Factors influencing households' vulnerability to desertification in rural communities of Northern Katsina, Nigeria

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Abstract

Rural livelihood and economic development in northern Nigeria has been characterised by the devastating effects of desertification. This paper provides an avenue to examine the peculiar factors influencing vulnerability to desertification among farm households of rural communities in desertification prone areas of Katsina State. Data was 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 chosen for the study. The research instruments used were questionnaire, key informant interview and focus group discussion. Findings revealed that 93% of the respondents were from male-headed farm households, 71% were above 45 years of age and 80% have no basic primary education. Millet was the most important crop grown and 73% were full time farmers. The main perceived causes of desertification are climate change, deforestation, acts of God and environmental mismanagement. Effects of desertification were manifested in declining crop yields, loss of farmlands as well as the extinction of flora and fauna species. The factors influencing vulnerability of farm households to desertification were the ages of household heads, farming status, size of the households, access to non-farm income, migration and improved seed varieties ($p < 0.05$). The study, therefore, recommended the need to promote adult education, increase access to improved seed varieties and farm input, encourage livelihood diversification, intensified efforts towards effective management of environmental resources, and the involvement of vulnerable groups in the formulation and implementation of policies aimed at combating desertification.

Keywords: Desertification; farm households; livelihood; vulnerability

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Received on December 31st, 2020/ Accepted on September 28th, 2021/ Published online on December 19, 2021

Ghana Journal of Geography Vol. 13 (3), 2021 pages 1-21

Doi: https://dx.doi.org/10.4314/gjg.v13i3.1

Introduction

The concept 'vulnerability' has become a central issue in a variety of hazards and risk-related researches including but not limited to food security, sustainability studies, climate change and desertification. Vulnerability represents the physical, economic, social susceptibility or tendency of a community to damage in the case of threatening circumstances of natural or anthropogenic origin (Emrich & Cutter, 2011). In the words of Deressa et al. (2008), the term vulnerability connotes the degree or extent to which a system or host is prone to harm due to exposure to a perturbation or stress, and the ability of the exposed unit to cope, recover, or fundamentally adapt. It is an internal risk factor of a system that is exposed to a hazard and corresponds to its intrinsic tendency to be affected, or susceptible to damage. It is however the nature and rate of exposure, sensitivity and adaptive capacity of people that defines their vulnerability to any form of hazard.

Vulnerability to desertification has been a key issue in dryland region because desertification processes such as soil erosion, secondary salinization, and over grazing have negatively impacted provisioning ecosystem services in drylands, particularly food and fodder production (Majeed & Muhammed, 2019). Although desertification may have acquired a number of contradictory definitions, it generally represents all forms and levels of land degradation occurring in drylands. The most accepted definition of it in literature 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, 2015; UNCCD, 2016). Desertification is generally considered a serious threat to the environment, human health, income generating activities and food security especially of the drylands (United Nations Economic and Social Council, 2007; Moussa et al. 2016).

In Nigeria, there is a consensus that desertification poses one of the greatest environmental challenges and constitutes a major barrier towards meeting basic human needs in the dryland parts of the country, especially among the rural populace (Okoye & Ezeonyejiaku, 2010; Emodi, 2013; Olagunju, 2015). The problem of desertification in Nigeria has a very long history for it was recognised as a problem during the British Colonial Government in the early 1930s when it was revealed that the Sahara was expanding and encroaching into the Sudan Savannah at a rate that would only increase if the trend is not checked. Thereafter in 1977, Food and Agricultural Organization (FAO), World Meteorological Organisation (WMO) and United Nations Educational, Scientific and Cultural Organisation (UNESCO) (as cited in Oladipo, 1993) reported that about 15% (or 140,000 km^2) of the total land cover of Nigeria was prone to severe desertification. Millennium Ecosystem Assessment clearly emphasised that as a result of desertification, persistent reductions in the capacity of ecosystems to provide services such as food, water, and other necessities, are leading to a major decline in the well-being of people living in drylands (Adeel et al., 2005). The argument in support of this is that desertification influences productivity, biodiversity and food security negatively.

In the words of Reynolds (2001), rural populations are the world's most vulnerable populations to desertification. While it is recognised that rural populations are the most vulnerable to desertification, rural farm households are considered the most important households at risk among the natural resource-dependent categories vulnerable to desertification. The rural populations of Katsina State as in any other desertification frontline state depend on drylands ecosystem for farming and aree likely to be vulnerable to the menace of desertification. When people are exp osed to hazards such as desertification occurring in northern Nigeria, it is usually their limited or lack of capacity to cope that makes them become vulnerable. Adaptation was

seen as a viable option in reducing the vulnerability associated with the anticipated negative impacts of environmental hazards. Adaptation forms an essential component of any policy response to desertification. It will likely play a key role in reducing vulnerability and give room for multiple opportunities to be realised.

Evidence abound in literature that people of northern Nigeria have responded in multiple ways to reduce the effects of the hazard of desertification among which are cross-ridging to conserve water, planting of early maturing and drought resistant crop varieties, intercropping, dry planting, liquidating accumulated assets such as livestock, and migration into the cities as discussed in Mortimore, Gashua and NEST's study (as cited in Oladipo (1993), Yahaya and Ishiak (2014)). Despite this, recent vulnerability study by Yahaya (2021) revealed that most of the farm households of northern Katsina were vulnerable to desertification. This, therefore, necessitates the need to examine the specific factors influencing vulnerability to desertification among the households of the affected areas. With this, strategic interventions that can increase the resilience of the rural small farm holders can be identified and used to develop comprehensive adaptation measures.

Study Area

Katsina State lies between latitudes 11º 07/ N and 13º 22/ N and longitudes 6º 52/ E and 9º 20/ E. The State is bounded to the east by Kano and Jigawa State, Kaduna State to the south, Zamfara State to the west and Niger Republic to the north (Figure 1). The focus of this study is on the northern fringe of Katsina state where the incidence of desertification is more pronounced. The local government areas that are more susceptible to desertification as shown in figure 1 are located between latitudes 12.4º and 13.2ºN and longitude 6.5º and 9.2^0 in the semi-arid region of the State. They are Baure, Jibia, Kaita, Mai'adua, Mashi, and Zango local government areas. They are situated on the arid zone of the Sahel Savannah agro-ecological belt of Katsina State with a semi-arid continental climate having average annual rainfall ranging from 600mm to 700mm or less in some local governments areas. The raining season lasts for 5 months with a long dry season of 7 months. The temperature of the area is high especially at the peak of dry season when temperature reaches from about 38^0C - 40^0C and sometimes above this figure. The climate of the zone supports mostly Savanna Vegetation and Sudan Savanna is particularly found in northern Katsina with shrubs and scarce vegetation cover. The tree species in the area are those with deep tap roots that are able to withstand the long dry season. They include *Acacia nilotica, Parkia biglobosa, Feidherbia albida* and *Adansonia digitata.* The main perennial ecological problems of Katsina State are desertification, drought, and soil erosion. These are experienced mostly in the northern part of the State. These areas have been grappling with the challenge of desertification every year leading to soil erosion and disruption of the ecosystem (Adamu, 2000).

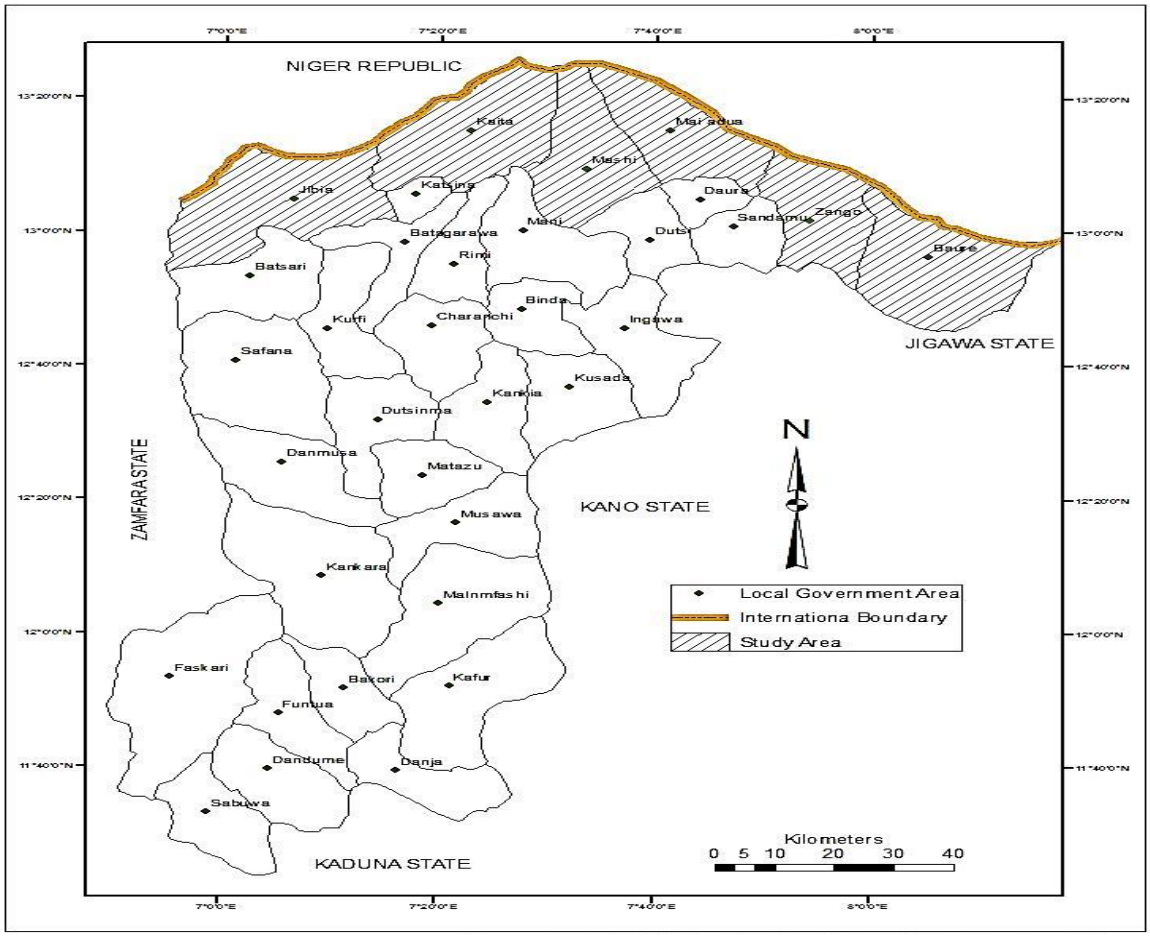

Figure 1: Location of the Study Area within Katsina State
Source: Author's Creation from Katsina State Administrative Map, 2019

Katsina State is predominantly rural with a great majority of Hausa-Fulani speaking people and 70 percent of its population lives in rural areas. The 2006 population census put the population of Katsina State at 5,792,578 with a total land mass of 24.192km^2. There are 244 communal forest areas out of which 80% are being threatened with extinction by desertification, drought and human activities. Agriculture is the main economic activity of the people of the study area and their agricultural practice is largely rain fed. The soil of the area contains drift deposits which are coarser, resulting in light sandy soils of buff or reddish colours of low fertility. They are marginal for efficient arable crop production. Millet and sorghum are the main food crops grown while the predominant crop mixtures are sorghum/millet/cowpea or groundnut. Livestock

production is also widespread in the area as it is known for large production of cattle, goats, sheep, horses, donkeys, and camel (Katsina State Ministry of Environment, 2002).

Material and Methods

A multi-stage sampling procedure was employed to select the respondents for the study. This involved identification of areas that were susceptible to desertification in Katsina State which were 8 Local Government Areas (LGAs). However, 6 LGAs known for the perennial ecological problems of desertification were chosen. They were Baure, Jibia, Kaita, Mashi, Mai'adua, and Zango LGAs. Consequently, a systematic purposive sampling was used to select 3 desertification-prone rural farming settlements from each LGA to come up with a sum of eighteen (18) communities across the 6 LGAs (see Table 1). Research instruments used include a structured questionnaire, key informant interview and focus group discussion to gather the necessary information from the farm households in each of the selected communities. Key informant interview was held with key members of the community such as chairmen of community based organizations and village heads in the selected communities while focus group discussion was used for heads of farmers' association, community opinion leaders, and settlers of various ethnic groups. The household was selected as the main unit of analysis because major decisions about adaptation to livelihood processes are taken at that level as emphasized by Thomas (2008). The sample households, though selected randomly, were proportional to population size of each community making sure that at least 10 percent of households from each of the eighteen (18) selected communities were sampled to come up with a total of six hundred and thirty-three (633) respondents for this study (see Table 1).

Table 1: Distribution of Respondents in Selected Communities of the Study Area

L.G.A	Selected Communities	Total Population	Number of Respondents (Sample size)
JIBIA	Dan Aro	338	33
	Madachi	365	36
	Kaura	327	32
ZANGO	Yardaje	381	38
	Kanda	374	37
	Dargage	352	35
KAITA	Dankama	347	34
	Abdallawa	322	32
	Yandaki	367	36
MASHI	Gurje	362	36
	Tsamiya Makada	373	37
	Zabaro	345	34
BAURE	Mai Bara	322	32
	Dadin Sarki	364	36
	Bukudu	343	34
MAI' ADUA	Bum- Bum	387	38
	Gwajo- Gwajo	378	37
	Dogon Hawa	366	36
Total	18	6,413	633

Source: Author's compilation, 2019

Vulnerability has always been studied as a composite of adaptive capacity, sensitivity and exposure to hazards. As such, 21 variables of measurement of these three components of vulnerability were selected. Table 2 shows the variables that were selected for each components as well as the description of the elements that was taken into consideration in measuring the variables. Tobit Model was then used to determine the factors influencing households' vulnerability to desertification because it has the advantage to determine both the strength of the independent variables and changes in the value of the dependent variable. Tobit Model has been

used in several studies such as Bamire et al. (2002), Ojiako, et al. (2007) and Idrisa et al. (2012). The formula was given as:

$\mu_i = \beta_0 + \beta_1 X_1 + \ldots\ldots\ldots \beta n Xn$, where μ_i is the observed dependent variable i.e. vulnerability to desertification of i^{th} household; β_0 is the intercept; $\beta_1 \ldots$ βn are the coefficient of the independent variables; $X_{1\ldots\ldots}Xn$ are the independent variables/explanatory variables (socio-economic characteristics of households and adaptation strategies).

Table 2: Components and Variables of Measurement of Vulnerability

Component of vulnerability	Variables	Description of the variables
Exposure (biophysical)	Rainfall	Change in annual rainfall
	Temperature	Experiencing increase
	Drought	Frequency of drought
	Wind	Noticed unusual change
Sensitivity (socio-economic)	Sex of household	% of Male/Female headed Household
	Age of household	Below and Above 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	Accessibility to information
	Experiences in the area	Number of years of experience
Adaptive capacity	Fertilizer supply	Access to fertilizer use
	Livelihood diversification	Accessibility to non- farm income
	Early planting	% engage in early planting
	Insecticide/pesticide	% of population with accessibility
	Migration	Movement to cities
	Credit access	% of population having access
	Improved seed varieties	% of population having access
	Accumulated assets	Ownership of assets

Source: Author's compilation, 2019.

Results and Discussion

The results of the findings on socioeconomic characteristics of the farm households as shown in Table 3 reveal that 93% of the households are headed by males. Majority are grown up adults of above 45 years of age with an average household size of 10 persons. Going by educational qualification, 64% of them have no basic primary education and that majority attended Quranic School. The major occupation is farming in which 72% are full time farmers. The findings indicate that the area is dominated by male-headed households which reflect the cultural household hierarchy in Katsina State where females becoming heads of households is very rare; this is only made possible by the death of the husband. By implication, men of the study area bear the brunt of desertification by headship more than women. Furthermore, majority have no formal education with relatively more dependants. They are fully involved in the production of grains such as millet, sorghum, groundnut and cowpea with millet cultivation having the most important land use in the area. Based on this finding, it is clear that majority of the households heavily depend on farming as their source of income and there is little likelihood of diversified income sources.

Table 3: Socio-economic Characteristics of Respondents

Socio-economic characteristics	Items	Frequency	Percentage
Sex	Male	589	93
	Female	44	7
	Total	633	100
Age	18- 26	32	5.1
	27- 35	148	23.4
	36-45	275	43.4
	46-65	142	22.5
	Above 65	36	5.7
	Total	633	100
Educational Qualification	No formal education	122	19.2
	Quranic education	285	45
	Primary education	86	13.6
	Secondary education	82	13
	Tertiary education	58	9.2
	Total	633	100
Size of Household	1 – 10	497	78.5
	11 – 20	122	19.3
	Above 20	14	2.2
	Total	633	100
Farming Status	Full Time	461	72.8
	Part Time	172	27.2
	Total	633	100

Source: Author's Field Work, 2019

Respondents' Perception of Desertification

Table 4 shows data on household's perceived causes of desertification and respondents were offered multiple causes to pick from. The multiple response choices were then ranked in ascending order of importance. Climate change was perceived by 73% of the respondents and this makes it to be ranked as the first most important among other causes in the study area. This was attributed to persistent insufficient and unreliable annual precipitation experienced over the years. Respondents' perception about climate change being one of the major causes of desertification in the study area concurred with previous studies (Nasiru, 2007; Odjugo 2010; Medugu & Majid, 2014) that attributed it to inherent extreme variability of climate as manifested

in severe and prolonged drought events in northern Nigeria. Other perceived causes of desertification among the respondents were deforestation, environmental mismanagement (e.g. bush burning, over cultivation, uneconomic agricultural practices etc) overgrazing and an act of God. Deforestation is a serious issue in the area as pointed out here and emphasised by Mohammed et al (2013) that Katsina State has its over 90% energy from fuel wood. Consequently, the demand for fuel wood caused 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). The perception of respondents on environmental mismanagement in this finding was in line with Oladipo's assertion (1993) 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 which had accelerated the desertification process.

Furthermore, about 65% of the respondents perceived desertification as an act of God which had been destined to affect their land. This option ranked third and was perceived by more than half of the respondents as a cause of desertification. This showed that it was 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 influenced them to believe that desertification could not have happened if not destined by God while the relative role of climate, droughts and human impacts only helped in the process. The findings in general affirmed that desertification in northern Nigeria is a result of a complex inter-relationship between social and natural systems.

Table 4: Respondents' Perceived causes of Desertification

Perceived Causes	Frequency	Percentage	Rank
Climate Change	465	73.2	1
Deforestation	454	71.7	2
An Act of God	413	65.2	3
Environmental	407	64.3	4
Mismanagement	157	24.8	5
Overgrazing			

Source: Author's Field Work, 2019

*Multiple responses resulted in a total percentage ≠ 100%

Consequences of Desertification

Limited ground water available for use was identified as the first important consequences of desertification in the area followed by low income from farm produce, declining crop yields, extinction of flora and fauna species, among others. The results agreed with studies such as those Katsina State Ministry of Environment (2002), Nasiru (2007) and Yahaya & Malik (2019) which similarly observed some of these factors to be the main effect or consequence of desertification in the study area in particular and northern Nigeria in general.

Focus group discussion and interview sessions 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 1) and other economic activities of the people.

Plate 1: Soil desiccation/soil parches preventing land tillage for crop production

Plate 2: Sand dunes rendering vast areas of farmlands unproductive in Gwajo-Gwajo community of Mai'Adua LGA

Desertification has also resulted to soil desiccation (see Plate 2). Because of the dry spells and inadequate rainfall of the area, soil compaction occurs forming soil parches that become difficult to till for crop production. Soil desiccation is one of the major consequences of desertification which has reduced agricultural output. Other effects include conversion of productive land to marginal land, households' farm lost to desertification, and extensive waste farmland – all of which have become useless for crop production (see Plate 3). Also, many economic and medicinal trees appeared to have been lost to desertification.

Plate 3: Unproductive farmland caused by desertification on Bum-Bum community in Mai'adua LGA

Factors Influencing Households Vulnerability to Desertification

The results of the Tobit analysis for the variables influencing households' vulnerability are presented in Table 5.

Table 5: Tobit Estimates of Factors Influencing Households Vulnerability

Variables	**Coefficient**	**SE**	**Z**	**P value**
Rainfall	-0.1254	0.5226	-0.2397	0.8106
Temperature	-0.0413	0.2174	-0.1892	0.3501
Drought	-0.2124	0.6268	-0.3388	0.7351
Wind	-0.2463	0.3356	-0.7337	0.2636
Sex of household	-1.3838	0.2302	-6.6047	0.0601
Age of household	1.5716	0.2704	5.8107	0.0001*
Farming status	2.1435	0.2638	8.1213	0.0021*
Educational level	-0.1756	0.2683	-0.6535	0.1411
Farm holding size	-1.8786	0.3413	-5.5021	0.0601
Household size	2.2153	0.2652	8.3585	0.0002*
Crop production	0.5667	0.3715	1.5114	0.1317
Early warning information	-1.0171	0.2536	-4.0118	0.0711
Experiences in the area	-0.6184	0.399	-1.5505	0.1221
Fertilizer supply	-1.0896	0.4268	-2.5529	0.0712
Livelihood diversification	2.3333	0.2715	8.5948	0.0001*
Early planting	-1.0896	0.4288	-2.5527	0.0611
Insecticide/pesticide	-0.2694	0.2161	-1.2478	0.2133
Migration	1.2985	0.2424	5.3754	0.0003*
Credit access	-1. 1825	0.2706	-4.3753	0.0751
Improved seed varieties	3.3877	0.3508	9.663	0.0031*
Accumulated assets	-1.0719	0.2238	-4.7908	0.1211

*statistically significant level at 5%

Source: Author's Data Analysis, 2019

The results showed that the age of the household head (p value of 0.0001) was statistically significant at 5% and had a significant influence on households' vulnerability. It was an important variable in determining how vulnerable a household could be. This might be because households headed by youths or persons below 45 years of age have the tendency to migrate to cities and towns in search of complementary sources of income in order to support their families against adverse effects of desertification. The socio-economic characteristics of the respondents revealed that

majority of the households were headed by people of above 45 years with a relatively limited tendency to leave home. By implication, this has contributed more to their being vulnerable compared to younger persons. Farming status of the household was also found to be a significant variable ($p < 0.05$) determining how vulnerable a household could be. This could be attributed to the fact that majority of the sampled respondents are full-time farmers who derive their means of subsistence from seasonal crop production system in the face of increasing climate variability and human impacts. This, therefore, means that farm households largely bear the brunt of negative impacts of extreme climate events like drought and desertification. Households that are part-time farmers with other means of livelihood are more likely to be less vulnerable compared to full-time farmers who depend solely on farming for survival.

Household size with p value < 0.05 was equally observed to be a significant determinant of households' vulnerability to desertification. The average household size of the area was 10 persons indicating relatively large dependants. It follows that households with more dependants will use a larger proportion of the household resources for feeding. This, therefore, means that the more dependants a household has, the more the likelihood of its vulnerability since a larger proportion of household resources are directed on dependants who may not contribute much towards household welfare.

Similarly, the results showed that livelihood diversification (accessibility to non-farm employments) was observed to have a higher coefficient value and was 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 complementary sources of income. This implies that the greater the level of household reliance on natural resources, such as seasonal crop

farming, the greater their likelihood of vulnerability to desertification especially with limited capacity to cope under increasing climate variability. This is partly because crop production in the study area is largely dependent on rainfall (rain fed) characterised by unpredictability and unreliability.

The results further showed that migration (household mobility) and improved seed varieties with p value of 0.0003 and 0.0031 respectively were also observed to be significant in determining households' vulnerability to desertification. This might be because household heads that were younger and had no impediment to movements could easily migrate to towns and other areas in search of non-agricultural income sources. Similarly, households with access to improved seed varieties were more likely to change to better varieties and were more likely to experience reduced vulnerability level. It could be inferred from the results that the variables which were statistically significant at 5% and had significant influences on households' vulnerability were age of the household head, farming status, household size (number of dependants), livelihood diversification (non-farm income), migration to cities, and improved seed varieties. This implies that these variables contribute more to vulnerability of the households and as such be given proper attention.

Conclusion and Recommendations

Desertification is no doubt one of the perennial ecological problems bedeviling some areas in Katsina State with devastating impacts on rural communities that depended on climate-sensitive livelihood strategies. A combination of several indicators of vulnerability determined the rate of individual household vulnerability to desertification based on the level of exposure, sensitivity and accessibility to adaptive capacity. It was however their limited capacity to manage natural resources

upon which their livelihood depended, particularly under changing climatic conditions, that made them more vulnerable. Hence, this study established that the determinants of households' vulnerability were age of household head, farming status, household size (number of dependants), livelihood diversification (non-farm income), migration to cities, and improved seed varieties. There is, therefore, the need to address these issues in order to get the households exposed to desertification to resist, absorb, accommodate and recover from the hazards in a timely and efficient manner.

Based on this, the study recommended that government agencies and commission saddled with the responsibilities for combating desertification at the local, state and national levels should incorporate household-based intervention into the strategic plans and actions so as to rescue the vulnerable communities. Such interventions included but are not limited to, empowering elderly men, creating employment opportunities in and out of agriculture on a self-sustaining basis, controlling fertility rate, increasing access to improved seed varieties and farm input, and effective management of environmental resources. This becomes necessary because these factors are found to be the main determinants influencing household vulnerability to desertification in the area. Similarly, Participatory Rural Appraisal (PRA) approach should be considered at the centre of policy formulation and implementation. 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 reducing vulnerability and ensure sustainability of rural livelihoods.

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