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Farmers' perceptions and adaptation strategies to rainfall variability in northwestern Katsina State, Nigeria

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The research examined farmers' perception and adaptation strategies to rainfall variability in north-western Katsina. The objectives were to determine the level of rainfall variability using 1976 to 2015 rainfall data; find-out farmers' perceptions of rainfall variability; determine its effects on farming activities, and identify adaptation strategies within the farming systems. Rainfall data were sourced and established (Rainfall Variability Index, RVI of 1.6) to support the farmers' perception of very high variability. Some 385 questionnaires were administered to sampled farmers using Krejcie and Morgan's (1970) from nine selected wards. SPSS (16.0) was used to analyze the results. Findings indicated main adaptation strategies to rainfall variability employed were mixed cropping; use of early maturing crops; irrigation and *Fadama* farming against rain-fed agriculture; use of chemical fertilizers; reducing land-area of production; abandonment of agricultural activities or; selling of assets. It was concluded that rainfall characteristics negatively affect crop yields and the adaptation strategies have positive contributions to production. It is recommended that farmers should adapt efficient water harvesting techniques; planting of drought-resistant and early-maturing crops as well as dry-planting. Government, on the other hand, should intensify on small irrigation schemes, promote agricultural extension services, and invest in soil-water conservation.

Key words: Farmers' perceptions, adaptation strategies, rainfall variability, Northwestern Katsina.

INTRODUCTION

Africa is generally acknowledged to be a continent vulnerable to climate change in form of rainfall variability and temperature. West Africa is one of the most vulnerable to the vagaries of the climate, as the scope of the impacts of climate variability over the last three or four decades has shown (IPCC, 2007). Recent food crises in countries such as Nigeria are reminders of the continuing vulnerability of the region to the vicissitudes of climatic (especially rainfall) conditions. This is in large measure due to weak institutional capacity, limited engagement in environmental and adaptation issues, and a lack of validation of local knowledge (Spore, 2008). Adverse impacts of rainfall variability in Nigeria and other developing nations include frequent drought, increased rural-urban migration, increased biodiversity loss and the spread of infectious diseases and changing livelihood systems (Mustapha et al., 2012). In this context, the impact of rainfall variability on agriculture is an issue of great concern and significance to the lives and livelihoods of millions of poor people in Nigeria who depend on agriculture for food and livelihoods (Deressa and Hassan, 2009). The impact on agriculture could result in problems

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with food security and might threaten the livelihood activities upon which much of the population depends. This is because of the zone's fragile economy, weal resilience and low adaptive capacity. Most of the economy of the state in this zone is dependent on climate-sensitive resources such as rainfall. For example, the agriculture and fishing sectors employ up to 72% of the work force in Katsina State (Ibrahim and Abdullahi, 2015).

An understanding of global climate and its change is a pre-requisite to taking appropriate initiatives to combat climate change in terms of rainfall variability. Adaptation requires that farmers first notice that the rainfall has changed, farmers then need to identify potentially useful adaptations and implement them. Adaptation refers to all the responses to rainfall variability that may be used to reduce vulnerability (Deressa and Hassan, 2009). Perceiving climate variability is the first step in the process of adapting agriculture to climate change (Deressa et al., 2011). Adaptation requires the influence of multiple players from sectors such as research and policy, agricultural extension services and private welfare organizations. This realization makes it necessary to undertake a study to determine the ability of farmers to perceive and adapt to rainfall variability in the Northwestern part of Katsina state. An analysis of adaptation options and constraints to adaptation is important for the agricultural communities in this part of Katsina state, an area, highly dependent on agriculture for economic survival and at the same time highly prone to rainfall variability that has adverse effects on agriculture.

Aim and objectives

The aim of this study is to assess the perception of farmers and their adaptation strategies to rainfall variability in the 3 Local Government Areas of Jibia, Kaita and Katsina, North-western Katsina state, Nigeria. These were achieved through the following objectives:

1. Determining the level of rainfall variability in the study area using 1976 to 2015 rainfall data;
2. Finding out farmers' perception of rainfall variability in the study area;
3. Determining the effects of rainfall variability on farming activities in the study area and;
4. Determining the farmers' adaptation strategies in curtailing the effects of rainfall variability in the study area.

Study area

Location

The study area (Jibia, Kaita and Katsina LGAs) is by Niger Republic to the North, Zamfara State to the West, Batsari, Batagarawa and Rimi LGAs to the South and Mashi LGA to the East. It is located between Latitude 12º 59' North and Longitude 7º 36' East. It has a total land mass of 142 km^2 (Figure 1).

Population

Katsina state has a population of five million eight hundred and one thousand, five hundred and eighty four (5,801,584) people (FGN, 2009). The total population of the selected Local Governments is 667,972 (NPopC, 2006 census) and a projected population of 901,600 as at 2019.

Climate

Katsina state is classified into two zones climatically: The tropical continental and semi-continental. The north of Katsina state (from around Kankia to the extreme North-East has total rainfall figures ranging from 600 to 700 mm per annum. Generally, rainfall varies considerably according to months and seasons. There is cool dry (Hamattan) season from December to February, a hot dry season from March to May, a warm wet season from June to September, and a less marked season after rains during the months of October to November which is characterized by a decreasing rainfall and gradual lowering temperature (Umar, 2014).

For successful agricultural activity, which is the mainstay of the economy of the area, rainfall is one of the most critical climatic factor and, a strong direct correlation between rainfall and drought occurrence is deeply entrenched. The variability of climatic elements such as rainfall and temperature is an important factor in determining crop yields and food production (Umar, 2014). Rainfall and temperature determine seed germination and healthy plant growth that result in bumper harvests. The area, like other areas neighboring it, experiences temperature and rainfall variability as a result of global warming that brings about changes in global climate conditions (Rafindadi, 2011).

Topography and drainage

The study area forms part of the extensive Hausa Plains known as the High Plains of Hausa Land. These plains lie at a lower base level than other parts of the state. The southwards of this area are flat to gently undulating surface which is the end result of years of erosion action on the surface rock (Tasi'u, 2011). The major draining rivers in the northern part of the state are Koza, Sabke, Tagwai and Gada, all flowing north-west wards and drain towards the northern end.

These river/drainage systems hold water in their

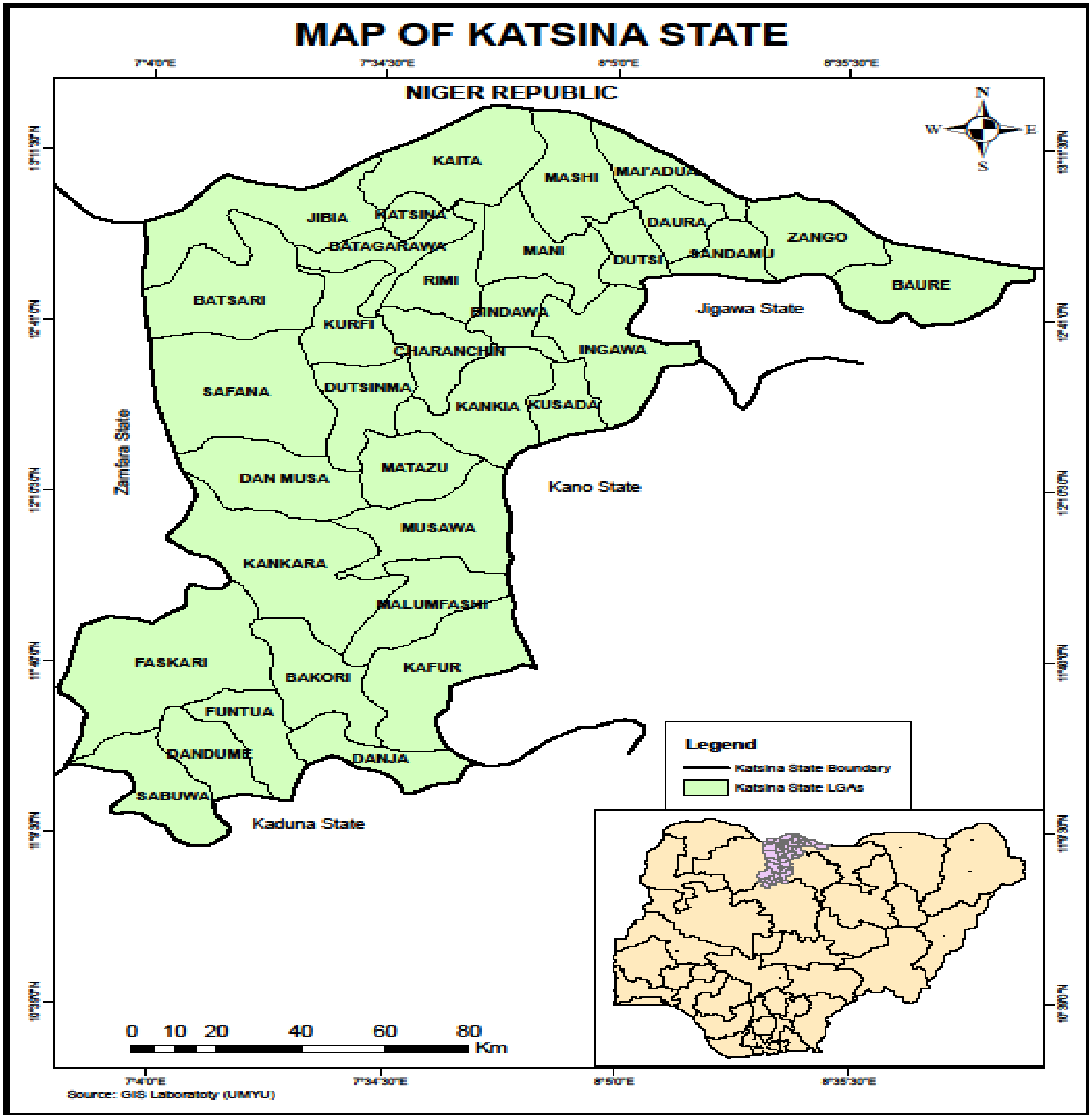

Figure 1. Katsina State and the study area.
Source: UMYU GIS LAB (2017).

channels only during the rainy seasons and have little or no water during dry seasons. Of these rivers/drainages, Gada and Sabke have been dammed mainly for irrigation purposes and the dams are Jibia and Daberam dams (Ibrahim and Abdullahi, 2015).

Geology and soils

The geological formation of the state is of the basement complex origin in the south, and sedimentary formation in the north, giving rise to the clay, loamy and sandy soils in the south and north respectively. The underlying rocks in the state are overlain by sandy drift deposits laid down during the last arid phase, about twelve thousand years ago.

In the study area, the drift deposits are coarse, resulting in light sandy soils of reddish color with low to medium fertility. These soils are easily worked and well situated for crops such as millet and groundnut which are less demanding in their water and nutrient requirements than cotton, maize and guinea corn which are grown in

Table 1. Some common trees found in the study area.

English name	Vernacular name	Scientific name
African Ebony	Kanya	*Diospyeros mispiliformis*
Baobab	Kuka	*Adansonia digitata*
Deleb Palm	Giginya	*Borassus aethiopium*
Dum Palm	Goriba	*Hyphaene thebaica*
Locus Bean	Dorowa	*Parkia biglobosa*
Mango	Mangwaro	*Mangifera indica*
Neem	Bedi	*Azadirachta indica*
Winter Thorn	Gawo	*Faidhabia albida*

Source: Authors' Field Work, 2019.

the southern part of the state (Umar, 2014).

Vegetation

Katsina state consists largely of shrubs and vegetation with some woody savanna in the south. The study area belongs to the Sudan Savannah zone while the southern part belongs to the Northern Guinea Savannah zone. The vegetation in the study area consists of trees that grow long tap roots and thick barks which make it possible for them to withstand long dry seasons and bush fires. The grass cover has durable roots that remain underground after the stalks were burnt away or wilted in the dry season, only to germinate with the first rain.

The vegetation is further characterized by sparse bushes, open grasslands and few natural forests that support the growth of a variety of trees and shrubs, some of which seeds and fruits are edible, the leaves serve as fodder, the fiber and trunks as firewood and many are of medicinal value (Umar, 2014). Some of the commonest farmland trees found in the study area are indicated in Table 1.

Socio-economic activities

Agricultural production reflects the ecological zonation of the state where there are about two million hectares of arable land, out of which 1.6 million hectares are under cultivation. Katsina state is bestowed with many livestock, consisting of one million cattle, 2.5 million sheep and goats and 600,000 horses and donkeys which are at present above the carrying capacity of the range lands (Ibrahim and Rumah, 2014). The state forest estates comprising of 96 forest resources, 244 communal forest areas over 2000 ha of forest plantation belt/wood lots cover 10% (2,420 km^2) of the total land area of the state (Ibrahim and Rumah, 2014).

The study area is also exemplary in irrigation in response to successive governments' efforts in revolutionizing agricultural activities in the state. Its location in the arid zone makes it vulnerable to deforestation of the environment due to persistent tree felling, overgrazing, desertification and over-irrigation practices. This has greatly affected the socio-economic life of the inhabitants and impacted population pressure and human activities which, coupled with non-adherence to existing legislation against land degradation problems, posed serious threats to humans and livestock in the entire state (Hamza, 2015; Ibrahim and Maiwada, 2014). The area is also blessed with abundant mineral resources that could be tapped for industrial growth. Prominent amongst these include Lead, Iron oxide, Gold, Iron ore, Manganese, Kaolin, Silica sands, Fire clay, Asbestos, Feldspars, Mica, Serpentine, Gemstones and Precious stones that are being mined and produced into various products (Umar, 2014). The economy of the state is basically agrarian with a cultivable 2.4 million hectares of land out of which 1.6 million is under cultivation, leaving a land area of 800,000 hectares, equivalent to one third of the total cultivable land available for investment. The state also has over 61 water bodies suitable for irrigation farming with a capacity of 1121 M^3 (Ibrahim and Abdullahi, 2015).

MATERIALS AND METHODS

Data sources

Primary and secondary data were generated. The primary data include the observed and derived parameters of rainfall variability that determine the vulnerability level of the rural households. The secondary data include the use of relevant literatures and maps. Specifically, rainfall data were collected from the Nigeria Meteorological Agency (NiMet) Abuja for the period of 40 years (1976 to 2015). From these records, rainfall variability was established scientifically to support or oppose the perceptive views of the farmers.

Field survey for generating primary data was complemented with questionnaires to obtain salient information to determine the farmers' vulnerability to the effects of rainfall variability.

Assessment of rainfall variability

Data collected was analyzed via descriptive statistics to determine the rainfall variability. Correlation analysis was used to determine

Table 2. Selected political wards for the study.

Jibia	Kaita	Katsina
Gurbin Baure/ Mallamawa	Abdallawa	Shinkafi 'B'
Faru	Kaita	Wakilin Kudu 2
Jibia 'B'	Yanhoho	Wakilin Yamma 1

Source: Authors' Field Work, 2019.

the relationships between farmers' perception of rainfall variability and adaptation methods used by farmers.

Index (Measures) of rainfall variability

Rainfall variability was assessed by using the index of rainfall variability used in climatological studies, thus (Ayoade, 1988):

$$\frac{90\% - 10\%}{50\%} \quad (1)$$

The index of rainfall variability used in climatological studies makes use of the 10, 50 and 90 percentiles.

The values of this index are interpreted as follows; More than 1.75: Extreme variability; 1.50 to 1.75: Very high variability; 1.25 to 1.50: High variability; 1.00 to 1.25: Moderately-high variability; 0.75 to 1.00: Moderate variability; 0.50 to 0.75: Moderately-low variability; Less than 0.50: Low variability.

The index depicted is very suitable for quantifying the degree of variability in rainfall data from less humid areas that are not normally distributed (Ayoade, 1988).

The three precipitation indices were derived from rainfall data for each year. These were analyzed alongside the total annual rainfall and subjected to descriptive statistical techniques of mean and standard deviation. Inferential statistical techniques of correlation and regression analyses were also employed.

Analyses of farmer's perception on rainfall variability

The farmers' responses on the administered instruments were extracted and analyzed using SPSS 18.0 Software. This is to find out the extent to which rainfall variability affect agriculture in the study area.

Determining the effects of rainfall variability

To determine the effects of rainfall variability, the farmer's responses from the administered instruments were analyzed using SPSS 18.0 Software.

Analyses of local adaptive strategies

The responses from the instruments were analyzed using SPSS 18.0 software and the results presented in Charts to ascertain the past and present traditional perception, adaptation strategies and expertise in the communities. Correlation analysis was used to analyze the relationship between farmer's perception of rainfall variability and their adaptation methods.

Regression analysis was employed because, according to Abaje et al. (2012) crop yields are affected by a wide range of factors and separation of the influence of one from the others can be extremely difficult or impossible. Thus, the practice of using the multiple regression techniques when subjecting farmer's perception adaptation methods, relationship to statistical analysis will be desirable. Therefore, in order to select the parameters that are critical to adaptation, a step-wise multiple regression analysis was adopted. The perception and adaptation methods of farmers were expressed as dependent variable (y) and rainfall variability indices as independent variables (x). The equation was thus (Ayoade, 1988):

$$Y = a + b1x1 + b2x2 + b3x3 + \ldots + bnxn \quad (2)$$

Where: Y = perception and adaptation methods of farmers; a = Constant; b = is the rise or falls as X changes; X1 = Total rainfall (mm); X2 = Number of dry spells between April and August (pentads with less than 2 mm of rainfall); X3 = Onset dates of rains; X4 = Hydrologic ratio.

Sampling methods

The three local government areas (Jibia, Kaita and Katsina) were purposively selected because of their high variability, since the rainfall generally moves from southern part of the state (and country in general) to the northern part. Rainfall therefore decreases towards the north where the study area is located. They also have similar rainfall characteristics with their rainy days ranging from 90 to 120 days. The responses of 382 farmers were considered as appropriate in assessing the rainfall variability in the areas.

Field sampling methods

Stratified random sampling method was used to divide the local government areas into stratum by using the political Wards in each local government area. Random sampling was used to further purposively select three (3) wards used for the study whereby each political ward has equal chance of being selected. The political wards randomly selected are three wards from each local government area (Table 2) making a total of nine (9) wards as shown in Table 1.

Population sampling

The total population of the selected Local Governments is 667,972 (NPC, 2006 census) and 901,600 people projected population (NPC, 2016). The samples taken as representative were selected following Morgan and Krejcie Table for determining sample sizes (S) in a given population (N). According to the Morgan and Krejcie Table, the sample size to be taken was 382 as depicted in Table 3. This number was divided among the Local Government Areas under study based on their population (percentage population) in order to avoid bias.

The instruments were further divided equally among the political wards and administered accordingly. For each local government

Table 3. Questionnaire administration per LGA.

Local government	Estimated population	No. of Instruments administered
Jibia	167,435	96
Kaita	182,405	104
Katsina	318,132	182
Total	667,972	382

Source: Authors' Field Work, 2019.

area, the instruments were administered within the three wards and the respondents were selected purposely based on their age (persons of 50 years and above who may recall the rainfall pattern/variability for about 40 years).

RESULTS AND DISCUSSION

Rainfall variability

Rainfall data from 1976 to 2015 were examined in order to scientifically establish variability occurrences in the area and perceptional views of the respondents. Variability may be said to prevail when rainfall varies from the annual average. The mean annual rainfall figure for the forty (40) years studied is 560.27 mm as obtained from the Nigerian Meteorological Agency (NiMet) Katsina Station No.1307.4.

Figure 2 shows the trend of the rainfall from 1976 to 2015 (40 years). There were pieces of evidence indicating that rainfall increased in 1979 and 1980 after a decrease in 1978 and again decreased from 1981 (554.8 mm) to 1985 (423 mm), increased above the average in 1986 before it dropped below the average in 1987 to 382.1mm. For nine years (1991 to 1999), rainfall fluctuates between values that were below the mean annual. From 2000 to 2015, the amount of rainfall increased above the annual average for all the years, with a standard deviation of 159.76 (except for 2009 and 2014 where it fell below the mean. The highest rainfall received was 1012.70 mm (2010) and the lowest was 259.80 mm (1996).

This result is in agreement with a number of models and the IPCC's Fourth Assessment Report (AR3) on Climate Change, that, Africa is at the highest risk of climate change, given the magnitude of existing stresses in the continent (IPCC, 2007). Thus, it is likely that in the coming years, sub-Saharan African countries including Nigeria, may witness changing rainfall pattern with more intense extreme events such as drought and floods. It is for this reason that in this study, rural households' levels of adaptation strategies were assessed.

Index of rainfall variability

Going by the rainfall data for the overall forty years under study, rainfall variability exist with a value of 1.6, which is a very high variability according to the rainfall variability index. This Index is very suitable for quantifying the degree of variability in rainfall data from less humid areas that are not normally distributed (Ayoade, 1988).

Vulnerability to rainfall variability

A household's vulnerability is a function of the household's exposure to the impacts of rainfall variability, and the livelihood assets available to the household, which provide the capacity to cope with, recover from and adapt to rainfall variability and its impacts. Variables used to characterize household exposure to rainfall variability include the episodes previously experienced by the households, receipt of rainfall information, use of drought resistant practices, and the existence of household rainfall variability and drought contingency plans. Previous exposure to rainfall variability could either increase vulnerability by depleting household assets or decrease vulnerability by increasing a household's knowledge about and adoption of rainfall variability practices. However, the more variable rainfall experienced by a household, the more vulnerable it is. Receipt of changing rainfall-related information, either in the form of seasonal forecasts and information about drought resilient crops and management practices coupled with the concomitant uses of drought resistant crop varieties and livestock breeds are expected to reduce vulnerability. Some households have rainfall variability contingency plans on increasing or decreasing rainfalls, and those that have, are less vulnerable than those that do not have.

Availability of rainfall variability information, including forecasts and information about rainfall variability resilient practices may be useful to households in reducing their exposures to the impacts. In this study, 79.5% of the respondents have experienced rainfall variability while 66.1% have access to rainfall forecast information as shown in Figure 3.

According to the data analyzed, rainfall variability manifests in three ways that is increase in rainfall, decrease in rainfall and both an increase and a decrease. 26.2% of those that experienced rainfall variability opined that there were increase in rainfall; 23.9% opined there were decrease; while 49.9% were of the view that there were both increases and decreases or fluctuations

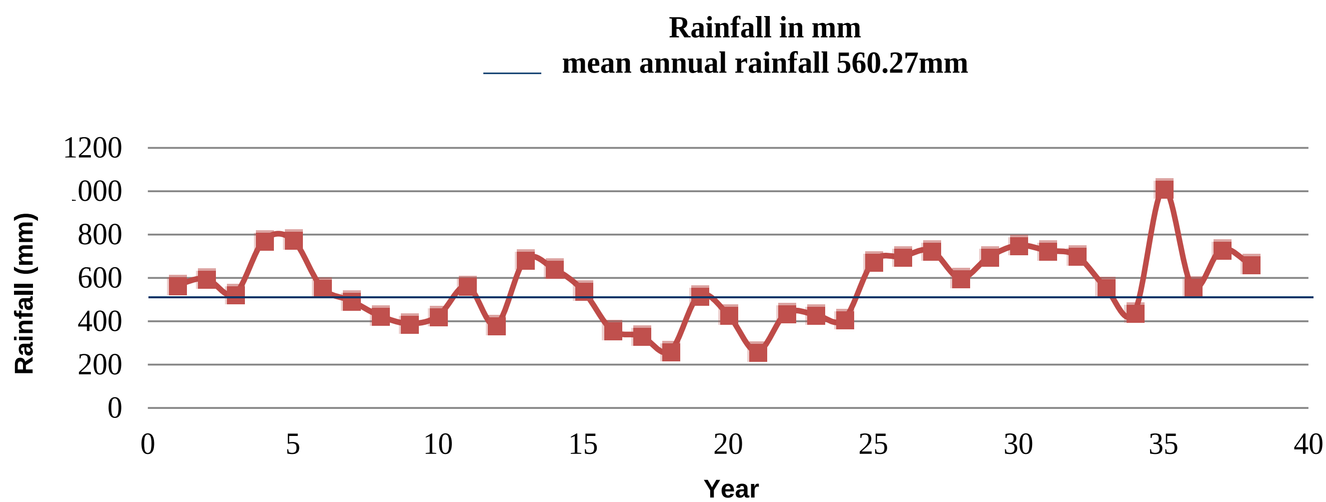

Figure 2. Amount of Rainfall within 40 Years (1976-2015).
Source: Author's Analysis of NiMet 40-years Rainfall data (2019).

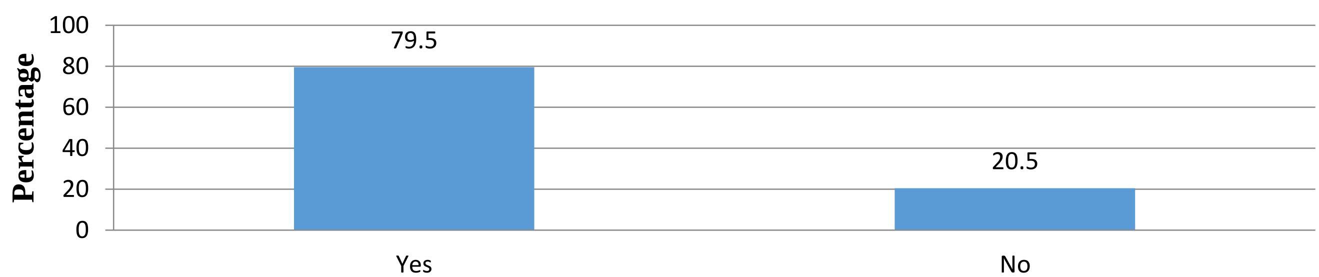

Figure 3. Experience on rainfall variability in the last forty years.
Source: Authors' Field Work, 2019.

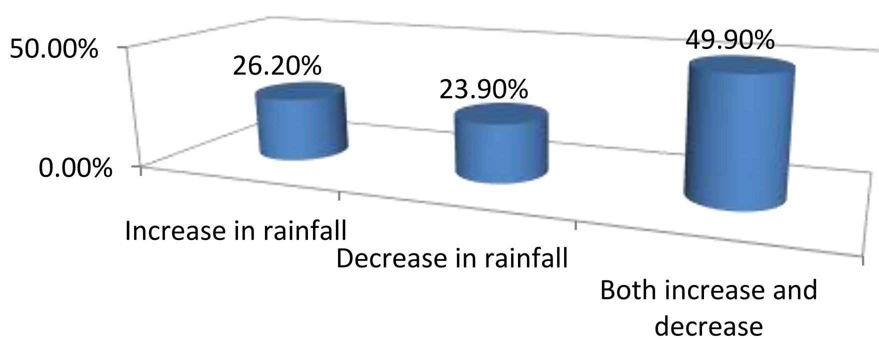

Figure 4. Manifestations of rainfall variability.
Source: Authors' Field Work, 2019.

(hence, variability) during the years under study as shown in Figure 4.

On whether the total amount of rainfall was on the increase yearly, 46% of the respondents agreed, 39% strongly agreed, while 2% strongly disagreed with the assertion. This is in agreement with the findings of Ati et al. (2007, 2009), Odekunle et al. (2008), Abaje et al. (2012), and Abaje et al. (2013) in which using recorded rainfall data observed that this zone is now experiencing wetter conditions in recent years.

Level of rainfall variability

According to the responses received in this study, the level of rainfall variability in the area was moderate as

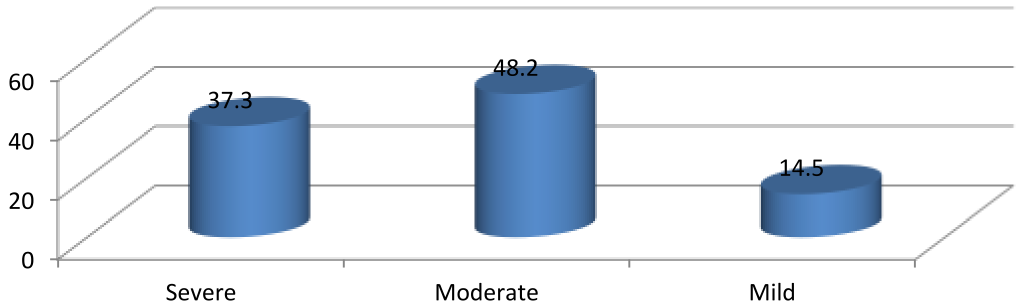

Figure 5. Responses on level of rainfall variability.
Source: Authors' Field Work, 2019.

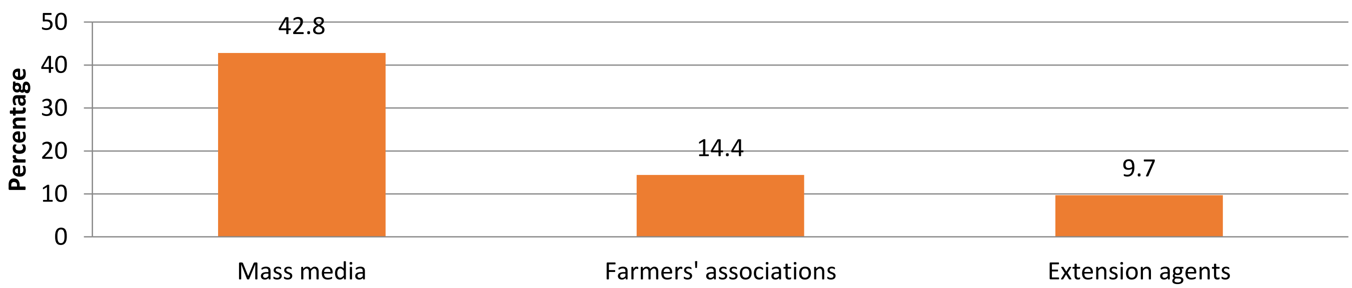

Figure 6. Sources of information on rainfall variability.
Source: Authors' Field Work, 2019.

opined by 48.2; 37.3% opined it was severe while 14.5% were of the view that it was mild as depicted in Figure 5.
Sources of rainfall information were mass media, farmers' associations and friends (Figure 6). More than 66.6% of the respondents regularly receive information on rainfall variability in the form of forecasts, while 33.4% do not have or did not receive information. Lack of information reduces the coping capacity to rainfall variability, hence, increasing the vulnerability to risks of rainfall variability. Respondents who receive forecast information got it from various sources, including radio, television, agricultural extension staff, traditional institutions and farmers' associations. Those who have access to the forecasts generally consider them reliable. However, often the information is not utilized due to language constraints, user unfriendliness and poor timeliness. Efforts are thus needed to make forecasts available to larger proportions of households, in local languages and in forms that are easily understood.

Within the last forty years, respondents have experienced extreme weather conditions (including floods and droughts) as a result of rainfall variability. 48.9% experienced flooding in their areas while 31.1% experienced drought as a result of rainfall variability; 6.7% said they experienced both drought and flooding; 86.0% experienced losses in agricultural productivity and 14.0% said they were not affected; 83.7% said their losses were on crops while 16.3% lost on livestock. This is line with the findings of Abaje et al. (2014) studies in Dutsin-ma Local Government Area of Katsina state that 83% of the people perceived that flood occurrences were increasing.

Livelihood diversification has become a well-accepted adaptation strategy in the Sahel. Households are less vulnerable to climatic stress if they have multiple sources of livelihood to fall back on in times of scarcity. This work obtained information from households regarding their non-agricultural income generation activities. The assumption was that the more the number of nonagricultural income-generating activities, and the more income generated from them, the less vulnerable a household.

Beside the expected increasing water deficit in the study area, evaporation from the surface water bodies would continue at the rate dictated by climatic conditions (Abaje et al., 2014). Consequently, water management steps must be taken to ameliorate the effects of these natural hazards. There is, therefore, the need to adopt methods that ensure optimum use of water with less wastage as well as embark on water resources management strategies that encourage conservation including sustainable dam construction, controlled ground water exploitation, rain harvesting, etc.

Impacts of rainfall variability

Other impacts include crop infestation as a result of

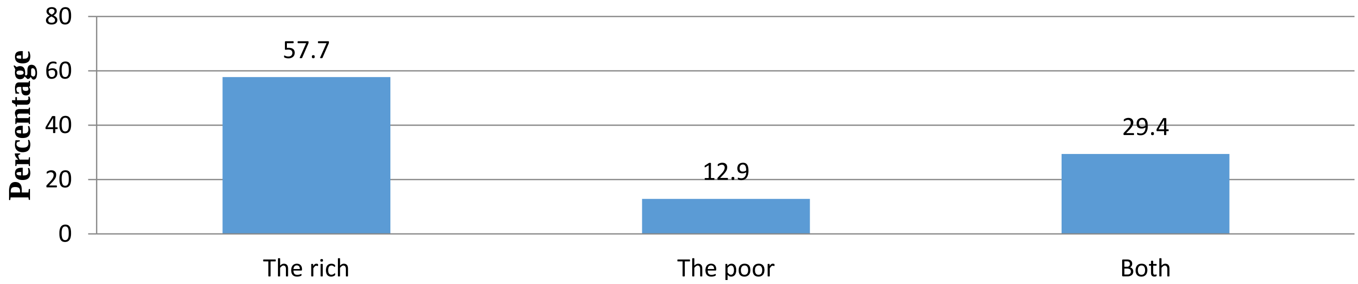

Figure 7. Category of people affected by rainfall variability.
Source: Authors' Field Work, 2019.

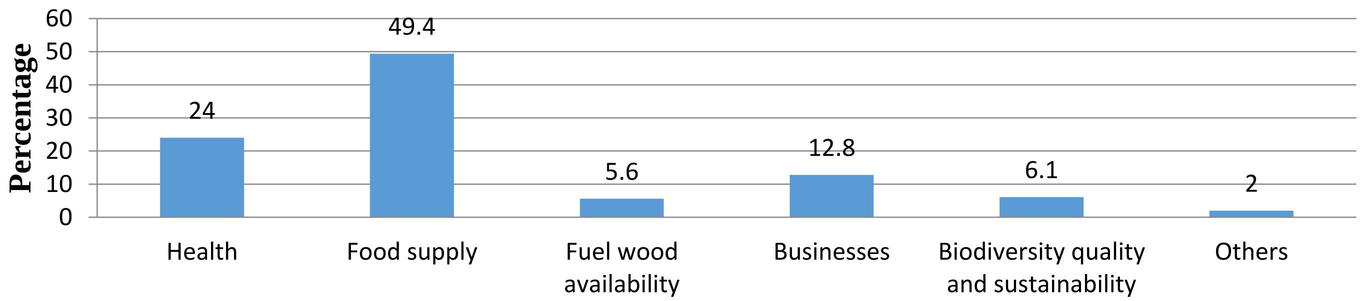

Figure 8. Impacts of rainfall variability.
Source: Authors' Field Work, 2019.

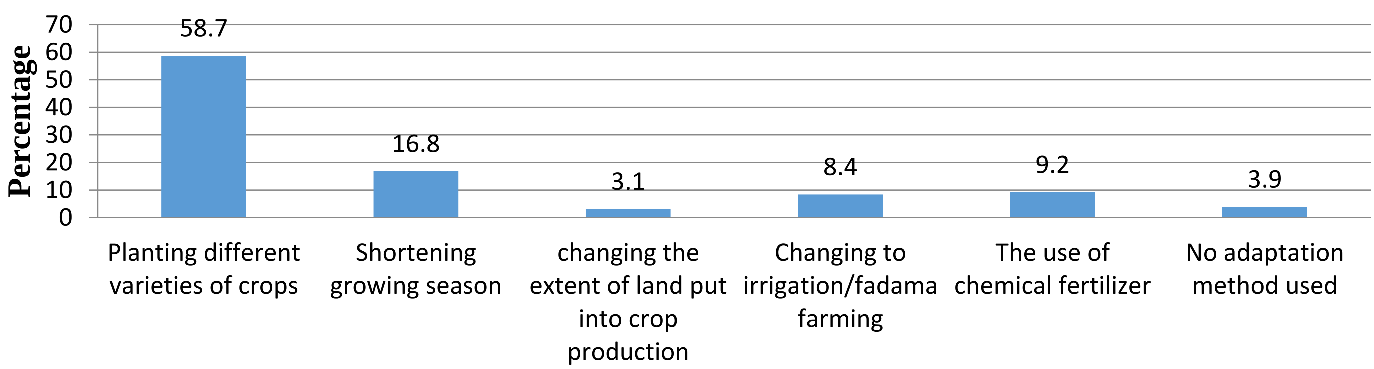

Figure 9. Strategies adopted by farmers on rainfall variability.
Source: Authors' Field Work, 2019.

rainfall variability, where, 78.6% of respondents affirmed that rainfall variability leads to crop infestation and diseases in the area; 16.7% opined that crop infestation does not occur due to rainfall variability, while 4.2% were indifferent. Costs of food crops also increase due to rainfall variability as suggested by 70.3% of the respondents. Other factors such as a decline in forest resources and changes in livelihood systems were also affected by the incidences of rainfall variability as agreed by 80 and 72.3% of the respondents respectively. Figure 7 reflects how various strata of respondents were affected, while Figure 8 depicts the major sectors affected by rainfall variability in the study area.

This result is in agreement with the findings of Bambale (2014) in which 46.8% of the sampled respondents in Katsina state agreed that climate change brought about changes in livelihoods, and that those most affected by rainfall variability are the poor people who have no option but to manage the little food they have and are in most cases compelled to migrate to the cities for paid

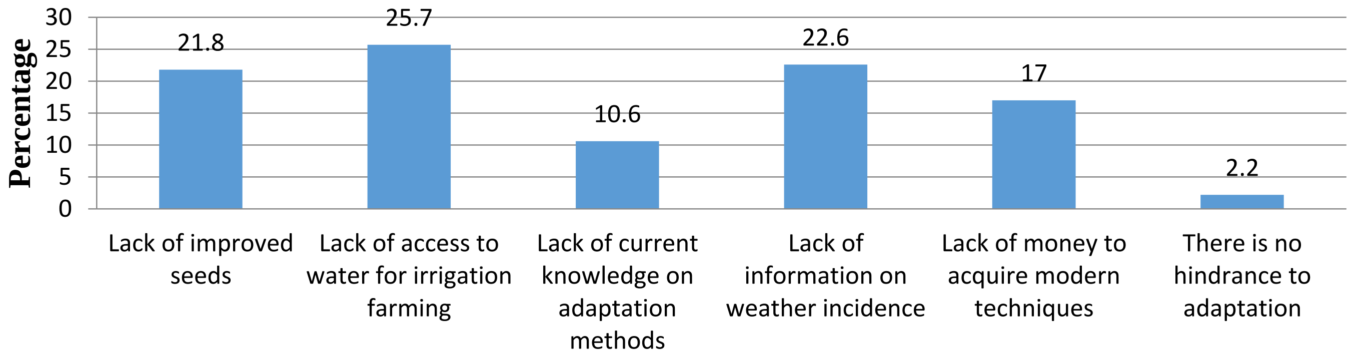

Figure10. Perceived hindrances to adaptation.
Source: Authors' Field Work, 2019.

employments to earn a living.

Adaptations and coping strategies employed

Adaptations are adjustments or interventions carried-out in order to manage losses or take advantage of the opportunities presented by a changing climate (IPCC, 2007). The goal of an adaptation measure is to increase the capacity of a system to survive external shocks or changes. An assessment of farm-level adoption strategies is important to provide information that can be used to formulate policies that would enhance adaptations as tools for managing variety of risks associated with climate change in agriculture.

Respondents in the study area adopt different techniques to ensure that household members access food following extreme weather events that decimate food production. As depicted in Figure 9, farmers adapt and cope by planting varying crops, shortening growing season, irrigation or *Fadama* farming practices, the use of chemical fertilizers, adjusting the extent of land put into crop production, switching to non-farming activities and in extreme cases, selling of assets.

Respondents have developed various long-term strategies to adapt and cope with both expected and unexpected rainfall variability. The strategies mainly relate to the local production systems and norms of the people within the surrounding environment. Some of these strategies include altering of the cultivation seasons, cultivation patterns, cultivation techniques and type of crops grown. These strategies were generally intended to reduce the expected risks of rainfall variability on the production systems and life in general.

The main strategy during severe rainfall variability was switching to off-farm activities. Few livestock farmers opt for off-farm activities compared to crop producers, because, they sell their animals to buy foods from the food markets. Many people worked as casual laborers for payments of either cash or food. Carpentry and brick making were prevalent especially in developed centers, because, they were in higher demands than in far interiors.

The study found out that farmers grow early maturing crop varieties. These varieties have been effective for seasons with short rains. Some farmers grow maize varieties that mature within 70 to 90 days. Other farming practices include precise timing of farm operations, planting high yielding varieties, use of manures, crop rotation and manual irrigation.

Hindrances to adaptation

Adaptation strategies are hindered by poor supplies of improved seeds, water shortages for irrigation, unreliable information and limited capital. Nearly 22% of respondents in this study indicate their hindrance to adaptation as limitation of improved seeds. About 26% mentioned shortages of water for irrigation; 10.6% limitation of current knowledge on adaptation strategies; 22.6% limited reliable information on weather incidences; 17% limited capital to acquire modern techniques while only 2.2% had no hindrances to adaptation as indicated in Figure 10.

Summary

This study aimed at assessing the farmers' perception and adaptation strategies to rainfall variability in North-western Katsina state using primary and secondary data. Instruments were administered to assess respondents' awareness of rainfall variability, socio-economic implications and adaptation strategies to rainfall variability. The level of rainfall variability was severe as opined by 37.3% of the respondents; 46% of the respondents agreed that annual rainfall is on the increase.

Conclusion

Farmers in the study area use varying techniques in ensuring that households get food following extreme weather events that decimate food production. As revealed from the findings of this study, farmers adapt and cope by planting varying crops, shortening growing seasons, adopting irrigation or *Fadama* farming against rain-fed, use of chemical fertilizers, reducing land sizes put to production, abandoning agricultural activities or, in extreme cases, selling off assets. The study also found out that farmers adopt early maturing crop varieties for short duration rainy seasons, some of the farmers grow maize varieties that take as short as 70 to 90 days to mature. Other farming practices adopted include proper timing of farm operations, planting of high yielding varieties, use of manures and chemical fertilizers and crop rotation.

Recommendations

Recommendations based on the findings of this study are that:

1. Farmers should learn to adopt water harvesting techniques of constructing ridges or tie ridges with a series of small basins as a useful technology for the collection and storage of rainwater in dry areas.
2. Farmers should also adopt a simple technique of cross-ridging to collect water for increased yields, especially when the rainfall is available, as well as adopt agro-forestry. This is because of the roles of trees in improving microclimate, reducing soil erosion and generating income in the advent of rainfall variability.
3. there is a need for agricultural extension agents, policy makers and researchers to get farmers to effectively adapt to climatic situations. This may be effectively achieved via the provision of timely information on early warning signals as well as improved farmer education on awareness of the vagaries of the climate and effective adaptation processes to be employed by farmers.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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