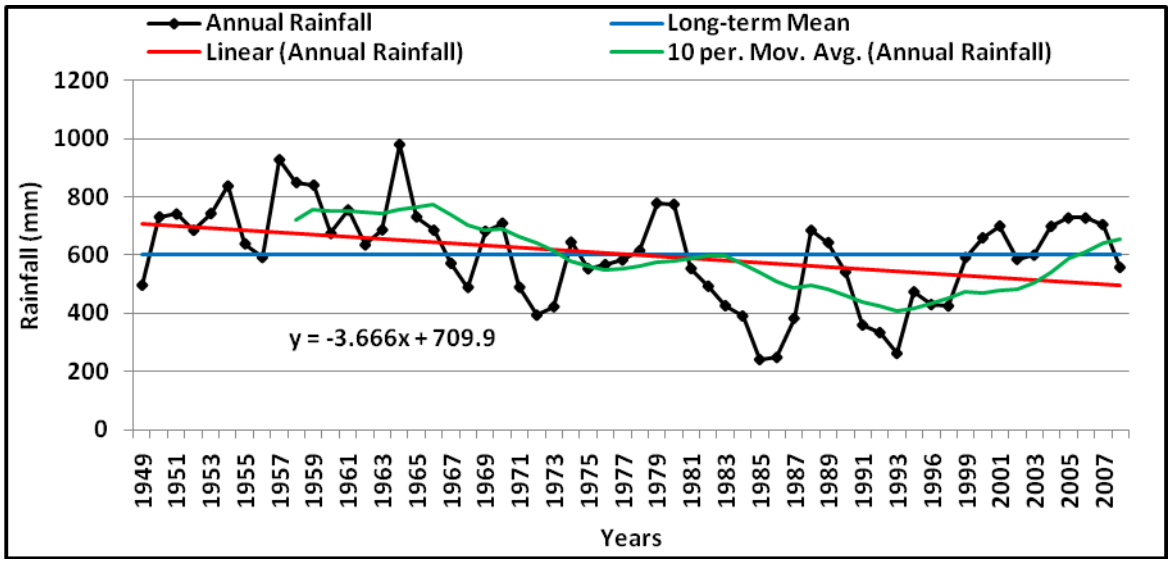

Figure 5.2: Variability in Annual Rainfall for 1949 to 2007 in the Study Area.

Source: Abaje et al., 2012.

Since agriculture constitutes an important component of rural economy and production system in the study area, any decrease in the rainfall amount will have a resultant effect on crop production and this explain why declining annual rainfall contributes to high vulnerability of the farm households to desertification.

The results of Table 5.9 also show that the vulnerability indices for temperature, drought and wind is equally high across the local government areas except for Jibia local government where temperature and wind has a positive indices of 1.843 and 1.632 respectively (low vulnerability). Drought is a recurrent climatic nemesis for northern Nigeria. It occurs with high frequency. Because of the large inter-annual variability of rainfall, typically over 20% of the average annual values, northern Nigeria is subject to frequent dry spells. In this region, noticeable widespread drought events were acknowledged to have occurred in the 20th century with 1970s characterised by larger areal extent of severe droughts than the preceding decades. This is equally same with the spatial coverage for the 1980s which may indicate a tendency towards a generally drier than normal moisture condition in northern Nigeria (Oladipo, 1993). The study area in particular is located within a region that has variously been described as Sudano- Sahelian, semi-arid and the Sahel ecological zone which faces several social and ecological crises including drought and desertification (Sawa et al., 2010, Abdulkadir, 2011). Drought in the area is therefore a product of climatic change which has contributed to the high vulnerability of the farm households in the study area as revealed by the analysis in Table 5.9.

Further breakdown of the results of the analysis based on local government areas show that Jibia local government has a vulnerability index of 1.228, and it is classified as less vulnerable (see Table 5.9 and figure 5.1). The analysis of the variables of measurement of vulnerability in Jibia local government area revealed that age of household head, crop production, migration, accumulated assets, and livelihood diversification were the main factors responsible for the lesser vulnerability of households of Jibia. All these variables have a low vulnerability index that ranges from 2.517 for migration to 2.854 for crop production. This indicates that majority of the households of Jibia are within the active age bracket (26-45) and the older the population of an area, the higher the vulnerability and vice-versa. Those

within the active age bracket are agile and can frequently migrate to other areas in search of job opportunities to complement their farm income when the need arises. This will however make them to be less vulnerable compared to the elderly that are above 50 years whose migration are somehow restricted. There is also improvement in crop production and hence it contributes to low vulnerability in the area. This could be attributed to the moderate vulnerability index of rainfall in Jibia compared to other local governments where the index is high as shown in Table 5.9. This indicates that rainfall annual amount is more in Jibia than other areas in northern Katsina. In addition, the Jibia irrigation scheme could also be of help to farmers to boost their crop production which can leads to increase in farm income and accumulated assets and hence making them less vulnerable.

The results in Table 5.9 further revealed that Kaita, Mashi and Mai'adua local government areas were moderately vulnerable with vulnerability indices of 0.523, 0.756 and 0.685 respectively. The vulnerability indices of the variables in the these local governments revealed that the households are highly vulnerable in terms of the general climatic factors (rainfall, temperature, drought and wind) all of which show high indices of vulnerability between -1.1 to -3.0. Similarly, farming status of the households also show moderate to high vulnerability indices of -0.714, -0.721 and -2.614 for Mai'adua, Mashi and Kaita respectively (see Table 5.9). Some of the factors that made the people of these local governments to be moderately vulnerable according to the analysis as contained in Table 5.9 are early planting, access to credit, accumulated assets, access to insecticides and pesticides and fertilizer supply. All these variables have low to moderate vulnerability indices and therefore responsible for the moderately vulnerability of households. For instance, in Mai'adua local government area, early planting, access to credit, and pesticides and insecticides have a low vulnerability index of 2.005, 2.741 and 2.315 respectively. In Mashi local government area, accumulated assets and fertilizer supply have low vulnerability indices of 2.851 and 2.105 respectively while the

use of insecticides and pesticides with vulnerability index of 2.312 contributes also to the low vulnerability of the farm households. This shows that the people of these areas mostly adopt early planting of crops as a better option of coping with desertification. It equally shows that the people have considerable access to microfinance or community based credit facilities where loan could be borrowed to purchase fertilizer to increase crop yields. The loans are equally used to meet up with family expenses when short fall in farm income become pervasive. The region is also known for its extensive rearing of livestock and with that the people have a solid base for accumulated assets. Most of the livestock were sold during financial crises to augment the low crop production occasioned by desertification. It is important to note that the factors that contributed majorly to moderate vulnerability of the three local governments in question were elements of adaptive capacity. This means that the higher the adaptive capacity, the lower the vulnerability and vice versa. It is therefore not farfetched why resources poor households are always considered the most vulnerable to the impacts of environmental hazards.

Zango and Baure local governments are found to be highly vulnerable according to the findings in Table 5.9. The formal has a vulnerability index of -1.629 while the latter has -1.405 both of which fall into the high vulnerability level (Table 5.9 and figure 5.1). The results of the vulnerability indices of the variable of measurements revealed some of the factors that made these two local governments to be highly vulnerable. Apart from the natural factors of low rainfall, high temperature, recurrent drought and wind which are persistent components of high vulnerability over much of the study area, others important factors mainly responsible for the high vulnerability of Zango and Baure local governments include educational level, farm household size, early warning information, farming status as well as livelihood diversification (see Table 5.9). Educational level has a high vulnerability index of -2.885 and -1.632 for Zango and Baure respectively. This means that literacy rate is very low

and hence high vulnerability index. Analysis of the socio-economic characteristics of the respondents contained in chapter four had earlier revealed that more than 80% of the respondents were not having basic primary education, while majority are illiterate who cannot read and write. With low literacy rate, farmers may not be able to adopt new innovation in farming techniques that could increase productivity and hence reduce vulnerability. Educated people are easily convinced to effect changes that could yield desired results. Education therefore in the form of raising awareness about potential options particularly in terms of increasing the effectiveness of new crops and techniques can help to enhance successful adaptation and increase overall resilience of farmers. The vulnerability index of average farm size of household is -2.678 for Zango and -2.014 for Baure (see Table 5.9). This indicates that average farm size of household is also small and hence, high vulnerability index. This could be the reason for decreasing crop production in the area and with this; there is possibility for increase in vulnerability. The results also revealed that farm households of Zango and Baure are highly vulnerable in terms of farming status, fertilizer supply and livelihood diversification. Farmers are operating on a full time basis. Farming is the main source of livelihood of the people of this area which means over dependency on natural ecosystem for survival. Any small change in climatic condition will therefore have a great impact on crop production. In addition, there is no other option for survival (livelihood diversification) except in few cases when the active adults migrate to cities for other survival mechanism. The application of fertilizer is also very low in the area. The low application of fertilizer may be due to poverty and the inadequate access to credit facilities. The people are therefore highly vulnerable due to over dependency on farming with no livelihood diversification coupled with unavailability of such farm inputs (e.g fertilizer) that would help in improvement of crop yields in the area.

The percentage distribution of the sampled households of the six local governments that constitute the study area based on their degree of vulnerability was also considered. The result is as presented in Table 5.10

Table 5.10: Percentage Distribution of Households' Vulnerability Level by LGAs

	Vulnerability category			
L.G.As	**Less**	**Moderate**	**High**	**Sampled household**
Jibia	54 (53.4%)	35 (34.7%)	12 (11.9%)	101
Zango	29 (26.4%)	38 (34.5%)	43 (39.1%)	110
Kaita	26 (25.5%)	63 (61.8%)	13 (12.7%)	102
Mashi	20 (18.7%)	73 (68.2%)	14 (13.1%)	107
Baure	31 (30.4%)	32 (31.4%)	39 (38.2%)	102
Mai'Adua	30 (27%)	69 (62.2%)	12 (10.8%)	111
Total	**190(181.4)**	**310(292.8)**	**133(125.8)**	**633**
Average	**30%**	**49%**	**21%**	

Source: Author's computation, 2016.

From the results (Table 5.10), 53.4% of households sampled in Jibia Local Government Area are less vulnerable, 34.7% are moderately vulnerable, while 11.9% are highly vulnerable. The breakdown of the vulnerability category of the households sampled in Zango shows that 26.4% are less vulnerable, 34.5% are moderately vulnerable, while 39.1% are highly vulnerable. The analysis in Kaita shows that 25.5% are less vulnerable, 61.8% are moderately vulnerable, while 12.7% are highly vulnerable. In Mashi Local Government Area, 18.7% of the sampled households are less vulnerable, 68.2% are moderately vulnerable, while 13.1% are highly vulnerable. The vulnerability category of the sampled households in Baure Local Government Area revealed that 30.4% are less vulnerable, 31.4% are moderate, while 38.2% are highly vulnerable. In Mai'adua Local Government Area, while 27% are less vulnerable and 62.2% are moderately vulnerable, 10.8% of the sampled households belong to the highly vulnerable category.

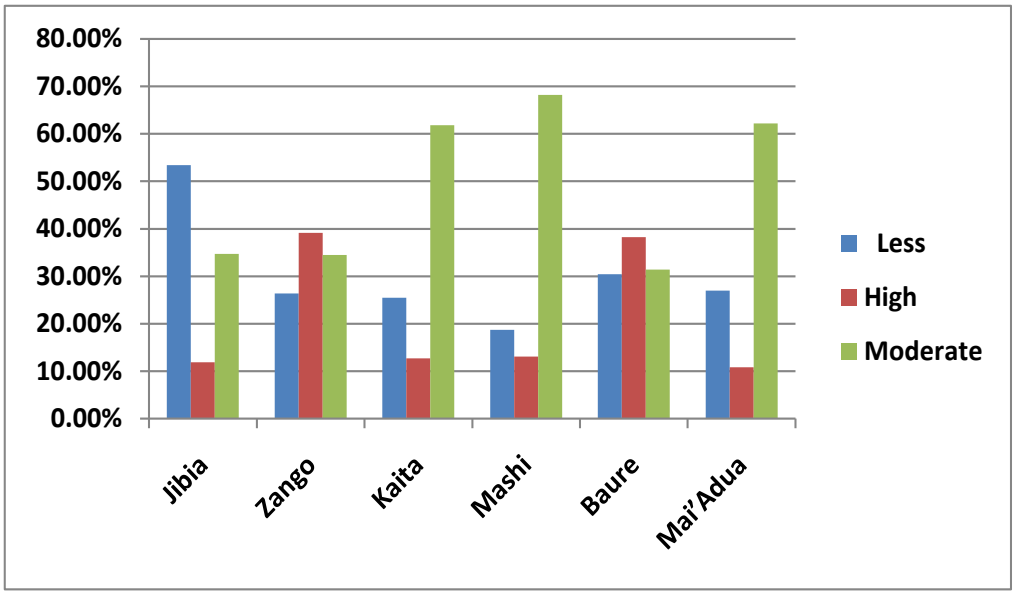

Figure 5.3: Variation in Households Vulnerability Level by L.G.As

Considering the variations in vulnerability level based on Local Government Areas (see Figure 5.3), the results shows that majority of the households (53.4%) from Jibia Local Government Area are considered less vulnerable while the highest percentage of the moderately vulnerable households are found in Kaita Local Government Area (61.8%), Mashi Local Government Area (68.2%), and Mai'adua Local Government Area (62.2%). It is also evident from the analysis that most of the highly vulnerable households are found in Baure Local Government Area and Zango Local Government Area with 38.2% and 39.1% respectively. In summary, Jibia is considered less vulnerable because the highest percentage of its households have vulnerability index value of 1.1 to 3.0 (less vulnerable); Kaita, Mashi and Mai'adua are rated as moderately vulnerable because the highest percentage of their households belong to the vulnerability index value of -1.0 to +1.0 (moderate vulnerability); while Zango and Baure constitute the highly vulnerable L.G.As due to the fact that they have the highest percentage of their households with vulnerability index value of -1.1 to -3.0 (high vulnerability). The result is represented with a map of the spatial variations in vulnerability across the study areas

as shown in figure 5.4. It should be noted that, although, Zango and Baure are considered highly vulnerable, they had 34.5% and 31.4% of their respective households in the moderate vulnerability category which shows a little difference compared to the highly vulnerable households of 38.2% in Zango and 39.1% in Baure.

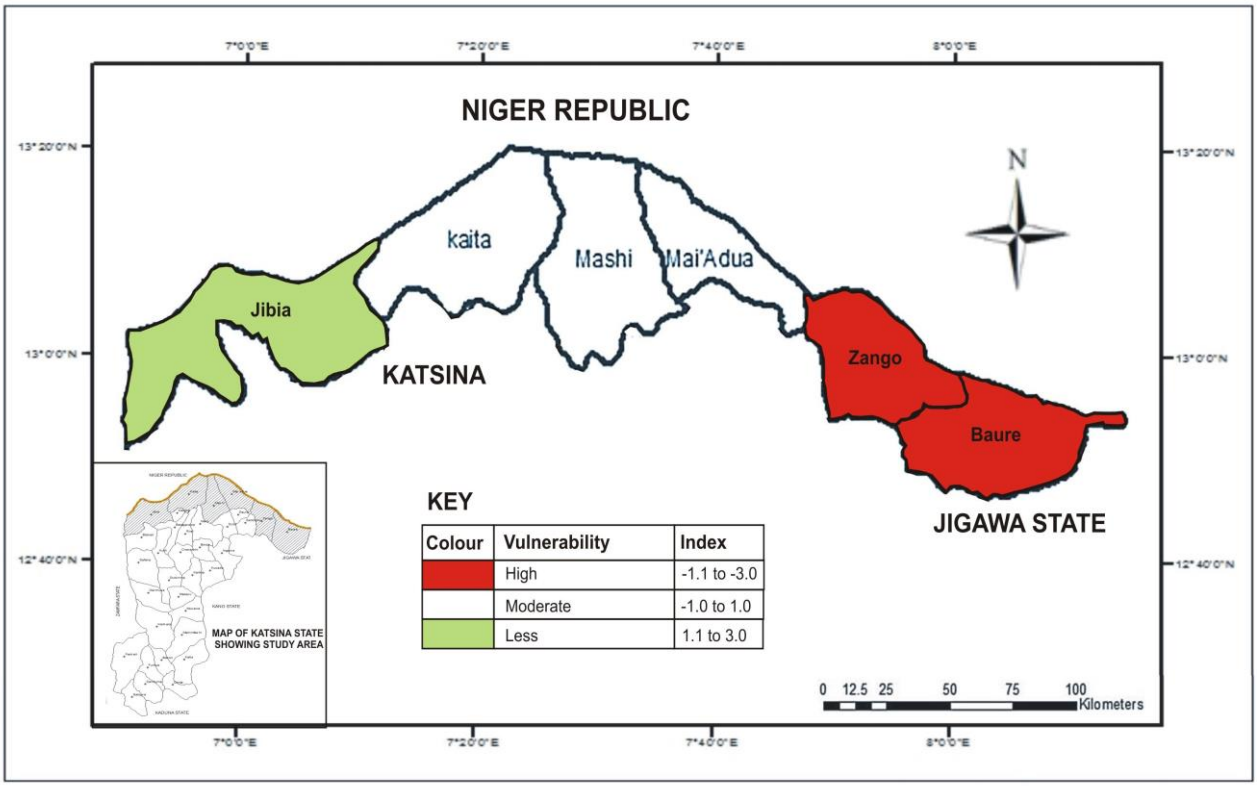

Figure 5.4: Spatial Variations in Vulnerability across the Study Area.

In all, 30% of the total households sampled of 633 for this study are less vulnerable, 49% are moderately vulnerable and 21% are highly vulnerable (see Table 5.10 and Figure 5.5)

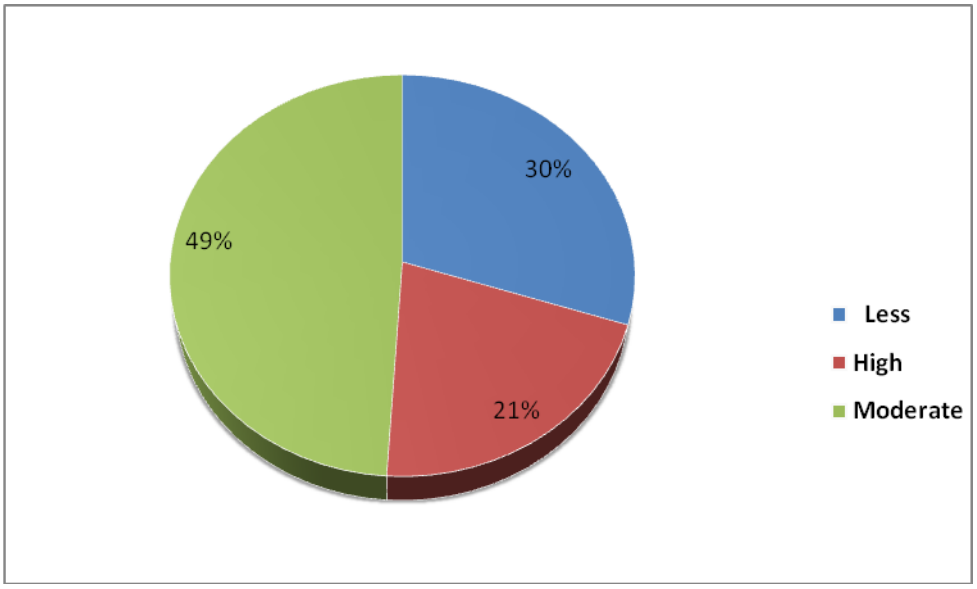

Figure 5.5: Vulnerability Status of the Total Households Sampled

This therefore means that in general, the results reveal low to moderate vulnerability of the farm households of the study area to desertification. This is however in contrast to the general catastrophic perspectives on both the issue of desertification and vulnerability of the affected communities in the study area as reported in Nigerian press.

The outcome of the key informant discussion with some of the respondents provided an important basis for understanding the main determinant of the variation that exist in vulnerability level of households as shown in Table 5.10 and Figure 5.3. Findings revealed that the determinant of vulnerability is a combination of the age, education level, farming status, household size, access to credit and access to non- farm income of the respondents. The majority of the respondents in the highly vulnerable category were headed by persons above 45 years of age with no primary level of education. Other things common to the highly vulnerable households are that they had more than six dependents (household size). Similarly, they are full time farmers with no livelihood diversification and with no access to credit. Households that are found to be less vulnerable are those headed by youths, person below 45 years of age with at least primary school education, complementary sources of income and less than five dependents. Since majority of the less vulnerable are headed by youths, it

become easier for them to engage in seasonal migration to towns and cities which according to them is known as 'cin rani' in search of part-time jobs that can fetch them non-farm incomes. The findings imply that a household may likely be less vulnerable when youths are the head of that household; when the household is literate; when the household has complementary source of income (livelihood diversification) and lesser dependents. Similarly, households having accumulated assets with access to credits and diverse coping strategies are reported to be comparatively less vulnerable to desertification.

5.5: Factors Influencing Households' Vulnerability to Desertification

Tobit regression model was used to know the influencing factors of households' vulnerability to desertification. The Tobit model was used in this study because it is a good measure of both the probability of use of the explanatory variables and the intensity of use of such variables. The Tobit model assumes that use of adaptation strategies is a continuous decision and therefore expresses households' use of adaptation strategies as a function of linear combination of some observable explanatory variables.

The Tobit model is expressed in its simplest form as:

$\mu_i = \beta_{Xi} + \mu$ …… (Equation 1)

The Tobit model is explicitly expressed for the ith household as:

$\mu_i = \beta_0 + \beta_1 X_1 +$ …….. $\beta n Xn, \quad i = 1$……..N (Equation 2)

where,

μ_i is the observed dependent variable i.e. vulnerability to desertification

β_0 is the intercept

β_1…..βn are the coefficient of the independent variables

$X_{1.....}Xn$ are the independent variables/ explanatory variables (socio-economic characteristics of households and adaptation strategies).

The results of the Tobit regression analysis of the influencing variables of households' vulnerability are presented in Table 5.11

Table 5.11: Tobit Estimates of Factors Influencing Household Vulnerability

S/N	Variables	Coefficient	SE	Z	P value
1	Rainfall	-0.1254	0.5226	-0.2397	0.8106
2	Temperature	-0.0413	0.2174	-0.1892	0.8501
3	Drought	-0.2124	0.6268	-0.3388	0.7351
4	Wind	-0.2463	0.3356	-0.7337	0.4636
5	Sex of household	-1.3838	0.2302	-6.6047	<0.0001*
6	Age of household	1.5716	0.2704	5.8107	<0.0001*
7	Farming status	2.1435	0.2638	8.1213	<0.0001*
8	Educational level	-0.1756	0.2683	-0.6535	0.5141
9	Farm holding size	-1.8786	0.3413	-5.5021	<0.0001*
10	Household size	2.2153	0.2652	8.3585	<0.0001*
11	Crop production	0.5667	0.3715	1.5114	0.1317*
12	Early warning information	-1.0171	0.2536	-4.0118	<0.0001*
13	Experiences in the area	-0.6184	0.3990	-1.5505	0.1221
14	Fertilizer supply	-1.0896	0.4268	-2.5529	0.0112*
15	Livelihood diversification	2.3333	0.2715	8.5948	<0.0001*
16	Early planting	-1.0896	0.4288	-2.5527	0.0112*
17	Insecticide/pesticide	-0.2694	0.2161	-1.2478	0.2133
18	Migration	1.2985	0.2424	5.3754	<0.0001*
19	Credit access	-1. 1825	0.2706	-4.3753	<0.0001*
20	Improved seed varieties	3.3877	0.3508	9.6630	<0.0001*
21	Accumulated assets	-1.0719	0.2238	-4.7908	<0.0001*

*statistically significant level at 5%

Source: Author's Data Analysis, 2016.

Findings from Table 5.11 revealed that the variables that were statistically significant at 5% and having significant influence on households' vulnerability include age of the household head, sex of household head, farm size of the household, farming status, access to early warning information, household size (number of dependents), access to fertilizer, livelihood diversification, early planting, migration to cities, access to credits, improved seed varieties and accumulated assets. It should be noted that the higher the coefficient value of a variable, the highly significant it was in influencing households' vulnerability. This implies that the variables that have more effects on the households' vulnerability level include age of the household heads, household size, farming status of the household, livelihood diversification, migration (mobility) and improved seed varieties.

The results showed that age of the household head is an important variable in determining how vulnerable a household was. This might be because youth headed households or person below 45 years of age are more likely to move to cities and nearby towns in search of complementary sources of income in order to relieve or reduce the suffering of their families occasioned by desertification. By implication, elderly headed households of persons above 45 years of age are more likely to be vulnerable compared with younger persons.

Farming status of the household was also found to be an important variable determining how vulnerable a household could be. This could as a result of the fact that higher percentage of the sampled respondents is full-time farmers whose seasonal crop production system that is weather sensitive becomes their means of survival. This therefore means that farm households largely bear the consequences of negative impacts of extreme climate events like drought and desertification. Households that are part-time farmers with other means of sustenance are more likely to be less vulnerable compared to full-time farmers who depend mainly on farming as a means of livelihood.

Household size was equally observed to be a significant influencing factor of households' vulnerability to desertification. The reason might be because households with more dependents will incur a considerable proportion of the household resources in feeding the dependents. This therefore means that the more dependents of a household, the more the likelihood for it to be vulnerable since a larger proportion of household resources may likely be directed to cater for dependents who cannot contribute much toward household welfare.

Similarly, the results showed that livelihood diversification was observed to have a higher coefficient value and significantly important in influencing households' vulnerability. This suggests that households with alternative livelihood options are more likely to be less vulnerable compared to those without additional sources of income. This implies that the

higher the level of household dependant on natural resources, such as seasonal crop farming, the greater the possibility of been vulnerable to desertification. The reason being that crop production in the study area is largely dependent on rainfall (rain fed), which is characterized by unpredictability and unreliability.

The results further showed that migration (household mobility) and improved seed varieties was also observed to be significant determinant of households' vulnerability to desertification. This might be because household heads that are younger and has no impediment to movements can easily migrate to towns and other areas in search of non-agricultural income sources. Similarly, households with access to improved seed varieties are more likely to adopt better crop varieties and are more likely to migrate from highly vulnerable category to moderately vulnerability level.

CHAPTER SIX

ADAPTATION STRATEGIES OF FARM HOUSEHOLDS TO DESERTIFICATION

6.1: Introduction

The main purpose of this chapter is to identify the adaptation strategies employed by farm households in dealing with desertification impacts and to highlights the measures taken by government to combat desertification in the study area.

Nelson et al. (2007) note that the goal of an adaptation measure should be to increase the capacity of a system to survive external shocks or change. Adaptation is thus essential in dealing with desertification and is also likely to play a key role in reducing the multiple pressure and threats that affects people's livelihood. Indeed, studies have shown that adaptation to desertification can help reduce vulnerability and increase resilience overall of rural smallholder farmers (Hermann et al., 2005; Stringer et al., 2009). However, the rate of reduced vulnerability depends on the level of adaptive capacity of individuals or regions.

6.2: Adaptation to Desertification

To understand measures employed to cope with desertification, questions relating to households adaptation strategies was sought through the administered questionnaire as well as key informant discussion with some elderly and prominent members of the studied communities. The results are summarized in Table 6.1

Table 6.1: Perceptual Ranking of Adaptation Strategies Adopted By Respondents

Adaption strategies	Frequency	Percentage	Rank
Intercropping	595	94	2
Early planting	512	81	3
Fertilizer/ manure application	318	50.2	5
Migration to cities	215	34	9
Livelihood diversification (non-farm income)	245	38.7	8
Changing of crop varieties	297	47	6
Planting of drought tolerant crops	602	95	1
Soil conservation techniques (mulching, afforestation)	285	45	7
Increase use of irrigation	157	24.8	11
Liquidating accumulated assets	463	73	4
Credit facilities	177	28	10

Source: Author's Field survey, 2016.

The result in Table 6.1 shows that more than half of the respondents adopted intercropping (94%), early planting (81%), planting of drought tolerance crops (95%), liquidating accumulated assets (73%) and fertilizer/ manure application (50%) as coping measures for desertification. This indicates that the dominant adaptation strategy employed to combat desertification were planting of drought tolerant crops, intercropping, early planting, liquidating accumulated assets and fertilizer/manure application. This therefore revealed why millet becomes the most cultivated crop available in the study area where drought occurrence is frequent. The reason is that millet is a drought resistant crop that requires less water, little nutrients and requires between 3-4 months to get matured. Similarly, intercropping happens to be one of the dominant adaptation measures to desertification. This might be because the most prominent cropping pattern in the area is mixed cropping. The most common crop combinations for intercropping are millet/sorghum and millet/cowpea/sorghum.

Farm households also resorted to early planting as a prominent adaptation strategy because of the variation and decrease in rainfall in the area. Studies has shown that states of

northern Nigeria, Katsina inclusive has suffered decrease in rainfall in the range of about 3 - 4% per decade since the beginning of the 19th century (FRN, 2003). As a result of this, farmers had resulted to planting of crops as early as possible during the rainy season which usually lasted for 3 – 4 months in the area. Farm households of the study area also considered liquidating accumulated assets, such as crops and livestock as one of the most adopted strategies used to reduce the ravages of desertification.

The results also revealed that 47% of the respondents employed changing of crop varieties as adaptation strategies while 38.7% adopted livelihood diversification as adaptation strategy option. Migration to cities was adopted by 34% of the respondents and about 28% employed credit facilities while 24.8% adopted irrigation method as adaptation strategy to combat desertification. The perceptual ranking of the adaptation strategy as shown in Table 6.1 revealed that planting of drought tolerant crops is ranked 1st among adaptation strategies employed by the respondents while intercropping and early planting were ranked 2nd and 3rd respectively. On the contrary, migration to cities, credit facilities and increase use of irrigation were the least adopted adaptation strategies among the respondents. This indicates that migration to cities; credit facilities and increase use of irrigation were the last resort to coping with desertification menace. People engaged in migration to Niger republic and towns farther south of Katsina state and other states in search of non-farm incomes. Migration was among the last resort because majority of the household heads were elderly men who will not want to leave their family unless serious condition demands. Migration therefore happens seasonally with the hope of improving quality of life on return to the village. Because of the small number of raining days in the area which usually lasted for 90 – 120 days, water problems becomes a major environmental constraint for agricultural production and hence makes use of irrigation as one of the last resort to cope with desertification. The study area is characterized by reduction in river flow and ground water level which has compounded the problem of over

exploitation of ground water leading to dismal living condition in rural area. The respondents also revealed that they have poor access to credit facilities especially from the government.

The result further revealed that almost all the respondents used more than two adaptation strategies to combat desertification.

6.3: Traditional Methods of coping with Desertification

Key informant discussion held with the respondents also provides some useful information about certain traditional adaptation strategies. The people have devised indigenous strategies of harvesting crops on the stand such that the stalk will hold the soil together. The stalks are later cut down and arranged bellow the furrows during the onset of rains in order to increase soil nutrients. The other way is to harvest the stalks but stumps are left to hold soil together for the prevention of wind-induced erosion that aid desertification processes due to near absence of vegetation cover. Similarly, the person has also resorted to ridges making in rows in opposite directions of wind in order to reduce the ravages of winds and storms-induced desertification processes. The respondents claimed to have learnt these strategies from their fathers and they continue to employ it and pass it on from generation to generation.

The outcome of the discussion (Plate 6.1 and 6.2) also revealed that planting of trees is one of the way in which the people of the area have responded to check desertification. They claimed to have planted trees especially in their farms, house, and along road sides in order to curb the incidence of desertification. Majority of the respondents have participated in planting of trees on their farm to reduce insolation, increases water infiltration and increases soil fertility which would in turn reduce the effect of land degradation.

Another important coping strategy employed by the people is borrowing. When financial crisis arise, the people resorted to borrowing to ameliorate the suffering resulting from poor crop yields and household food insecurity. The respondents claimed to have been borrowing grains from households with surplus with is usually paid back after the harvest of

the succeeding year. They equally resorted to borrowing of cash from neighbourhood and seeking assistance from politicians and religious institutions. Mobilizing social networks by which wealth is distributed from the relatively rich (known in Hausa as masu dan hali) to the common people (known in Hausa as talakawa) is also among the variety of adaptation strategies employed in the area.

Another traditional method of coping with desertification in the area is the planting of short-period and drought resistant varieties of crops. Farmers have realised the importance of planting a particular short-period black-eye cowpea known in Hausa as "Dan-lla mai hula makka kusa" especially among the people of Mashi, mai'adua and kaita local government areas. Because of the relatively short period of cultivation and harvest, they have been able to sell it and make good money from it.

The study also revealed that many of the respondents relied on prayers offered to the Almighty God, the ultimate controller of the universe, begging for His divine intervention and infinite mercy. In the course of the interview, the farmers in Dadin Sarki settlement of Baure local government area said that it has become a common thing in most communities through the years to see people of various age categories gather at prayer grounds and mosques to pray for rains. They affirmed that in several instances, the prayers were thought to be answered. Although the prayers were believed to be efficacious, the tendency for such prayers as reduced in recent years compared to about two decades ago (around 1989) after the 1981-1984 drought when the impact is most serious in the area and hence people and animals were put under great stress and peril.

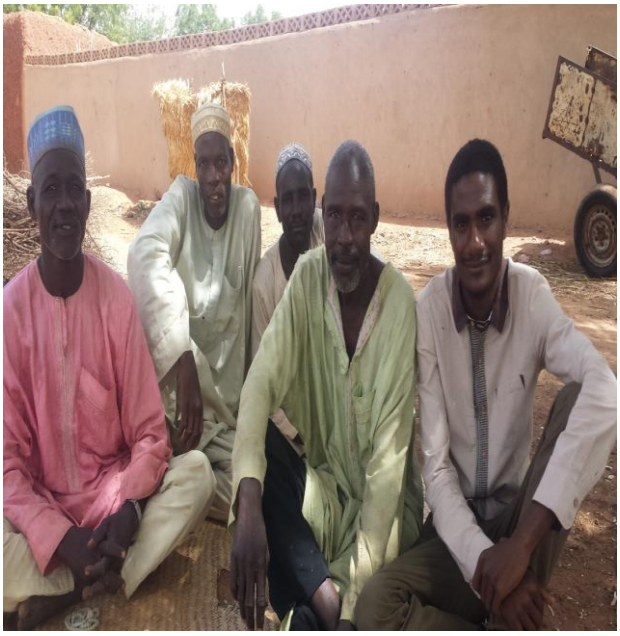

Plate 6.1: Key Informant Interview Session at Dadin Sarki Community, Baure L.G.A.

Plate 6.2: Focus Group Discussion Session

6.4: Government Responses at Combating Desertification

Katsina State Government in conjunction with the Federal Government of Nigeria and some other Non- Governmental Organizations (NGOs) has implemented various actions and policies over the years in response to combat desertification in the state.

6.4.1: Action Plan and Policies

With the loss being suffered from the widespread occurrence of drought and desertification in Katsina state, the state government has since the inception of these problems responded in a variety of ways through actions and policies. As part of actions taken by the state government to cushion the effects of the 1987 and 1990 drought was the constitution of a high-powered delegation sent to the federal government to indicate the seriousness of the situation and also asked for immediate assistance. Having been informed by the technical Department of Katsina State Agricultural and Rural Development Authority (KTARDA) and Ministry of Agriculture, the State dispatched official to all the affected areas for an on-spot assessment of the situation. With the creation of the Katsina State Emergency Relief Agency,

the Federal Government immediately granted the agency the sum of seven million naira for assistance to victims of natural disasters. Also, between 1987 and 1988, about four million naira worth of assorted grains was given out as relief. About two hundred and seventy thousand worth of animal feeds, one hundred thousand naira worth of chemicals, seven water tankers to each of the then seven local government areas (one per L.G.A) and five hundred thousand naira to the State water board for rehabilitation of boreholes were distributed (Saulawa, 1992). Others government policies that have helped in curbing the menace of desertification in the state and Nigeria in general include:

- National Policy on Environment which covers so many areas such as biological diversity, conservation of natural resources, soil conservation, water resources, flood and erosion control and the cross sectoral issues of public participation.
- National Agricultural Policy which covers protection of livestock, forestry, food production, and land and water resources.
- National Forestry Policy and Action Plan which is a framework for halting deforestation and associated destructive impacts. Its objectives include protection of forest resources, achieving 25% forest coverage in Nigeria and sustainable utilization of forest products.
- National Environmental Action Plan and State Environmental Action Plans: the policies, plans and programs include overall protection of the Nigerian environment, conservation of threatened flora and fauna species, environmental education and awareness creation and reduction of resources use conflict among land users.
- National Action Program to Combat Desertification: this National Action Program (NAP) is a report that spells out critical activities to be taken in a holistic manner to tackle the menace of desertification in the country.

Katsina state government in conjunction with the Federal Government, Multilateral and Donor Agencies have also implemented various programmes to address the problems of drought and desertification. The implementation of desertification control projects and schemes in the state has been through the following Agencies:

i. Daura Native Authority (1960-1970)
ii. National Committee on Arid Zone Afforestation Project (NCAZA) (1975-1984)
iii. Ecological Fund Project (1985-1986)
iv. Drought and Desertification Control Committee (DDC) (1987-1990)
v. European Economic Committee (EEC)/Federal Government of Nigeria and Katsina Arid Zone Development Programme (KAZP) (1987 till date)
vi. Katsina State Afforestation Project Unit (KTAPU) assisted by World Bank/FGN (1998 till date)
vii. Katsina state Agricultural and Rural Development Authority (KTARDA)
viii. International Fund for Agricultural Development (IFAD)
ix. State Forest Department (SFD)
x. Katsina State Environmental Protection Agency (KASEPA)
xi. Local Government Council (LGCs).

These agencies embarked on various programmes for combating desertification through afforestation project, joint grazing and soil conservation schemes.

6.4.2: Afforestation Programmes

In 1977, the Federal Government set up the National Committee on Arid Zone Afforestation Project with the responsibility of examining the problem of desertification in depth and drawing up a suitable programme of afforestation geared towards checking desert encroachment. A programme of shelterbelt planting for the protection of adjoining

agricultural lands against desiccating winds in the extreme northern part of northern Nigeria was embarked upon, but this committee was dissolved in 1985. Its function was transferred to Rural Development and River Basin Development Authorities in the then Federal Ministry of Agriculture, Water Resources, and Rural Development where a new sub-committee on drought and desertification was formed in 1986 (Oladipo, 1993).

Afforestation Project (AP) was one of the three main components of forestry II, a World Bank and Federal Government funded project implemented in Nigeria from 1986 to 1996. The main objectives were to stabilize soil conditions in arid regions, to develop forest reserves and plantations in the southern Nigerian, and to strengthen project management through policy development and institutional strengthening. Forestry II followed forestry I (1980-1986), which focused on plantation development in south-central Nigeria and infrastructural development and institutional support for the Federal and state forestry department. Forestry Management Evaluation and Coordinating Unit 1 (FORMECU) were established in 1987 to oversee forestry II. Simultaneously, the Afforestation Program Co-ordination Unit (APCU) was established to manage the AP in all northern states, and state co-ordinating units were established to implement the field program working in collaboration with local governments (UNEP, 1998).

In Katsina state, afforestation programme was established in order to arrest the dangerous development of desert encroachment in the state. About four agencies are operating this project since its inception in 1987. The state is assisted by the Federal Government of Nigeria (FGN), the European Economic Community (EEC) and the World Bank. The European Economic Community supported a pilot project in the state covering a total area of 1.6 million hectares involving the establishment of shelterbelts, windbreaks, woodlots, trees on farmlands, extension programmes and tree planting campaigns. The EEC/FGN has 25 nurseries, the State has 36 and World Bank has 6 and over 5 million assorted seedlings are

usually raised annually. About 1,815 hectares of woodlots, 3,205 numbers of windbreaks, 1,163,110 trees are on farmlands and 2,623.97 hectares of shelterbelts were established in Katsina state before 2004 through the assistance of those agencies. Some of the shelterbelts established in the state are shown in plate 6.3 and 6.4.

Plate 6.3: Shelterbelt established along farmlands in Zango Local Government Area

Plate 6.4: Shelterbelt along Road side in Baure Local Government Area

6.4.3: Katsina State Drought and Desertification Control Activities

The Department of Drought and Desertification in the Katsina State Ministry of Environment oversees activities aimed at combating drought and desertification. These include measures that mitigate climate change, improve the bio-physical environment and adaptation measures. The department hosts the Federal Government Great Green Wall Programme meant to strengthen the resilience of human and natural systems in the Sahel and Sahara areas. The department control activities cover local government areas such as Batsari, Jibia, Kaita, Mashi, Mai-adua, Daura, Zango, Sandamu and Baure. Major activities carried out by the department to date are summarized in Table 6.2.

Table 6.2: Katsina State Department of Drought and Desertification Control Activities.

ACTIVITIES CARRIED OUT	**WORK PERIOD**	**PURPOSE**	**REMARK**
Green Area for Commercial Seedling Production (PPP Arrangement)	May – August, 2012	To provide suitable place for private nursery operators to carry out their activities (31 plots and 2 boreholes were provided by the government.	Completed. Activities of propagation and selling of seedlings is on-going in some of the plots.
Katsina Green Initiatives, and Roadside Planting Programme	June, 2012 – July, 2013 and August, 2013 – August, 2014.	Establishment of 3 rows of trees on each side of the road in 7 L.G.As affected by desertification (250M in 14 lots)	Completed. They have matured and visible on the road side.
Great Green Wall (GGW) Programme	2013/2014	Establishment of shelterbelts in the far most north of Katsina State bordering	Completed. State government assist the federal government in

		Niger Republic for desertification control.	fencing in the 2nd year. Trees started growing steadily in the 2nd year of planting
Delivery of 2 tractors with working implements for GGW activities	2013/2014	Community based afforestation drive	Available in 20 communities within the project areas. Equipped with borehole and water reservoir.
Flag-off of the Great Green Wall Programme at Gurbin Baure, Jibia L.G.A.	January, 2015-February 2015	State level GGW F lag-off ceremony	Successfully conducted.

Source: Katsina State Ministry of Environment, 2016.

6.4.4: Afforestation Programme of National Agency for Great Green Wall in Katsina State

The Great Green Wall (GGW) Programme was conceptualized as part of the efforts at finding solution to the impacts of desertification on economic growth and sustainable development in Africa. The participating countries include Senegal, Mauritania, Burkina Faso, Mali, Niger, Nigeria, Chad, Sudan, Ethiopia, Eritrea and Djibouti. It was launched in Abuja in 2006 and adopted by the African Union (AU) in 2007. The objective of the Great Green Wall is to strengthen the resilience of human and natural systems in the Sahel and Sahara areas through sustainable ecosystem management and development of natural resources.

Implementation of the Great Green Wall programme in Nigeria commenced in 2013. One of the major components of the Nigerian Great Green Wall programme is the establishment of two contiguous shelterbelts (15km apart) stretching from Kebbi State in the northwest to Borno State in the northeast, a distance of 1,358.62km. The participating states include Katsina, Yobe, Jigawa, Borno, Zamfara, Kebbi, Sokoto and Kano. The main aim of the contiguous shelterbelts is to serve as windbreaks and achieve among others the following: intercept the southward movement of Sahara desert, rehabilitated degraded lands, shield and improve the quality of farmlands, increase vegetation cover, improve biodiversity, combat climate change, protect human settlements and other infrastructure, stabilize shifting sand and enhance rural livelihoods.

The Great Green Wall Afforestation programmes in Katsina State include the establishment of shelterbelts, woodlots; orchards and community nursery (see Table 6.3). A total of 335, 300 seedlings were planted for the various afforestation types as shown in Table 6.3.

Table 6.3: Afforestation Activities of GGW (2013-2015) in Katsina State.

Afforestation Type	**Total seedlings established**	**Total seedlings planted**	**Total planted seedlings surviving**	**% planted seedlings surviving**	**Total wilted seedling**	**% wilted seedlings**
Shelterbelts (km)	74	251,600	88,060	35	163,540	65
Woodlots (Ha)	45	54,000	23,382	43.3	30,618	56.7
Orchards (Ha)	14	5,600	2,262	40.4	3,338	59.6
Date palm seedling	42,000	42,000	N/A	N/A	N/A	N/A
Community nurseries	19	8,516		N/A	N/A	N/A
TOTAL		**355,300**				

Source: National Agency for the Great Green Wall, 2016.

CHAPTER SEVEN

SUMMARY, IMPLICATIONS, RECOMMENDATIONS AND CONCLUSION

7.1 Introduction

The analysis of the vulnerability and adaptation of rural farm households to desertification in Katsina State as presented in preceding chapters (4-6) has revealed several important findings which can be summarised and from which implications, recommendations and conclusion can be made. These are the main content of this chapter.

7.2: Summary of Findings

This study established the fact that Katsina State has suffered from the ecological problem of desertification which has deprived rural farm households the opportunity of meeting their basic needs and livelihood survival. It was revealed from the study that more than 80% of the sampled respondents were not having basic primary education and majority could not read and write. About 70% of the respondents have more than six persons as household members, while more than 71% are above 45 years of age and are full time farmers mainly involved in the production of grains such as millet, sorghum, groundnut and cowpea. The study revealed that about 93% of the households are headed by males mainly operating on below 5 hectares of land involving mixed cropping pattern. The most common crop combinations are millet/sorghum/cowpea. Agricultural production is a key component of local livelihoods in the study area, with millet cultivation being the most important land use.

Information on household awareness on desertification showed that 93% of the sampled households were quite aware of the occurrence of desertification in the area and more than 50% of them claimed to have been experiencing it for the past two decades. The main perceived causes of desertification among the households are deforestation, environmental mismanagement, climate change an act of God destined by God to befall them. Their firm believe in desertification as an act of God was however rooted in their religious ideology mainly because majority had quranic education. The study has shown that farm

households recognised desertification as a threat to livelihood and had suffered declining yields per hectare for more than two decades. In addition, majority of the respondents had experienced low income from farm produce, declining soil productivity, decrease use of irrigation/groundwater, extinction of flora and fauna species as well as loss of economic and medicinal trees among other consequences of the perennial problem of desertification in the area.

Households vulnerability in the area were found to be influenced by age of household head, farming status, education level, size of the household, access to non-farm income of households as well as access to credit. The implication is that a household is likely to be less vulnerable when they are headed by youths, literate person, having lesser dependents (household size) and has complementary source of income with access to credit facilities. Another major finding of the study is that while 49% of the total households are moderately vulnerable to desertification, 30% are less vulnerable and 21% found to be highly vulnerable. This therefore means that farm households in Katsina are generally moderately vulnerable to desertification.

In response to their vulnerability, farm households of the study area had employed a variety of adaptation strategies to reduce the menace of the problem. This among others include early planting, intercropping, planting of drought tolerant crops, application of manure/fertilizer, liquidating accumulated assets and migration to cities. In addition, traditional coping methods adopted include harvesting of crops on the stand leaving the stalk to hold soil together to prevent wind-induced erosion that aid desertification; making ridges in rows across the direction of wind; planting of tree on farmland and road side; borrowing and mobilizing social network as well as prayers offered to the almighty God for His divine intervention.

7.3: Implications of the Study

The major finding in this study is that desertification impact directly or indirectly on all aspect of human life in semi-arid environment of northern Katsina and that the people of this area are in general moderately vulnerable to desertification. This is however in contrast to the general perception that the rate of desertification in northern Nigeria is severe. A combination of several indicators of vulnerability determines the rate of individual household vulnerability to desertification based on the level of exposure, sensitivity and accessibility or inaccessibility to adaptive capacity. The major causes of desertification are climatic factor (extreme variability in climate) and human interference through environmental mismanagement practices such as deforestation, over cultivation, over grazing, bush burning and excessive fuel wood extraction.

The findings of this study have theoretical, academic and planning implications that can help to further improve the standard of living of the affected households at the local level. On theoretical implication, this study corroborates previous theoretical standpoints that desertification constitutes a serious threat to the livelihoods of millions of people living in the dry lands regions of the world in general and the rural small holders farmers of the semi-arid regions of northern Nigeria in particular.

A major planning implication of this study is that although desertification problems could be ameliorated through national actions and policies, the more effective way to combat desertification is to adopt a bottom-up approach with full participation of the local people in the formulation and implementation of national and state policies and programmes. This will ensure that the households who are directly affected become part of the process aimed at improving their standard of living. This becomes necessary because despite several efforts by the government to combat desertification, the problem still persist due to the gap between the local people and formulation of policy to address the problems of desertification.

Academically, a micro-level vulnerability analysis of this type is an essential prerequisite for local-level planning and prioritization of resilience planning and adaptation measures particularly among the rural communities that are vulnerable to desertification. The findings in particular create potential room for research that may further increase our understanding of household vulnerability and adaptation to desertification in the semi-arid regions of Nigeria. Future researches can also be done to expand the scope of households' vulnerability to cover other regions/states in northern Nigeria with a view of conducting comparative study analysis that have implication for regional and national planning.

7.4: Recommendations

Since households are the major decision maker at the community level, any meaningful intervention at reducing vulnerability to desertification should be targeted at the individual household. This study therefore recommends the followings:

Government agencies and commission saddled with the responsibilities for combating desertification at the local, state and national level should incorporate household based intervention such as empowering the elderly men, promoting adult education, increasing access to credit and farm input, creating employment and enhancing access to early warning information into the strategic plans and actions to rescue the vulnerable communities. This becomes necessary because these factors are found to be the main determinants influencing household vulnerability to desertification in the area.

Efforts should be intensified towards effective management of environmental resources. Such efforts should be directed towards local and regional development policies that would recognize soil and water conservation strategies for achieving sustainable livelihood and agricultural production. Emphasis should be on policy which will facilitate regeneration of vegetative cover, the rehabilitation of soil quality, increase use of irrigation, provision of water catchment and biomass stability. Renewable energy sources such as wind

energy; solar energy, hydro-electric power energy and gas should be encouraged and made available at affordable rates as alternative to fire wood consumption.

Autonomous locally driven adaptation strategies employed by farm households in the study area should be encouraged and integrated within the socio-economic framework of society. Such local/traditional methods need to be studied, translated to scientific terms, validated, strengthened and incorporated into development planning of existing strategies.

Since the study area in particular and northern Nigeria in general is more susceptible to desertification partly because of variable climate, formulation of a comprehensive, coherent and well co-ordinated development strategy which takes into account the vagaries of climate is highly necessary.

Lastly, Participatory Rural Appraisal (PRA) approach should be considered at the centre of policy formulation and implementation to combat desertification and ensure sustainability of rural livelihoods. By using the PRA technique, people whose lives are directly affected become part of the decision making process and will be able to make significant contributions to achieving sustainable development strategies.

7.5: Conclusion

This study focused on farm household-level vulnerability analysis and adaptation to desertification at the rural area of northern Katsina. The rural population are considered more vulnerable and mostly affected by desertification because of their limited capacity to manage natural resources upon which their livelihood depends particularly under changing climatic conditions. The problem of desertification is likely to increase as climate change impacts become more pronounced and droughts emerge as a regular phenomenon in northern Nigeria. In the arid and semi-arid areas of Nigeria where agricultural production is climate sensitive, sustainable solution to the problems of desertification is a better understanding of the vulnerability and adaptation of the most vulnerable places and people. It therefore becomes

necessary for policy makers to understand farm households' vulnerability to desertification in order to develop effective mitigation and adaptation programmes for long-term resilience. In view of the perennial ecological problem of desertification experienced in Nigeria, the approach and recommendations of this study could be applied to other states and areas of northern Nigeria despite the fact that the findings are specific to Katsina State.

References

Abaje, I.B., Ati, O.F. and Iguisi, E.O. (2012). Recend Trends and Fluctuations of Annual Rainfall in the Sudano-Sahelian Ecological Zones of Nigeria: Risks and Opportunities. *Journal of Sustainable Society.* 1(2): 44-51.

Abaje, I.B., Sawa, B.A. and Ati, O.F. (2014). Climate Variability and Change, Impacts and Adaptation Strategies in Dutsin-Ma Local Government Area of Katsina State, Nigeria.*Journal of Geography and Geology; 6(2): 103-112.*

Abaje, I.B., Sawa, B.A., Iguisi, E.O. and Ibrahim, A.A. (2015). A Quantitative Approach to Vulnerability Assessment of Rural Communities to Climate Change in Kaduna State, Nigeria. *Nigeria Geographical Journal,* 10(2): 180-195.

Abdulkadir, A. (2011). Delineation of Agroclimatological Zones of Nigeria using Integrated Approach. Unpublished Ph.D. Thesis, Federal University of Technology, Minna, Nigeria.

Adamu, I.A. (2000). State Survey of Katsina. In Mamman A.B., Peter S.W., and Oyebanji J.O. (Eds.), *Nigeria: A people United, A Future Assured*. Volume 2, pp. 291-302. Nigeria: Federal Ministry of Information, Abuja.

Adedayo, A. And Yusuf, R.O. (2012) Environmentally-Induced Rural Out-Migration in Borno State, Nigeria. *The Nigerian Geographical Journal*, 8(2): 9-23.

Adeel, Z.U., Safriel, D., Niemeijer, R., White, G., De Kalbermatten M., Glantz, B., Salem, B., Scholes, M., Niamir-Fuller, S., Ehui, and V. Yapi-Gnaore (2005) *Ecosystems and Human Well-being: Desertification Synthesis*, a Report of the Millennium Ecosystem Assessment, World Resources Institute, Washington DC, USA.

Adefolalu, D.O.A. (2007). Climate Change and Economic Sustainability in Nigeria. *Paper presented at the International Conference on Climate Change, Nnamdi Azikiwe University,* Awka 12-14 June 2007.

Adejuwon, J.O. (2006). Food Crop Production in Nigeria; Potential Effects of Climate Change. *Climate Research*, Vol.32, pp 229-245.

Adger, W.N. (2006). Vulnerability. Global Environmental Change 16(3):68–281.

Adger, W.N., Arnell, N.W. and Tompkins, E.L. (2005) Successful Adaptation to Climate Change Across scales. *Global Environmental Change*, 15: 77–86.

Agnew, C.T. and Warren, A. (1993). The Sand Trap. In: Hatton, J., Plouffe, P.B. (Eds.), *The Culture of Science*, (pp. 517–525). New York, Macmillan.

Ahmad M. (2000). Water Pricing and Markets in the Near East: Policy Issues and Options. *Water Policy*, 2(3): 229-242.

Aketeyon, I.S and Ogundele, F.O. (2008). Climate Change and Health in Nigeria: Incidence of Vector-Borne Diseases (Malaria). *In proceedings, 50th Annual Conference of the Association of Nigerian Geographers (ANG)* held at the University of Calabar between 25 and 28 August, 2008. Pp. 112-132.

Aliyu, S.B. (2008). An Appraisal of Climate Change Risks and Institutional Adaptation Strategies in Kano State, Nigeria. *In proceedings, 50th Annual Conference of the Association of Nigerian Geographers (ANG)* held at the University of Calabar between 25 and 28 August, 2008. Pp 103-112.

Anyadike, R.N.C. (2009). Climate Change, National Development and STI Policy Planning in Africa. *Paper Presented at the International Conference and Capacity Building Workshop on Africa's Response to Global Challenges through Sciences, Technology and Innovation, Abuja, Nigeria.*

Arif, G.M., N. Iqbal, and S. Farooq (2010). The 2010 Flood and Poverty in Pakistan: A Preliminary District-Level Analysis. Background paper prepared for the Conference on the Environment of the Poor, held on 24-26 November 2010, New Delhi. Assessment Report on Disaster Risk Reduction, 207. 207:207.

Ati, O.F., Stigter, C.J., Iguisi, E.O. and Afolayan, J.O. (2009). Profile of Rainfall Change and Variability in the Northern Nigeria, 1953-2002. *Research Journal of Environmental and Earth Sciences. 1(2):58-63.*

Aubreville, A. (1949). Climats, forêts et désertification de l´Afrique tropicale.-Soc d´´editions geographiques maritimes et coloniales, Paris. pp 351.

Ayuba, K.H. and Dami, A. (2011). *Environmental Science. An Introductory Text.* A Revised and Enlarged Edition. (pp. 72-76). Nigeria: Apani Publications, No 27, Bagaruwa Road, Costain, Kaduna.

Ayuba, H.K., Marya, U.M. and Gwari, D.M (2007). Climate Change Impact on Plant Species Composition in Six Semi-Arid Rangelands of Northern Nigeria. *Nigerian Geographical Journal*, 5(1): 35-42.

Babugura, A.A. (2005). Vulnerability to Climate Variability in Botswana. A Ph.D. Thesis, University of the Witwatersrand, Johannesburg.

Bamire, A.S., Fabiyi, Y.L., Manyong, B. (2002). Adoption Pattern of Fertilizer Technology among Farmers in the Ecological Zones of South-western Nigeria: A Tobit Analysis. *Australian Journal of Agricultural Research, 5: 901-910.*

Barroca, B., Bernardara, P., Mouchel, J. M., and Hubert, G. (2006). Indicators for Identification of Urban Flooding Vulnerability, Natural Hazards Earth System. Science, 6: 553–561.

Barrow, C.J. (1991). Land Degradation: Development and Breakdown of Terrestrial Environments. Cambridge University Press, Cambridge, UK.

Bashir, D. (2008). Sustainable Management of Drought and Desertification in Nigeria. Report of the First National Environmental Summit: *Greening the Environment for Sustainable Development*, (pp. 96-112). Federal Ministry of Environment, Housing and Urban Development.

Blaikie, P. and Brookfield, H. (1987). *Land Degradation and Society*, London: Routledge.

Blaikie, P., Cannon, T., Davies, I. and Wisner, B. (2004). At Risk: Natural Hazards, People's Vulnerability and Disasters. 2nd edition, (pp. 464), London: Routledge.

Brett, H. (2009). Food and Agriculture, Features, Climate Change Threat to Food Security. Available at http://www.people and planet. Net/doc. Php? Id = 3482. Retrieved on March 20, 2015.

Bromley, D.W. (1991). *Environment and Economy, Property Rights and Public Policy*, Blackwell.

Brooks, N., Adger, W.N. and Kelly, P.M. (2005). The Determinants of Vulnerability and Adaptive Capacity at the National Level and the Implications for Adaptation. *Global Environmental Change*, 15(2):151–163.

Burton, I., Huq, S., Lim, B., Pilifosova, O. and Schipper, E.L. (2002). From Impacts Assessment to Adaptation Priorities: The Shaping of Adaptation Policy. *Climate Policy* 2, 145–159.

Callaway, J.M., (2004). Adaptation Benefits and Costs: How Important are they in the Global Policy Picture and how can we estimate them? *Global Environmental Change*, 14: 273–284.

Carpenter, S., Walker, B., Anderies, J.M., and Abel, N. (2001). From Metaphor to Measurement: Resilience of what to what? *Ecosystems*, 4(8):765–781.

Charney, J.G. (1975). Dynamics of Deserts and Drought in the Sahel. *Quarterly Journal of the Royal Meteorological Society*, 101:193-202.

Chase, T.N., Pielke Sr., R.A. Kittel, T.G.F., Nemani, R.R. and Running, S.W. (2000). Simulated Impacts of Historical Land Cover Changes on Global Climate in Northern Winter. *Climate Dynamic*, 16:93-105.

Cheung, S. (1970). The Structure of a Contract and the Theory of Non-Exclusive Resource, *Journal of Law and Economics 13 (April 1970)*, Reprinted in Futubotn and Pejovich, (Eds.) (1974), *The Economics of Property Rights*, Ballinger Publishing Company.

Collado, A.D., Chuvieco, E. and Camarasa, A. (2002). Satellite Remote Sensing Analysis to Monitor Desertification Process in the Crop-Rangeland Boundary of Argentina. *Journal of Arid Environments,* 52: 121–133.

Cutter, S. L., Mitchell, J.T. & Scott, M.S. (2009). Revealing the Vulnerability of People and Places: A case study of Georgetown County, South Carolina. *Annals of the Association of American Geographers, 90*(4): 713-737.

DeFries, R.S., C.BField, I. Fung, G.J. Collatz, and L. Bounoua. (1999). Combining Satellite Data and Biochemical Models to Estimate Global Effects of Human-Induced Land Cover Change on Carbon Emissions and Primary Productivity. *Global Biochemical Cycles,* 13:803-815.

Demsetz, H. (1967). Toward a Theory of Property Rights, *American Economic Review 57 (May 1967)*, Reprinted in Futubotn and Pejovich, (Eds.) (1974), *The Economics of Property Rights*, Ballinger Publishing Company.

Deressa, T., Hassan, R.M. & Ringler, C. (2008). Measuring Ethiopian Farmers' Vulnerability to Climate Change Across Regional States. *International Food Policy Research Institute (IFPRI) Discussion Paper 00806.*

Diouf, A. and Lambin, E.F. (2001). Monitoring Land-Cover Changes in Semi-Arid Regions: Remote Sensing and Field Observations in the Ferlo, Senegal. *Journal of Arid Environments,* 48: 129–148.

Downing, T.E. (1992). Climate Change and Vulnerable Places: Global Food Security and Country Studies in Zimbabwe, Kenya, Senegal and Chile. Environmental Change Unit Research Report. Oxford: University of Oxford.

Dregne, H.E. and Chou Nan-Ting (1993). Global Desertification Dimensions. In Dregne H.E. (ed.), Degradation and Restoration of Arid Lands. (pp. 249-282). International Center for Arid and Semi-Arid Studies, Texas Technology University, Lubbock, Texas, USA.

Dregne, H.E., Kassas, M. and Rozanov (1991). A new Assessment of the World Status of Desertification. *Desertification Control Bulletin,* 19: 6-18.

Ekpoh, I. J. (1999b). Estimating the Sensitivity of Crop Yields to Potential Climate Change in North-Western Nigeria. *Global Journal of Pure and Applied Sciences,* 5(3):303-308.

El-Tantawi, A.A.M. (2012). An Evaluation of Long Term Rainfall Changes in the Three Bioclimatic Zones of Katsina State. *Katsina Journal of Natural and Applied Sciences.* (3)2: 45-54.

FAO (1976). A Framework for Land Evaluation. *FAO Soils Bulletin* 32. Rome, Italy.

FAO (1978). Agricultural Report on Agric-ecological Zones Project1. Methodology and Result for Africa. World Soils Resources Report No. 48, Pp. 148. FAO, Rome.

FAO (1993). Definition and General Approach to the Problem. In: Sustainable Development of Dry lands and Combating Desertification. A Position Paper. FAO, Rome.

FAO (1994). Land Degradation in South Asia: *Its Severity, Causes and Effects upon the People*. FAO, Rome.

FAO (2006). Food Security Statistics in Nigeria. Food and Agricultural Organization Statistics, *FAOSTAT, Rome.*

FAO (2006). Global Forest Resources Assessment 2005. Progress towards Sustainable Forest Management. Food and Agricultural Organization Forestry Paper 147, pp. 320.

FAO/UN (2000). FAO CLIM2-Word Wide Agroclimatic Data Base. *Food and Agriculture Organization*. Agrometeorology Group, Rome.

FAO (2010). Global Forest Resources Assessment – Key Findings. Food and Agricultural Organization of the United Nations, Rome.

FAO/UNEP (1984). Provisional Methodology for Assessment and Mapping of Desertification. Food and Agriculture Organization of the United Nations, United Nations Environmental Programme, (pp. 73), Rome.

FAO, UNESCO, and WMO (1977). World Map of Desertification, United Nations Conference on Desertification, Nairobi.

Federal Ministry of Environment (2001). National Action Programme Report: *Combating Desertification and Mitigate the Effect of Drought*, Abuja, Nigeria.

Federal Republic of Nigeria, (FRN). (2003). Nigeria's first National Communication under the United Nations Framework Convention on Climate Change. The Ministry of Environment of the Federal Republic of Nigeria.

Fellmann, T. (2012). The Assessment of Climate Change-Related Vulnerability in the Agricultural Sector: Reviewing Conceptual Frameworks. In Meybeck, A., Lankoski, J., Redfern, S., Azzu, N. and Gitz, V. (Eds), Building Resilience for Adaptation to Climate Change in the Agricultural Sector, pp. 37-61. Proceedings of a joint FAO/OECD Workshop. Retrieved from http://www.fao.org/docrep/017/i3084e/i3084e

Ford, J.D., Berrang-Ford, L. and Paterson, J. (2011). A Systematic Review of Observed Climate Change Adaptation in Developed Nation. *Climatic Change*, 106(2): 327-336.

Fussel, H. (2005). Vulnerability in Climate Change Research : A Comprehensive Conceptual Framework. University of California International and Area Studies. Retrieved from http://ww.pik-potsdam.de/-fuessel/download/breslo5_published.pdf.

Füssel, H. (2007). Vulnerability: A Generally Applicable Conceptual Framework for Climate Change Research. *Global Environmental Change*, 17:155–167.

Fussel, H. (2010). Review and Quantitative Analysis of Indices of Climate Change Exposure, Adaptive Capacity, Sensitivity, and Impacts. World Develpoment Report. Retrieved from http://siteresources.worldbank.org/INTWDR2010/Resources/5287678-1255547194560/WRD2010_ BG_Note_Fussel.pdf.

Füssel, H.M. & Klein, R.J.T. (2006). Climate Change Vulnerability Assessments: An Evolution of Conceptual Thinking. *Climate Change*, *75*(3), 301-329.

Gadzama, N.M. (1991). Keynote Address: Sustainable Development in Nigeria's dry belt: In K.O. Ologe (ed.), Problems and Prospects. (pp. 5-18). *Sustainable Development in Nigeria's Dry Belt.* Ibadan, NEST.

Gashua, M.A. (1991). An evaluation of Indigenous Techniques of Coping with Drought in Bede Local Government Area, Borno State. M.sc., Thesis, Department of Geography, Ahmadu Bello University, Zaria, Nigeria.

Gavian, S., and Fafchamps, M. (1996). Land Tenure and Allocative Efficiency in Niger. *American Journal of Agricultural Economics*, 78: 460–471.

GEF (2003). News release: GEF to provide $500 Million to Combat Land Degradation. Internet: www.theGEF.org

Glantz, M.H. and Orlovsky, N. (1983). Desertification: A review of the concept. *Desertification Control Bulletin*, 9: 15-22.

Graetz, R.D. (1991). Desertification: A Tale of two Feedbacks. In Mooney, H.A., Schindler, E.M.D., Schulze, E.D. and Walker, B.H. (Eds.), *Ecosystems Experiments.* Wiley, UK.

Grainger A (1990). The Threatening Desert: Controlling Desertification. London, UK. Earth Scan Publications Ltd.

Gretton, P. and Salma, U. (1997). Land Degradation: Links to Agricultural Output and Profitability. *Australian Journal of Agricultural Resources Economy*, 41: 209-225.

Harden, G. (1968). The Tragedy of the Commons. *American Association for the Advancement of Science,* 162 (3): 1243-1248.

Hare, F.K. (1985). Climatic variability and change. In Kates, R.W., Ausubel, J.H., and Bererian, M. (Eds.), *Climatic Impact Assessment*. (pp 7- 68). Chichester: West Sussex, UK. John Wiley and Sons Ltd.

Hare, F.K. (1987). Drought and Dessication: Twin Hazards of a Variable Climate. In D.A. Wilhite et al. (eds), Planning for Drought: Towards a Reduction of Societal Vulnerability. (pp. 3-9). Colorado. Westview Press, Boulger.

Harrison, M.N. and Jackson, J.K. (1958). Ecological Classification of the Sudan. Forest Department, *Forest Bulletin* No. 2. Ministry of Agriculture, Republic of the Sudan.

Hassan, R.M. (2002). Implications of Climate Change for Agricultural Sector Performance in Africa: Policy Challenges and Research Agenda. *Journal of African Economies,* 19 (2): 77- 105.

Hellde´n, U. (1988). Desertification Monitoring: is the Desert Encroaching? *Desertification Control Bulletin,* Volume 17, pp. 8–12.

Hellden, U., (1991): Desertification-Time for an Assessment. *Ambio,* 20(8): 372-383.

Helldén, U. (2003). Desertification and Theories of Desertification Control: A discussion of Chinese and European concepts. Proceedings of the China-EU Workshop on Integrated Approach to Combat Desertification, (pp. 94-104). China Association for International Science and Technology Cooperation held on 15-17 October 2003, Beijing, China.

Herrmann, S.M., Anyamba A. and Tucker, C.J. (2005). Recent Trends in Vegetation Dynamics in the African Sahel and their Relationship to Climate. *Global Environmental Change*, Part A, 15(4): 394-404.

Hewitt, K. (1995). Excluded Perspectives in the Social Construction of Disaster. *International Journal of Mass Emergencies and Disasters,* 13:317–319.

Hinkel, J. (2011). Indicators of Vulnerability and Adaptive Capacity: Towards a Clarification of the Science–Policy Interface. *Global Environmental Change,* 21:198–208.

Hodge, I. (1995). *Environmental Economics: Individual Incentives and Public Choices,* in *Economics Today.* Edited by A. Leake, Macmillan Press.

Holling, C.S. (1986). The Resilience of Terrestrial Ecosystems, Local Surprise and Global change. In Clark, W.C. and Munn, R.E. (Eds.), Sustainable Development of the Biosphere. (pp. 292–317). Cambridge: Cambridge University Press.

Holm, A.M., Cridland, S.W. and Roderick, M.L. (2003). The use of Time-Integrated NOAA NDVI Data and Rainfall to Assess Landscape Degradation in the Arid Shrub Land of Western Australia. *Remote Sensing of Environment,* 85:145-158.

Hulme, M. (1992). Rainfall Changes in Africa: 1931-60 to 1961-90. *International Journal of Climatology,* 12: 685-699.

Hulme, M. and M. Kelly (1993). Exploring the Links between Desertification and Climate Change. *Environment,* 35(4):11-45.

Idrisa, Y.L., Ogunbameru, B.O., Ibrahim, A.A., and Bawa, D.B. (2012). Analysis of Awareness and Adaptation to Climate Change among Farmers in the Sahel Savannah Agro-ecological Zone of Borno State, Nigeria. *British Journal of Environment and Climate Change, 2(2): 216-226.*

Inkani, A.I. (2015). Households' Vulnerability and Adaptation to Water Scarcity in Rural Areas of Katsina State, Nigeria. Ph. D. Thesis submitted to the Department of Geography and Environmental Studies, University of Nairobi, Kenya.

Intergovernmental Panel on Climate Change, IPCC (1998). The Regional Impact of Climate Change: An Assessment of Vulnerability. In: R. T.Watson, M.C., Zinyowera, and R.H

Moss. (Eds.) Special Report of IPCC Working Group II, (pp 517). Cambridge Cambridge: University Press.

Intergovernmental Panel on Climate Change (IPCC) (2001). Climate Change 2001: Impacts, Adaptations and Vulnerability. Report of Working Group II. Synthesis Report. Cambridge: Cambridge University Press.

Intergovernmental Panel on Climate Change (IPCC) (2007). Climate Change 2007: Synthesis Report. In Pachauri, R.K and Reisinger, A. (Eds). Contribution of Working Groups 1, 11, and 111 to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, (pp. 104). IPCC, Geneva, Switzerland.

Intergovernmental Panel on Climate Change, IPCC (2007b). Climate Change 2007—Impacts, Adaptation and Vulnerability. Contribution of Woking Group II to the Fourth Assessment Report of the IPCC, Cambridge University Press.

Intergovernmental Panel on Climate Change, IPCC. (2012). Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change. Cambridge, UK: Cambridge University Press.

International Food Policy Research Institute, (IFPRI) (2007). Micro-Level Analysis of Farmers'Adaptation to Climate Change in Southern Africa IFPRI Discussion Paper 00714 Washington, DC 20006-1002 USA.

Jagdish, C.K. and Paul L.G.V. (2000). Desertification Concept, Causes and Amelioration, ZEF *Discussion paper on Development Policy* No. 33, (pp. 65). Centre for Development Research, walter-flex-strasse 3, Born, Germany.

Jones, L. (2010). Overcoming Social Barriers to Adaptation.*Overseas Development Institute, (ODI) Background Note*, www.odi.org.uk/50 years. Accessed January, 2015. *Journal of Arid Environments*. 7, 213–247.

Kasperson, J., Kasperson, R., and Turner, B. (eds). (1995). Regions at Risk: Comparisons of Threatened Environments. New York: United Nations University Press.

Kassas, M. (1995). Desertification: A General Review. *Journal of Arid Environments,* 30: 115-128.

Katsina State Community and Social Development Project (2012). Baseline Survey of 25 LGAs in Katsina State. Draft Final Report submitted by Quality Environmental Consult Limited, 61, Yahaya Madaki way, Katsina, Katsina State.

Katsina State, Ministry of Environment (2000) Situation Report of the State. Presented at the Meeting of the Sub-Committee on Drought and Desertification. Held at EEC/KISG Conference Hall on February 1st, 2000.

Katsina State, Ministry of Environment (2002). *Katsina State Position paper on Desertification Control.* Presented at the meeting organized by the Federal Ministry of Environment for the Front line states with desertification problems. Held at Katsina on the 16th of May, 2002.

Katsina State Ministry of Environment (2013). Facts about Katsina. Accessed online at www.katsinaenvironment.com on June 7, 2013.

Kelly, P.M., and Adger, W.N. (2000). Theory and Practice in Assessing Vulnerability to Climate Change and Facilitation Adaptation. *Climatic Change,* 47(4):925–1352.

Kerr, R. (1998). The Sahara is not Marching Southward. *Science,* 281: 633–634.

Khalil, I.M. (1974). North-Eastern State Report on Long Term Measures to Combat Drought. Government Printer, Maiduguri.

Khan, F.A. and Salman, A. (2012). A Simple Human Vulnerability Index to Climate Change Hazards for Pakistan. *International Journal of Disaster Risk Sciences,* 3(3): 163-176. Doi: 10.1007/s13753-012-0017-z.

Klein, R.J., Eriksen, S., Naess, L.O., Hammill, A., Tanner, T.M., Robledo, C. and O'Brien, K. (2007). Portfolio Screening to Support the Mainstreaming of Adaptation to Climate Change into Development Assistance, Tyndall Centre Working Paper No. 102.

Kumpulainen, S. (2006). Vulnerability Concepts in Hazard and Risk Assessment. In Natural and Technological Hazards and Risks Affecting the Spatial Development of European Regions, edited by P. Schmidt-Thome, 65-74. Geological Survey of Finland Special Paper 42. Helsinki: Centre for Urban and Regional Studies/Helsinki University of Technology.

Kutzbach, J., Bonan, G., Foley, J. and Harrison, S.P. (1996). Vegetation and Soil Feedbacks on the Response of the African Monsoon to Orbital Forcing in the Early to Middle Holocene. *Nature,* 384:623-625.

LaFrance, J.T. (1992). Does Increased Commodity Prices lead to more or less Soil Degradation? *Australian Journal of Agricultural Economics*, 36(1): 57-82.

Lal R. (1997a). Soil quality and sustainability. In Lal, R. Blum, W.H.,Valentine, C. and Stewart, B.A. (Eds.) *Methods for Assessment of Soil Degradation*. (pp 17-30). Florida: USA. CRC Press, Boca Raton.

Lal, R. and Okigbo, B.N. (1990). Assessment of Soil Degradation in the Southern State of Nigeria, Working Paper No. 39. Environment Department, the World Bank, Washington, D.C.

Lamprey, H. F. (1975). Report on the Desert Encroachment Reconnaissance in Northern Sudan, 21 October to 10 November, 1975. UNESCO/UNEP. (mimeo) pp. 16.

Larson, B.A. and Bromley, D.W. (1990). Property Rights, Externalities, and Resource Degradation: Locating the Tragedy, *Journal of Development Economics.* 33, 235-262.

Le Houe´rou, H.N. (1977). The Nature and Causes of Desertification. Arid Zones News Letter. University of Arizona, Tucson. 3:1-7.

Le Houe´rou, H.N. (1984). Rain Use-Efficiency: A Unifying Concept in Arid-Land Ecology. *Journal of Arid Environments.* 7: 213–247.

Le Houe´rou, H.N. (1996). Climate Change, Drought and Desertification. *Journal of Arid Environments.* 34, 133-185.

Le Houe´rou, H.N. (2002). Man-Made Deserts: Desertification Processes and Threats. *Arid Land Research and Management.* 16: 1-36.

Lele, U., Mitra, K. and Kaul, O.N. (1994). Environment, Development and Poverty: A Report of The International Workshop on India's Forest Management and Ecological Revival. CIFOR Occasional Paper, No. 3. *Center for International Forestry Research*, Bogor, Indonesia.

Liverman, D.M. (1990). Vulnerability to Global Environmental Change. In Kasperson, R.E. et al. (Eds.), Understanding Global Environmental Change (pp. 27–44). Worcester: Center for Technology, Environment, and Development, Clark University.

Madu, I.A. (2012). Partial Vulnerability of Rural Households to Climate Change in Nigeria: Implication for Internal Security. Working Paper Number 2; May 2012. University of Texas, USA: The Robert S. Strauss Center for International Security and Law.

Mainguet M. (1994). Desertification-Natural Background and Human Mismanagement. (pp. 314). Berlin, Germany: Springer-Verlag.

Mainguet, M., (1991). Desertification Natural Background and Human Mismanagement. Springer Series in Physical Environment, ISBN0937-3047, 306 pp.

Matazau, H.K. (2013). Nigeria: How Yobe Varsity Plans to Tackle Desertification. The Daily Trust. Accessed online at http://allafrica.com/stories/201302280564.html? View all = 1. Retrieved on March 18, 2013.

McConnel, S. (1983). An Economic Model of Soil Conservation, *American Journal of Agricultural Economics*, 64: 83-89.

MEA (2005). Ecosystem and Human Well-Being. Desertification Synthesis. A Report of the Millennium Ecosystem Assessment (MEA). World Resources Institute, Washington, DC.

Mohammed, D., Akpan, A.E. and Aliyu H.S. (2013). Role of Community Participation in Combating Desertification in the Arid Zone of Nigeria: An Overview. *Journal of Environmental Management and Safety*, 4(3): 49-58.

Molua, E. L. (2003). Climate Variability, Vulnerability and Effectiveness of Farm-level Adaptation on Food Security in South Western Cameroon. *Environment and Development Economics*, **7**:529–545.

Mortimore, M. & Adams, W. M. (2001). Farmer, adaptation, change and 'crises' in the Sahel. *Global Environmental Change*, 11:49-57.

Mortimore, M. (1989). Adapting to Drought: Farmers, Famines and Desertification in West Africa. U.K: Cambridge University Press, Cambridge.

Mortimore, M. (1998). Roots in the African Dust: Sustaining the Dry Lands. UK: Cambridge: Cambridge University Press.

NAP (2000). National Action Programme to Combat Desertification and Mitigate the Effect of Drought, towards the Implementation of the United Nations Convention to Combat Desertification and Mitigate the Effect of Drought in Nigeria. Federal Ministry of Environment Abuja, Nigeria.

Nasiru, I.M. (2007). A Comprehensive Approach to Addressing Drought and Desertification in Nigeria. Unpublished Master's Thesis, Department of Urban Planning, Faculty of Built Environment, University Teknologi Malaysia.

National Agricultural Research Project (NARP) (1994). National Agricultural Research Strategy Plan for Nigeria, Report on North West Zone, Federal Ministry of Agricultural and Natural Resources, Abuja.

National Bureau of Statistics (NBS) (2010). Annual Abstract of Statics 2010, pp. 4.

National Population Commission (NPC) (2006). Nigerian Population Census 2006, Abuja, Nigeria.

Nelson, R. (1988). Dryland Management: The Desertification Problem. World Bank, Environment Department, Working Paper No. 8, pp 42.

Nelson, D.R., Adger, W.N. and Brown, K. (2007) Adaptation to Environmental Change: Contributions of a Resilience Framework. *Annual Review of Environment and Resources*, 32: 395–419.

Nicholson, S. E. (1983). Sub-Saharan Rainfall in the Years 1976–1980: Evidence of Continued Drought. *Monthly Weather Review*, 1646–1654.

Nicholson, S.E. (1989). African Drought: Characteristics, Causal Theories and Global Teleconnection in Understanding Climate Change. IUGG and AGU Publication, pp. 79-100.

Nigerian Environmental Study/Action Team, (NEST) (1991). Nigeria's Threatened Environment: A National Profile. Nigerian Environmental Study/Action Team (NEST). A NEST Publication. Ibadan, Nigeria.

Nyong, A., Adepetu, A., Ihemegbulem, V. and Dabi, D. (2003). Vulnerability of Rural Households to Drought in Northern Nigeria. AIACC Notes, November 2003: 2(2): 6-7.

O'Connor, T.G., Haines, L.M. and Snyman, H.A. (2001). Influence of Precipitation and Species Composition on Phytomass of Semi-Arid African grassland. *Journal of Ecology*, 89: 850–861.

Odjugo, P.A.O. (2010). General Overview of Climate Change Impacts in Nigeria. *Journal of Human Ecology, 29(1): 47-55.*

Odjugo, P.A.O. and Ikhuoria, A.I. (2003). The Impact of Climate Change and Anthropogenic Factors on Desertification in the Semi-Arid Region of Nigeria. *Global Journal of Environmental Science, 2(2): 118-126.*

Oguntoyinbo, J.S. and Richards, P. (1977). The extent and intensity of the 1969-73 Drought in Nigeria. In D. Dalby et al., (Eds.), A Provisional Analysis: Drought in Africa 2 (pp. 144-126). London. African Environment Special Report No. 6.

Ojiako, I.A., Manyong, V.M., and Ikpi, A.E. (2007). Determinants of rural farmers' improved Soybean Adoption Decision in Northern Nigeria. *Journal of Food, Agriculture and Environment,* 5(2): 215-223.

Okoye, C.O. and Ezeonyejiaku, D.C. (2010). Desertification in the Drylands of Nigeria: Causes, Consequences and Solutions. *Journal of the Faculty of Environmental Sciences,* Nnamdi Azikiwe University (UNIZIK), Awka, Nigeria. 1(1): 49-51.

Oladipo, E. O. (1989). *Desertification, its Definition, Causes, Processes and Relationship to Drought. Journal of the Geographical Society,* Ahmadu Bello University, Zaria Nigeria. 13:46-59.

Oladipo E.O. (1993). A Comprehensive Approach to Drought and Desertification in Northern Nigeria. *Natural Hazards*, 8(3): 235-261.

Oladipo, E. O. (2013). Contemporary Climate Change Science: Opportunities for Multidisciplinary Research Approach. *Public Lecture Delivered at Federal University, Dutsin-ma, Katsina State* on 15th May, 2013.

Olagunju, T.E. (2015). Drought, Desertification and the Nigerian Environment: A Review. *Journal of Ecology and the Natural Environment, 7(7): 196-209.*

Olagunju, T.E. (2015b). Forest Transition: Towards Modulating Climate Change. *Nature and Science, 13(5): 86-91.*

Olderman, K., Van Engelen, R.V.W.P., and Pulles, J.H.M. (1990). The Extent of Human-Induced Soil Degradation, Annex 5. In Olderman, L.R., R.T.A. Hakkeling and W.G. Sombroek (Eds.), World Map of the Status of Human-Induced Soil Erosion : An Explanatory Note. International Soil Reference and Information Centre, Wageningen, Netherlands.

Olschewski, R., Tscharntke, T., Benı´tez, P.C., Schwarze, S.,and Klein,A.(2006). Economic Evaluation of Pollination Services Comparing Coffee Landscapes in Ecuador and Indonesia. Ecology and Society 11 (1), 7 [online]URL:http://www.ecologyandsociety.org/vol11/iss1/art7/.

Onoja, A.O., and Idoko, O. (2012). Econometric Analysis of Factors Influencing Fuel Wood Demand in Rural and Peri-Urban Farm Households of Kogi State. *Consilience: The Journal of Sustainable Development*, 8(1): 115-127.

Onokala, P.C. (2011). Climate Change and the Need for Curriculum Development in Geography.*The Nigerian Geographical Journal, 7(2): 1-17.*

Opiyo, E.O., Wasonga, O.V., and Nyangito, M.M. (2014). Measuring Household Vulnerability to Climate-Induced Stresses in Pastoral Rangelands of Kenya: Implications for Resilience Programming. *Pastoralism: Research, Policy and Practice*, 4(10): 1-15.

Osbahr, H., Twyman, C., Adger, N.W., Thomas, D.S.G., in review. Successful Adaptation: Social Networks, Resilience and Climate Change. Ecology and Society.

Ostrom, E. (1990). *Governing the Commons, the Evolution of Institutions for Collective Action*, Cambridge University Press.

Ostrom, E., Gardner, R. and Walker, J. (1994). *Rules, Games and Common-Pool Resources*, The University of Michigan Press.

Paavola, J. (2008). Livelihoods, Vulnerability and Adaptation to Climate Change in Morogoro, Tanzania. *Environmental Science and Policy*, 11(7):642–654.

Perrings, C. (1989). An optimal path to extinction? Poverty and Resource Degradation in the Open Agrarian Economy. *Journal of Development Economics,* 30, 1-24.

Pigou, A.C. (1920). The Economics of Welfare. London, Macmillan.

Prince, S.D. (2002). Spatial and Temporal Scales for Detection of Desertification. In: Reynolds, J.F., Stafford Smith, D.M. (Eds.), Global Desertification: Do Humans Create Deserts? Berlin: Dahlem University Press.

Prince, S.D., Brown de Colstoun, E., Kravitz, L.L. (1998). Evidence from Rain-use Efficiencies does not Indicate Extensive Sahelian desertification. *Global Change Biology,* 4: 359–374.

Pulwarty, R.S., and Riebsame, W.E. (1997). The political Ecology of Vulnerability to Hurricane-Related Hazards. In Hurricanes: Climate and Socioeconomic Impacts, (pp. 185–214). Berlin: Heidelberg, New York, Springer.

Reynolds, J. F. and Stafford Smith M. (2002). Do Humans Create Deserts? In: J. F. Reynolds and M. Stafford Smith (Eds.) Global Desertification: Do Humans Cause Deserts? (pp. 1-22). Berlin, Dahlem University Press.

Reynolds, J.F., (2001). Desertification, Encyclopedia of Biodiversity. (pp. 61-78). San Diego: Academic Press.

Ribot, C. J, (1996). Climate Variability, Climate Change and Vulnerability: Moving toward by Looking Back. In J., Ribot, A., Magalhaes and S., Panagides (Eds.) Climate Variability, Climate Change and Social Vulnerability in Semi-arid Tropics. Great Britain: Cambridge University Press.

Rockstrom, J., Barron, J. and Fox, P. (2003). Water Productivity in Rain-Fed Agriculture: Challenges and Opportunities for Smallholder Farmers in Drought-Prone Tropical

Agro-ecosystems. In *Water Productivity in Agriculture: Limits and Opportunities for Improvement,* 145-162.

Rowell, D.P., C.K. Folland, K. Maskell, J.A. Owen, and M.N. Ward. (1992). Modeling the Influence of Global Sea Surface Temperatures on the Variability and Predictability of Seasonal Sahel Rainfall. *Geophysical Research Letters,* 19: 905-908.

Rozanov, B. (1990). Gobal Assessment of Desertrification: Status and Methodologies. Paper Contributed to the Örenäs Meeting on Desertification, Lund/Örenäs December 1990, pp. 12.

Safriel, U. and Adeel, Z. (2005). Development Paths of Dry lands: Thresholds and Sustainability. *Sustainability Science,* 3: 117-123.

Saulawa, A.M. (1992). The State and Ecological Problems in Katsina, Nigeria. African Arid Land, Working Paper Series, No.1/92. Pp. 5-13. Nordiska Afrika Institutet. The Scandinavian Institute of African Studies, Uppsala, Sweden.

Sawa, B.A. (2010). Climate Change and Spatio-Temporal Variability in the Occurrence of Dry Spells in Northern Nigeria. A Paper presented at the Annual Conference of the Association of Nigerian geographers held between 16th -20th March 2010 in Calabar, Nigeria.

Schneider, S. H. (1996). Encyclopaedia of Climate and Weather. (pp 960). USA: Oxford University Press.

Scones, I. And Toulmin C. (1999). Policies for Soil Fertility Management in Africa. Institute for Development Studies (IDS) and International Institute for Environment and Development (IIED) for United Kingdom Department for International Development (DFID), London.

Smit, B. and Wandel, J. (2006). Adaptation, Adaptive Capacity and Vulnerability. *Global Environmental Change, 16: 282-292.*

Smit, B., Burton, I., Klein, R.J.T. and Wandel, J. (2000). An Anatomy of Adaptation to Climate Change and Variability. *Climatic Change*, 45, 223–451.

Smit, B., McNabb, D., and Smithers, J. (1996). Agricultural Adaptation to Climatic Variation. *Climatic Change*, 33: 7–29.

Stevenson, G. G. (1991) *Common Property Economics, A General Theory and Land Use Applications*, Cambridge University Press.

Stringer, L.C, Dyer J.C., Reed M.S., Dougill A.J., Twyman C., and Mkwambisi D. (2009). Adaptation to Climate Change, Drought and Desertification: Local Insight to Enhance Policy in Southern Africa. Environmental Science and Policy (2009), doi: 10.1016/j.envsci.2009.04.002. Retrieved on 18th April, 2016.

Swift, J. (1996). Desertification: Narratives, Winners & Losers. In M. Leach and R. Mearns (Eds.), The Lie of the Land: Challenging Received Wisdom on the African Environment. (pp. 73-90). Portsmouth and Oxford: Heinemann and James Currey.

Tesso, G., Emana, B. and Ketema, M. (2012). Analysis of Vulnerability and Resilience to Climate Change Induced Shocks in North Shewa, Ethiopia. *Agricultural Sciences,* 3:871–888.

Thomas, D.S.G. (1997). Science and the Desertification Debate. *Journal of Arid Environments,* 37: 599 – 608.

Thomas, D.S.G., Middleton, N.J. (1994) Desertification. Exploding the Myth-John Wiley & Sons, ISBN 0-471-94815-2, pp 194.

Thomas, R.J. (2008). Opportunities to Reduce the Vulnerability of Dryland Farmers in Central and West Asia and North Africa to Climate Change. Agriculture, Ecosystems and Environment, 126 (1–2): 36–45.

Tucker, C.J., Dregne, H.E., Newcomb, W.W. (1991). Expansion and Contraction of the Sahara Desert from 1980 to 1990. *Science*, 253: 299–301.

Turner, B.L., Kasperson, R.E., Matson, P.A., McCarthy, J.J., Corell, R.W., Christensen, L., Eckley, N., Kasperson, J.X., Luers, A., Martello, M.L., Polsky, C., Pulsipher, A. and Schiller, A. (2003). A Framework for Vulnerability Analysis in Sustainability Science. Proceedings of the National Academy of Sciences of the United States of America 100(14):8074–8079.

UN (United Nations) (1994). UN Earth Summit. Convention on Desertification. *UN Conference in Environment and Development*, Rio de Janeiro, Brazil, June 3–14, 1992. DPI/SD/1576. United Nations, New York.

UNCCD (1992). *Report of the United Nations Conference on Environment and Development Agenda* 21, chapter 12. Retrieved March 11, 2013, available at http://www.uncd.nt/convention/history/agenda21.php.

UNCCD (1999). *National Report on the Implementation of the United Nations Convention to Combat Desertification* in those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa for Submission at the Third Session of the Conference of the Parties, Recife, Brazil.

UNCCD (2000). Assessment of the Status of Land Degradation in Arid, Semi-Arid and Dry Sub-Humid Areas. *United Nations Convention to Combat Desertification*, Bonn.

UNCCD (2007). United Nations Convention to Combat Desertification. Available at the Official website of the United Nations Convention to Combat Desertification, http://www.unccd.int/. Retrieved on March 11, 2013.

UNCED (1992). *Report of the United Nations Conference on Environment and Development*, Chapter 12: Managing fragile ecosystems: Combating desertification and drought- (Rio de Janeiro, 3-14 June 1992), General A/CONF.151/26 (Vol. II), Chapter 12: available at (http://www.unccd.ch/) Retrieved on March 11, 2013.

UNCOD (1977). World Map of Desertification. Document of the UN Conference on Desertification, A/CONF 74/2.

UNEP (1977). *Report of the United Nations Conference on Desertification.* 29 August – 9 September 1977. United Nations Environment Programme, Nairobi, Kenya.

UNEP (1984). General Assessment of Progress in the Implementation of the Plan of Action to Combat Desertification, 1978–1984. Governing Council 12th Session, February 16, 1984, Nairobi, Kenya.

UNEP (1991). Status of Desertification and Implementation of the United Nations Action Plan to Combat Desertification-*Report of the Executive Director* UNEP/GCSS.III/3, pp 88.

UNEP (1992). United Nations Environmental Program. World Atlas of Desertification (Editorial Commentary by N. Middleton and D.S.G. Thomas). Arnold, London.

UNEP (1997). World Atlas of Desertification, 2nd Edition, Middleton N, Thomas DSG (Eds.) Edward Arnold, London, UK, pp 182.

UNEP, (1998). *Afforestation and Social Forestry in Northern Nigeria*. A Success Story in Desertification/Land Degradation Control.

United Nations International Strategy for Disaster Reduction-UNISDR. (2009). Global Assessment Report on Disaster Risk Reduction, 207. 207:207.

UNSO Office to Combat Desertification and Drought (1997). Aridity Zones and Dry land Populations: An Assessment of Population Levels in the World's Dry lands. (pp. 23). UNSO/UNDP, New York.

Van Aalst M.K., Cannon, T. and Burton, I. (2008). Community level Adaptation to Climate Change: the Potential Role of Participatory Community Risk Assessment. *Global Environmental Change,* 18: 165–179.

Vanguard News Paper (2010). Special Report on Desertification in Nigeria: The sun eats our Land. May 3, 2010. http//:www.vanguardngr.com/2010/05/special-report-on-desertification-in-nigeria-the-sun-eats-our-land. Retrieved on 07/06/2015.

Varejao-Silva, M.A., Franchito, S.H. and Rao, V.B. (1998). A Coupled Biosphere-Atmosphere Climate Model Suitable for Studies of Climatic Change due to Land Surface Alterations. *Journal of Climate,* 11:1749-1767.

Veron, S.R., Paruelo J.M. and Oesterheld, M. (2006). Assessing Desetification. *Journal of Arid Environments*, 66(4): 751-763.

Vosti, S. A., and Reardon, T. (1997). Sustainability, Growth, and Poverty Alleviation. A Policy and Agroecological Perspective. Baltimore, MD: Johns Hopkins University Press.

Wachter, D. (1992). Land Titling for Land Conservation in Developing Countries? Working Paper No. 1992-28, Environment Department, The World Bank, Washington, DC.

Wainwright, J. (2004). A Review of European Union Funded Research into the History and Evolution of Mediterranean Desertification. *Advances in Environmental Monitoring and Modelling, Special Issue*, 1(4):1-87.

Watts, M.J. (2010). Now and Then. *Antipode*, 41(1): 10–26.

Wessels, K.J., Prince, S.D., Frost, P.E. and Van Zyl, D. (2004). Assessing the Effects of Human-Induced Degradation in the Former Homelands of Northern South Africa with a 1km AVHRR NDVI time-series. *Remote Sensing of Environment*, 91: 47–67.

Williams, M.A.J. and Balling, R.C. (1996). Interactions of Desertification and Climate. Arnold, London.

Wisner, B., Blaikie, P., Cannon, T., Davis, I. (2004). At Risk. Routledge, London.

World Research Institute (WRI) (1992). World Resources 1992-93, Oxford University Press, New York, USA.

Yang, J. and S.D. Prince (2000). Remote Sensing of Savanna Vegetation Changes in Eastern Zambia 1972– 1989. *International Journal of Remote Sensing*, 21:301-332.

Yuga, N.G., Shivakoti, P.G., and Sylvain, R.P. (2010). Household-level vulnerability to Drought in Hill Agriculture of Nepal: Implications for Adaptation Planning. *International Journal of Sustainable Development and World Ecology*, 17(3):225–230.

Zeng, N., Neelin J.D., Lau K.M. and Tucker, C.J. (1999). Enhancement of Interdecadal Climate Variability in the Sahel by Vegetation Interaction. *Science*, 286: 1537-1540.

Zinyowera, M.C., B.P. Jallow, R.S. Maya, and H.W.O Okoth-Ogendo. (1998). Africa. In R.T. Watson, M.C. Zinyowera, R.H. Moss, and D.J. Dokken, (Eds), The Regional Impact of Climate Change: A Special Report of IPCC Working Group II. (pp. 29-84). Cambridge: Cambridge University Press.

APPENDIX I

DEPARTMETN OF GEOGRAPHY AND ENVIRONMENTAL MANAGEMENT,

UNIVERSTIY OF ILORIN, ILORIN.

QUESTIONNAIRE FOR THE RESPONDENTS

Dear Respondents,

This questionnaire is for a Ph.D. research on "vulnerability and adaptation of rural farm households to desertification in Kastina state of Nigeria". I hereby seek for your sincere response in order to achieve the aim and objectives of the study. I also assured you that all information supplied will be treated with utmost confidentiality. Thanks for your anticipated cooperation.

Instruction: please tick (√) as appropriate or fill in the gap.

Section A: General information

1. Name of community: ……
2. Local government area: ……
3. Senatorial district: ……
4. Languages(s) spoken: ……..

Section B: Background Information (Household Survey of Respondents)

5. Age: (a) 18 – 25 [ ] (b) 26 – 35 [ ] (c) 36 – 45 [ ] (d) 46 – 65 [ ]
   (e) 65 and above [ ]
6. Sex: (a) male [ ] (b) female [ ]

7. Marital status: (a) married [ ] (b) divorced [ ] (c) widowed [ ]
8. Educational qualification: (a) non – formal education [ ] (b) quranic [ ] (c) primary [ ] (d) secondary [ ] (e) tertiary [ ]
9. Farming status: (a) full time [ ] (b) part – time [ ]
10. Cropping pattern: (a) mixed cropping [ ] (b) mono – cropping [ ]
11. Farm size in hectares: (a) less than 1 [ ] (b) 1 – 3 [ ] (c) 3 – 5 [ ] (d) above 5 [ ]
12. Size of household: (a) 1 –5 [ ] (b) 6 – 10 [ ] (c) 11 – 15 [ ] (d) 16 – 20 [ ] (e) Above 20 [ ]
13. Kindly tick the type of crops grown by your household.

Crops Grown	**Tick**
millet	
Wheat	
Sorghum	
Groundnut	
Maize	
Cowpea	
Rice	
Sugarcane	
Others	.....

Section C: Households' Perception/Knowledge of Desertification

14. Are you aware of desertification occurrence in your area? (a) Yes [ ] (b) No [ ]
15. How long have you been witnessing desertification? (a) less than 10 years ago [ ] (b) 11 – 20 years ago [ ] (c) 21 – 30 years ago [ ] (d) above 30 years [ ] (e) can't say precisely [ ]

Information on Natural Elements that induce Desertification

16. Have you being experiencing low rainfall over the last decades? (a) Yes [ ] (b) No [ ]
17. Is their change in annual rainfall amount and intensity over the years? (a) Yes [ ] (b) No [ ]
18. Has low rainfall caused reduction in the natural potential of the land? (a) Yes [ ] (b) No [ ]
19. In what way (s) has low rainfall affected your farming activities ……
……
20. Have you being witnessing drought over the last decades? (a) Yes [ ] (b) No [ ]
21. Is the occurrence of drought persistent in your area? (a) Yes [ ] (b) No [ ]
22. Has drought contributed to the degradation of fertile land? (a) Yes [ ] (b) No [ ]
23. Have you been experiencing excessive wind pressure? (a) Yes [ ] (b) No [ ]
24. Does wind-induced erosion contribute to degradation of the environment?
(a) Yes [ ] (b) No [ ]
25. Have you ever noticed formation of sand dunes in your area? (a) Yes [ ] (b) No [ ]
26. How does formation of sand dunes affect your farming activities? .....
27. Have you being experiencing extreme high temperature over the decades?
(a) Yes [ ] (b) No [ ]
28. Does the extreme high temperature affect your livelihood? (a) Yes [ ] (b) No [ ]
29. Please kindly tick (in multiple) any of the under listed variables you perceived as causes of desertification in your area:

Perceived Causes of Desertification	**Tick**
Deforestation (uncontrolled fuel wood extraction)	
Environmental mismanagement (bush burning, unplanned agric activities, faulty irrigation practices etc)	
Overgrazing due to high livestock population.	
Climate change (extreme variability in climate)	
Over cultivation of marginal land	
Natural occurrence destined by God	
Others	**.....**

Section D: Information on Exposure and Sensitivity of Households to Desertification

30. Do you consider desertification a threat to your environment? (a) Yes [ ] (b) No [ ]
31. If yes in (30), is your household affected by desertification? (a) Yes [ ] (b) No [ ]
32. Have you being witnessing declining yields per hectare? (a) Yes [ ] (b) No [ ]
33. If yes in (32), for how long have you been witnessing decreasing productivity? (a) less than 10 years [ ] (b) 11 – 20 years [ ] (c) 21 – 30 years [ ] (d) above 30 years [ ]
34. Does falling agricultural output causes food shortage for local consumption?
    (a) Yes [ ] (b) No [ ]
35. Do you have enough harvested staple food to feed your household annually?
    (a) Yes [ ] (b) No [ ]
36. If no in (35), how do you complement the deficiency?.....
    If yes, do you normally have excess harvested staple food after feeding your household annually? (a) Yes [ ] (b) No [ ]

If you have excess, do you sell out the excess? (a) Yes [ ] (b) No [ ]

37. What do you consider as the consequences of desertification as applicable to your household among the followings:

Consequences	**Yes** **No**
Reduced crop yield	( ) ( )
Low income from farm produce	( ) ( )
Declining soil fertility	( ) ( )
Conflicts between farmers and pastoralists	( ) ( )
Loss of livestock	( ) ( )
Inadequate water for irrigation	( ) ( )
Extinction of flora and fauna species	( ) ( )

38. If there are others not mentioned in (37) above, please list them……
……

39. How would you generally rate the degree of your household's vulnerability to desertification? (a) severe [ ] (b) moderate [ ] (c) low [ ]

Section E: Information on household adaptation Strategies

40. Do you believe that desertification effects could be reduced through adaptation measures? (a) yes [ ] (b) no [ ]
41. Have you been adopting certain coping strategies? (a) yes [ ] (b) no [ ]
42. Please, kindly tick (in multiple) any of the under listed adaptation measures you have being adopting:

Adaptation measures	**Tick**
Intercropping	
Early planting	
Fertilizer/manure application	
Migration to cities	
Livelihood diversification	
Changing of crop varieties	
Planning drought tolerant crops	
Soil conservation techniques	
Increase use of irrigation	
Liquidating accumulated assets	
Mulching	
Afforestation	

43. Do you have other measures apart from those listed in (42) above? If yes, please mention

    ……

    …….

44. Do you have adequate control over these adaptation measures? (a) yes [ ] (b) no [ ]

45. What do you think can be done to enhance your adaptive capacity?.....

    .....

    .....

46. How can you describe your access to the following information:

Types of information	**Inaccessible**	**Inadequately accessible**	**Adequately accessible**
Early warning information			
Fertilizer supply			
Insecticide/pesticide			
Credit facilities			
Improved seed supply			
Off-farm employment			
Irrigation scheme			
Government afforestation programme			
Government disaster relief programmes			

47. In what ways has government help in reducing the menace of desertification in your area?

.....

.....

.....

Thanks.

Yahaya, O.Y.

APPENDIX II

Factor Analysis: Aggregated Data

Descriptive Statistics

	Mean	Std. Deviation	Analysis N
Sex of household head	0.38	.486	633
Age of household head	.97	.619	633
Farming status	0.88	.320	633
Household size	0.42	.730	633
Access to early warning information	0.39	.489	633
Access to fertilizer	0.47	.500	633
Livelihood diversification	0.29	.455	633
Early planting	0.58	.494	633
Migration to cities	0.06	.239	633
Access to credit facilities	0.44	..497	633
Access to improved seed varieties	0.17	.373	633
Accumulated assets	0.31	.464	633

Correlations Analysis

	Sex of household head	Age of household head	Farming status	Household size	Access to early warning information	Access to fertilizer	Livelihood diversification	Early planting	Migration to cities	Access to credit	Improved seed varieties	Accumulated assets
Sex of household Head	1.000	-.034	.076	-.179	.057	.204	.078	-.155	.077	-.139	.022	.209
Age of household head	-0.34	1.000	-.035	.015	-.001	-.024	-.047	-.012	.230	.004	-.019	.068
Farming status	0.76	-.035	1.000	.042	.147	.096	.054	.103	.008	-.003	.080	.006
Household size	-1.79	.015	.042	1.000	.094	-.203	-.097	.288	.001	.364	.168	-.246
Access to early warning information	0.057	-.001	.147	.094	1.000	.061	-.025	-.012	.015	.089	.098	.063
Access to fertilizer	0.204	-.024	.096	-.203	.061	1.000	.219	.034	.111	-.224	.064	.266
Livelihood diversification	0.078	-.047	.054	-.097	-.025	.219	1.000	-.117	.102	.214	.036	.387
Early planting	-.155	-.012	.103	.288	-.012	.034	-.117	1.000	.051	.383	.080	-.242
Migration to cities	0.077	.230	.008	.001	.015	.111	.102	.051	1.000	.017	.174	.175
Access to credit	-1.139	.004	-.003	.364	.089	-.224	-.214	.383	.017	1.000	.157	-.294
Improved seed varieties	0.022	-.019	.080	.168	.098	.064	.036	.080	.174	.157	1.000	.050
Accumulated asssets	0.209	.068	.006	-.246	.063	.266	.387	-.242	.175	-.294	.050	1.000

**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2 tailed).

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.664
Bartlett's Test of Sphericity	Approx. Chi-Square	669.855
	Df	66
	Sig.	.000

Communalities

	Initial	Extraction
Sex of household head	1.000	.816
Age of household head	1.000	.704
Farming status	1.000	.417
Household size	1.000	.361
Access to early warning information	1.000	.413
Access to fertilizer	1.000	.240
Livelihood diversification	1.000	.270
Early planting	1.000	.840
Migration to cities	1.000	.815
Access to credit	1.000	.743
Improved seed varieties	1.000	.600
Accumulated assets	1.000	.986

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigen values			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.341	19.509	19.509	2.341	19.509	19.509	1.910	15.918	15.918
2	1.555	12.960	32.470	1.555	12.961	32.470	1.732	14.433	30.351
3	1.234	10.280	42.749	1.234	10.279	42.749	1.279	10.662	41.013
4	1.040	8.644	51.414	1.040	8.665	51.414	1.248	10.401	51.414
5	.976	8.133	59.547						
6	.925	7.704	67.251						
7	.827	6.893	74.145						
8	.772	6.432	80.577						
9	.684	5.699	86.275						
10	.622	5.186	91.462						
11	.534	4.450	95.912						
12	.491	4.088	100.000						

Extraction Method: Principal Component Analysis.

Rotated Component Matrix

	Component			
	1	2	3	4
Sex of household head	-.324	.215	.047	.448
Age of household head	-.082	-.179	.785	-.050
Farming status	.170	.153	-.183	.559
Household size	.655	-.210	.037	.043
Access to early warning information	.030	-.143	.087	.772
Access to fertilizer	-.067	.640	-.040	.196
Livelihood diversification	-.065	.728	-.022	-.112
Early planting	.734	.033	-.086	-.075
Migration to cities	.162	.299	.707	.010
Access to credit	.671	-.316	.054	.054
Improved seed varieties	.444	.268	.206	.250
Accumulated assets	-.345	.602	.253	.109

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.