LEVELS AND DRIVERS OF VULNERABILITY TO CLIMATE CHANGE BY IFAD-VCDP FARMERS IN NORTH CENTRAL NIGERIA

***Sallawu, H., Oha, E., Barnabas, C., Oyebisi, K. L., Oyelami, S. O., Mohammed. U. S., Coker, A. A. A. and Nmadu, J. N.**

[1]Department of Agricultural Economics and Farm Management, Federal University of Technology, Minna, Nigeria.

*Corresponding author: Email: halima.sallawu@futminna.edu.ng +2348034532845

Abstract

Although a number of studies have been carried out on climate change but the levels of vulnerability of farmers and factors affecting vulnerability of the farmers to this topical issue have not been sufficiently determined in the study area, giving rise to this study. The study was conducted in Benue and Niger States involving 483 IFAD-VCDP farmers. A total of 500 questionnaires were distributed, however only 96.6% were completed and returned. As such the data analysis was based on 483 farmers under International Fund for Agricultural Development (IFAD) – Value Chain Development Programme (VCDP) from 10 participating Local Government of the two States. Both primary and secondary data were utilized for this study. The primary data were collected via questionnaire administered by trained enumerators, while the secondary data were collected from Food and Agriculture Organization (FAO) and Nigerian Meteorological Agency (NIMET). The data were analysed using descriptive statistics, vulnerability index and Beta regression model. The farmers were aware of eighteen climate change variables with assorted levels of occurrences. There was moderate vulnerable to climate change in the study area necessitating the need of enhanced awareness and capacity building to upgrade their home-grown adaptation strategies. Poverty status (3.0) was found to increase vulnerability while adaptive capacity (-23.8), age (-0.1), education (-0.7), gender (-2.8), distance to market (-0.1), livestock ownership (-0.4), social amenities (-1.9), total livelihood activities (-2.4) and membership of association (-3.8) decreased vulnerability by the percentages indicated in parenthesis. The study therefore recommended that the level of literacy among farm households and availability of social amenities should be critical issues when formulating climate adaptation policies and developmental issues. Government and NGOs should install processes that can enhance the adaptive capacity of the farmers.

Keywords: North Central Nigeria, IFAD-VCDP, Climate change, Vulnerability index, Adaptive capacity.

Introduction

The VCDP is a six-year development initiative of the Federal Government of Nigeria (FGN) and International Fund for Agricultural Development (IFAD) that is aimed at improving and addressing the constraints along the cassava and rice value chains for smallholder farmers in the six states of Anambra, Benue, Ebonyi, Niger, Ogun and Taraba. VCDP is well anchored in Nigeria government's vision for agricultural transformation through commodity value chain approach, with emphasis on productivity enhancement and markets access for rice and cassava smallholder farmers. The programme takes a holistic and demand-driven approach to addressing constraints along the cassava and rice value chains. It does so through an inclusive strategy, strengthening the capacity of actors along the chain including producers and processors as well as public and private institutions, service providers, policy-makers and regulators. At the same time, the programme strongly emphasizes the development of commodity-specific Value Chain Action Plans at the local government level, which serve as the basis for rolling out sustainable activities to reduce poverty and accelerate economic growth. The objectives of the programme is to sustainably enhance rural incomes and food security. The target groups include 15,000 smallholder farming households, 1,680 processors and 800 traders (VCDP, 2016).

Climate change and development connect in an iterative style. Climate change weakness and effects impact possibilities for advancement, and thus, improvement decisions and choices impact a nation or region's future ability to adjust (Bizikova *et al*., 2007). The antagonistic impacts of climate change are now clear in developing nations like Nigeria where population growth, food insecurity, and other socioeconomic factors exacerbate families' vulnerability to impacts. In the available literature, climate changes have been seen to have at any rate had three fundamental effects on the country poor and their occupations: Increasing environmental risks, reducing livelihoods opportunities and in consequence stressing existing social institutions (Intergovernmental Panel on Climate change (IPCC), 2007). In addition to other things, climate change and the decrease in ecological assets brought about by anthropogenic and different components have had the joined impact of making many households vulnerable. In that capacity, households in certain parts of the world, for example those in developing world, have to depend on their capacity to adjust to life under the states of declining availability of natural resource and a consistently evolving climate change.

Adaptation to climate change is defined by IPCC (2014) as human systems in response to actual or expected climatic stimuli or their effects, which moderates harm change, either in anticipation of (proactive adaptation) or in in reaction to (reactive adaptation) external processes of change. While there are numerous angles that determine adaptive capacity at different levels, adaptive capacity is understood to be existence of preconditions that a vulnerable entity (individual, community, society, an institution, a system-natural or social or a country) possesses in creating ability and a base from which it can adjust itself (execute adaptation interventions) in response to a stimulus (Ozor *et al*., 2010). Furthermore, much as this is the overall comprehension of the idea, it is important to take note of that preconditions for determining adaptive capacity certainly vary, contingent upon numerous variables including time, space, level of the vulnerable entity as well as intensity of the stimuli or hazard. For example, there are required various preconditions to be accessible at the national level contrasted with the household level (Berrang-portage *et al*., 2011). Notwithstanding, the essential preconditions incorporate accessibility of sufficient monetary assets, the degree to which the entity is organized, institutional equity in terms of resources distribution, levels of knowledge, awareness, information access and sharing as well as availability of appropriate technologies options, such as appropriate early warning systems (IPCC, 2014).

Africa, despite everything, encounters and is undermined by presence of various socio-economic stresses which may interact with climate change impacts to increases vulnerability and reduce adaptive capacity. These contribute and intensify the effects of current climate change in Africa, and having negative effects on the continent's ability to cope with climate change. Such stresses include rampant poverty, various political, ethnic and economic conflicts, ignorance, lack of skills, low level of technological advancement, weak institutional capacity, limited infrastructure, lack of technology, lack of information, and poor access to resources by majority (Conway and Schipper, 2011). The vulnerability of developing countries like Nigeria especially the North Central region is worsened by heavy reliance on renewable natural resources for livelihoods, employment and incomes. Climate change is and will interact with every one of these factors to additionally keep the region at an elevated level in terms of vulnerability at the same time eroding its little capacity to adapt.

Climate change likewise has direct antagonistic consequences for humankind (particularly poor people) by restricting the plausible monetary exercises in various geological regions occupied by individuals thereby perpetrating reduced livelihood opportunities (IPCC, 2014). The way that the practices and livelihood pattern of rural households often impact negatively on their immediate natural environment and the regional/global climatic patterns cannot be denied. For most rural households, disturbances in farming frequently lead to critical misfortunes or significant losses of income and decreased standard of living or even neediness. Poverty (low degrees of living) has been connected to a low ability to adapt to ecological pressure and climatic changes (Defiesta and Rapera, 2014).

Climate change is a serious challenge to human livelihoods especially in the developing world because it increases food insecurity, accelerates health risks like spread of malaria and other diseases related to disasters such as cholera and it builds water shortage just as builds plausibility of contentions over assets

among social groups (IPCC, 2014). FAO (2016) revealed that under climate change, the food system is vulnerable because it affects the four main components of food security, namely food availability, food accessibility, food utilization and food system stability.

Climatic changes are occurring with regards to other formative burdens, strikingly neediness, fluctuating oil prices, and food insecurity as well as in combination with environmental change, drought and land degradation. This makes it basic to create and actualize effective adaptation measures so that climate-related risks and opportunities might support local development objectives (IPCC, 2007). There is therefore, the need to gadget all fundamental way to diminish the effect of climate change on the welfare of farmers. However, the knowledge of level of vulnerability and factors that affects vulnerability to climate change could likewise upgrade strategy towards handling the difficulties climate change is imposing on Nigeria farmers. The result of this investigation will enable the design of appropriate interventions, and researchers will also find the body of literature useful in their quest to extend frontiers of knowledge. The aim of this study is to describe the awareness and frequency of occurrence of the various climate change variables experienced by the farmers, estimate the level of vulnerability of the farm households to climate change and analyze the factors affecting vulnerability to climate change in the study area.

Theoretical Framework:
This study adopted the social constructivist framework. The social constructivist framework is applied to analyse who is most vulnerable, and why. According to this framework, vulnerability denotes the socioeconomic response capacity of individuals and groups to a variety of stressors. With a focus on natural hazards. Dow (1992) defines vulnerability as the differential capacity of groups and individuals to deal with hazards, based on their positions within physical and social worlds. While Blaikie *et al*. (1994) perceived vulnerability as the capacity of a person or group to anticipate, cope with, resist, and recover from the impact of a natural hazard. In a broader view, Adger and Kelly (1999) defined vulnerability as the state of individuals, groups or communities in terms of their ability to cope with and adapt to any external stress placed on their livelihoods and well-being. The social constructivist framework, which is rooted primarily in political economy, prevails in the poverty and development literature. Its vulnerability definition refers exclusively to people, and it is based on an explanatory model of socioeconomic vulnerability to a range of stresses and consequences. This framework also looks at vulnerability as conceived by IPCC (2001); IPCC (2007) which is operationalized on a household level. The IPCC framework identifies three dimensions of vulnerability namely: exposure to climate change induced shocks or hazards, sensitivity to climate change induced shocks or hazards and adaptive capacity that is, the capacity to adapt to or mitigate the effects of climate change induced shocks or hazards. The framework seeks to identify which determinants have the greatest impact on household vulnerability. This study therefore adopted IPCC (2014) which defines vulnerability as a function of exposure, sensitivity, and adaptive capacity. These three components are the key factors in determining a system's vulnerability to climate change and provide useful information for assessing and reducing climatic threats. *Exposure:* Climate exposure indicators include temperature rise, heavy rain, drought, and sea level rise. The IPCC predicts that the impact of global warming will continue as the probability of severe heat waves, heavy rain, drought, tropical depression and sea level rise increases over time (Parry *et al*., 2005). *Sensitivity:* The degree of a system's sensitivity to climatic hazards depends not only on geographic conditions but also socio-economic factors such as population and infrastructure. Indicators of sensitivity can encompass geographical conditions, land use, demographic characteristics, and industrial structure such as dependency on agriculture and extent of industrial diversification. *Adaptive capacity*: Adaptive capacity describes the ability of a system to cope with climatic extremes. Generally speaking, adaptive capacity to climate change depends on physical resources, access to technology and information, varieties of infrastructure, institutional capability, and the distribution of resources. Indicators for adaptive capacity compose economic capability, physical infrastructure, social capital, institutional capacity, and data availability. Economic capability represents the economic resources available to reduce climate change vulnerability. It includes human resources, technological alternatives and social capital (Yohe and Tol, 2005).

The anticipated outcomes of environmental variability and climate change are diverse (Stern, 2009).

Among them, projections propose that before the end of the 21st century, they will have generous effect on agricultural production and consequently the scope of reducing poverty in sub-Saharan Africa, where most of the populace live in rural areas and depend on smallholder agriculture for their livelihood (Slater *et al*., 2007). The vulnerability of small-scale agriculture to climate variability and change is caused by the inherent climate and weather-sensitivity of agricultural livelihoods and the chronic poverty that torment the segment. It is projected that crop yield in Africa Nigeria inclusive may fall by 10 to 20 per cent by 2050 or even up to 50 per cent due to climate change Rahman (2014), especially on the grounds that Africa's agriculture is predominantly rain-fed and hence fundamentally dependent on a very basic level reliant on the caprices of climate. As individuals of Africa endeavour to overcome poverty and advance economic growth, this marvel takes steps to extend vulnerability, erode hard-won grains and seriously undermine prospects for development (Ozor *et al*., 2010).

Methodology

The study was conducted in North Central Nigeria. The States that make up the North Central zone are Benue, Kogi, Kwara, Nasarawa Niger, Plateau and Federal Capital Abuja. Central Nigeria covers a total land area of 242,425km^2 and lies between Latitude 4^0 and 14^0 North and Longitudes 3^0 and 14^0 East. The area has a projected population of 27,937,252 as at 2019 based on the National Population Census (NPC) (2006) of 2.5% growth. This research used a combination of primary and secondary data to examine the contribution of a set of indicators categorized as extreme event, climatic variables, demography, vulnerable social group, land, agricultural productivity, economical capability, social capability, human resources capability and institutional capability. Multi-stage sampling technique was employed in the collection of primary data for this study. In the first stage, the two (2) participating States in North Central Nigeria under the IFAD - VCDP were selected. In the second stage, all the five (5) participating Local Government Areas (LGAs) in each State were selected, giving a total of ten (10) LGAs. In the third stage, sampling of farm households in each community were determined proportionately using Krejcie and Morgan (1970) formula and adopted by Ardakani *et al*. (2012).

$$S = \frac{X^2 NP(1-P)}{d^2(N-1)+X^2P(1-P)} \quad (1)$$

Where:
S = The required sample size
X^2 = Table value of chi-square for 1 degree of freedom at the desired confidence level (1.96)
N = Population size
P = Population proportion (assumed to be 0.80)
d^2 = Degree of accuracy expressed as a proportion (0.05)

The primary data were obtained through administration of structured questionnaire and interview schedule to elicit information from the respondents, on all the information needed. The questionnaires were administered by trained enumerators supervised by the team of researchers. The secondary data were obtained from Food and Agriculture Organization (FAO) (2019) and Nigerian Meteorological Agency (NIMET) (2019). The data were analysed using descriptive such as Likert type scale and normalization with the aid of Wickham (2016) in R. The normalisation was used to describe the level of awareness and frequency of occurrence of the various climate change variables experienced by the farmers. The level of vulnerability of the farmers to climate change were estimated using vulnerability index. The vulnerability index was calculated using three indicators, i.e., exposure, sensitivity and adaptive capacity with sub indicators presented in the Table 1. However, individual indexes rather than community or state-wide index were determined in this study. In all previous studies of vulnerability, only community or study-wide indexes were determined (Adger amd Kelly, 1999; Majahodvwa *et al*., 2013 and Jamshidi *et al*., 2018)

Factors affecting Vulnerability to Climate Change and Livelihood Change:
Factors affecting vulnerability to climate change and livelihood change were analysed using Beta regression. The explicit model is presented in eq. 2.

$$y = \beta_0 + \beta_1 AC + \beta_2 AGE + \beta_3 EHH + \beta_4 GEN + \beta_5 DFM + \beta_6 NFI + \beta_7 CRE + \beta_8 LSH + \beta_9 HHS + \beta_{10} PVS + \beta_{11} ASA + \beta_{12} LC + \beta_{13} MA + e \quad (2)$$

Where:

y = Vulnerability index;
AC = Adaptive capacity (score);
AGE = Age of household head (years);
EHH = Level of education (No. of years spent in school);
GEN = Gender of household head (Dummy variable: male =1, female = 0);
DFM = Distance of farm from main market (km);
NFI = Non-farm income (from off-farm employment) (₦);
CRE = Credit use by farm household (₦);
LSH = Livestock ownership by household (Tropical Livestock Unit);
HHS = Household size (Numbers);
PVS = Poverty status of the household head (poor = 1, non- poor = 0);
ASA = Availability of social amenities (Numbers);
CL = Livelihood change (Number of livelihood activities);
MA = Membership of association (Number of associations);
e = Error term;
β_0 = Intercept to be estimated and;
β_1 - β_{13} = coefficients to be estimated.

Results and Discussion

Climate change perceptions include the individuals' view and interpretation of the climate issue based on believes, experiences and understanding. Farmers must have believed in climate change for them to consider it as a threat to their livelihoods and then adapt and cope with the phenomenon (Dietz, 2015). The result of the awareness of climate change variables by IFAD farmers in North Central Nigeria are presented in Figures 1 - 3. The results in Figure 1 revealed that the farmers were mostly aware of increased/high temperature, soil erosion, soil infertility, high rainfall and disappearance of wildlife. The results further revealed that the level of awareness of all the climate change variables by the farmers is quite high as none of them was below the average normalized score. On the state basis, the result of awareness of IFAD farmers in Benue State in Figure 2 showed high level of awareness for fourteen of the climate change variables and low level of awareness for decreased sunshine hours, decreased in incident of flood, decreased/low temperature and decreased in incident of drought. Although the top five were the same with the combined results for the two states, the order are not the same. The result for Niger State in Figure 3 shows that the farmers expressed high level of awareness for all the eighteen climate change variables and the top five are the same with the combined results for the two states. These results agree with the findings of Garba (2018) who affirmed that the major significant changes of climate experienced by farmers in North Central Nigeria were increase in rainfall, increase in sunshine, disappearance of wildlife and increase in temperature.

The expressed frequency of occurrence of the various climate change variables by the respondents in North Central Nigeria are presented in Figures 4 - 6. The results revealed that soil infertility, disappearance of plant/vegetation, soil erosion, disappearance of wildlife and increased in incident of pest and diseases were the top five. On state basis, the results in Benue State (Figure 5) revealed that increased/high temperature, disappearance of plant/vegetation, disappearance of wildlife, increased sunshine hours, soil erosion and longer raining season were the top five. In Niger State (Figure 6), soil infertility, disappearance of plant/vegetation, soil erosion disappearance of wildlife and increased in

incident of pest and diseases were the top five. The results further revealed that frequency of occurrence of longer raining season, decreased sunshine hours, increased in incident of drought and decreased in incident of flood were very low in Niger State.

The level of vulnerability of the farm households to climate change is presented in Table 2. The combined results for the two states were classified into three groups according to the household vulnerability index. The first group with vulnerability value of less than 0.33 accounting for 13.87% were categorised as low vulnerability, which means that the households are vulnerable but still are able to cope with a number of external assistances. The second group with vulnerability value between 0.33 – 0.66 was categorised as moderately vulnerable. This group accounted for 50.73% and are the household that needs urgent but temporary external assistance to recover from climate change shock. Lastly, the third group, highly vulnerable households with values above 0.66 and accounted for 35.40%. They are household that are in serious situation but could be resuscitated through educational, financial, institutional and even political support to improve their adaptive capacity. This implies that a typical household in North Central Nigeria is moderately vulnerable to climate change and these households would need awareness and capacity building which could help fine tune and upgrade their already existing home-grown adaptation strategies.

Result of the Beta regression model on factors affecting vulnerability to climate change and marginal effects of the significant variables are presented in Table 3 and 4. Out of the 13 hypothesized explanatory variables in Beta regression model, 10 were found to be significant. The likelihood ratio test was significant ($p< 0.0000$) suggesting that the model had strong explanatory power. Adaptive capacity of the households was found to be negatively significant ($p<0.01$) with marginal effect of -0.238 implying that vulnerability is likely to decrease by 23.8% for a unit raise in in adaptive capacity of the farmers. Adaptive capacity makes it possible for the farmers to adjust to changing conditions in order to maintain or improve their well-being, it therefore means that the farmers under study are unable to utilise additional knowledge when it becomes available. Perhaps, their farm plans are not very flexible or the programme under which they are participating have not allowed them to use their own level of understanding of farming and farming practices. Meanwhile, the age of the household head is also negative ($p<0.1$) with marginal effect suggesting that an increase age of the household head would decrease vulnerability of the household by 0.1%. The possible reason for this that as the household head grows older, they tend to gain more experience to cope with the effect of climate change. This result is in accordance with the findings of Narayan and Sahu (2016) who revealed that older farmers are less vulnerable to climate change which may be due to their experience in farming. It therefore means that there must be a synergy between farm practices and package of operations and the ability of the farmer to adjust to changes for positive results. On the other hand, the effect of gender on vulnerability was negative ($p<.1$) implying that if there is a switch of the household head's gender then their vulnerability is likely to decrease by 2.8%. This is in concordance with the findings of Joshua (2018) who highlighted that climate change increases gender inequality (making women more vulnerable to the negative effects of climate change), reduces women's ability to be financially independent and has an overall negative impact on the social and political rights of women, especially in economies that are heavily based on agriculture.

The negative coefficient for level of education ($p<.01$) implies that as household head acquire more skills and education through various methods of training, the vulnerability would likely decrease by 0.7%. This is probably due to the facts that education tends to open up more opportunity through new technology and skills which increases the income generation activities of the household. This result is in agreement with the findings of Narayan and Sahu (2016) who affirmed that higher educational level of household head tends to less vulnerability to climate change shocks.

A one-kilometre increase in the distance to market caused a decrease in vulnerability by 0.1%. The possible reason for this is that accessing the market, no matter the distance, promotes the rural-urban linkages. This result is in line with the findings of Tun *et al*. (2018) who revealed that accessible markets are necessary not only for the agricultural inputs and sales of agricultural commodities but also for sharing of climate and market information among the farmers and brokers. In the same vein, acquiring

additional livestock decreased vulnerability by 0.4%. Farmers acquire livestock mainly as asset and store of value, which can be used as a coping strategy at the time of need, rather than indulging in livestock farming as agribusiness. The benefits of keeping some livestock also include the ability to generate off-farm income as well as a source of food. They also obtain manure and can use the animals for power. This result is in line with Inayatullah *et al*. (2012), who opined that educational level, age of household head, job experience of household head, number of employed members of household, index of livestock holding and per capita income of household affect vulnerability status of households.

A change in the poverty status of the household head was found to increase vulnerability by 3.0% implying that poor households are more vulnerable to the effects of climate change than non-poor households because they may lack the resources to adapt and cope with the phenomenon. This result is in accordance with the findings of Majahodvwa *et al*. (2013) who affirmed that factors that contribute to vulnerability include rapid population growth, poverty and hunger, poor health, low levels of education, fragile and hazardous location.

Coefficients of access to social amenities ($p<0.1$), total livelihood activities ($p<0.05$) and membership of association ($p<0.01$) were also found to decrease vulnerability. According to Deressa *et al*. (2009), fixed assets of farmers such as physical capital (agricultural machineries, agricultural infrastructure such as roads) are significant economic components that form local source of vulnerability. Furthermore, engaging in different livelihood activities serves as a coping strategy to the mitigate climate change effects. In addition, being a member of a farmer group or a commodity association would afford them to learn about certain adaptation strategies to climate change through their interaction with other members as highlighted by Adzawla *et al*. (2020) as they affirmed that farmers who are members of a farmer association have a higher probability of becoming less vulnerable to climate change.

Conclusion and Recommendations

This study found that farmers were aware of eighteen climate change variables with assorted levels of occurrences but they are moderately vulnerable to climate change. The households under study would need enhanced awareness and capacity building to upgrade their home-grown adaptation strategies. Adaptive capacity, age of the household head, level of education of the household head, gender of the household head, distance of farmer's home stead to the market, livestock ownership, poverty status of the household, access to social amenities, total livelihood activities and membership of association/cooperative were the factors affecting vulnerability to climate change. These complex and the inter-related factors needs a more coordinated policy strategies to ensure that the level of vulnerability is kept very low among the farmers. Particularly, farm households should diversify their sources of livelihood so as to reduce their vulnerability and improve resilience to climate change. Government and NGOs should assist in providing the enabling environment that makes it easy for the farmers to enhance their adaptive capacity, as such help fine tune and upgrade the existing local homegrown strategies. The level of literacy among farm households and availability of social amenities should be looked into when formulating climate change adaptation policies and developmental issues. This done tends reduce vulnerability to climate change. Finally, government and NGOs should help develop effective and responsive risk insurance programme with immediate claim payments so as to encourage greater investment.

Acknowledgement:
This study was conducted with a grant from funding support of TETFUND Institutional-Based Research Intervention (IBRI) FUND. Grant No. **TETFUND/FUTMINNA/2016-2017/6th BRP/08.**

Conflict of interest:
The authors have declared no conflict of interest.

References

Adger, W. N. and Kelly, M. (1999). Social vulnerability to climate change and the architecture of entitlements. *Mitigation and Adaptation Strategies for Global Change*, 4(1): 253–266.

Adzawla, W., Azumah, S. B., Anani, P. Y. and Donkoh, S. A. (2020). Analysis of farm households' perceived climate change impacts, vulnerability and resilience in Ghaza. *Scientific African*, 8(1), 1-10.

Ardakani, S. R., Ansari, A., and Ardakani, M. R. (2012). Organizational climate and commitment. *Research*, 4(12): 1-3.

Berrang-Ford, L., Ford, J. D. and Paterson, J. (2011). Are we adapting to climate change? *Global Environmental Change*, 21(1): 25-33.

Bizikova, L., Robinson, J. and Cohen, S. (2007). Linking climate change and sustainable development at the local level. *Climate Policy*, 7(4): 271-277.

Blaikie, P., Cannon, T., Davis, I. and Wisner, B. (1994). *At risk: Natural hazards, people's vulnerability and disasters*. London: Routledge.

Conway, D., and Schipper, E. L. F. (2011). Adaptation to climate change in Africa: Challenges and opportunities identified from Ethiopia. *Global Environmental Change*, 21(1): 227-237.

Defiesta, G., and Rapera, C. L. (2014). Measuring adaptive capacity of farmers to climate change and variability: Application of a composite index to an agricultural community in the Philippines. *Journal of Environmental Sciences and Management*, 17(2): 48-62.

Deressa, T. T., Hassan, R. M., Ringler, C., Alemu, T., and Yesuf, M. (2009). *Analysis of the determinants of farmers' choice of adaptation methods and perceptions of climate change in the Nile Basin of Ethiopi*a. International Food Policy Research Institute. Washington, DC.

Dietz, T. (2015). *Environmental value handbook of value: Perspectives from economics, neuroscience, philosophy, psychology and sociology*, Pp 329.

Dow, K. (1992). Exploring differences in our common future(s): The meaning of vulnerability to global environmental change. *Geoforum*, 23(1): 417–436.

Food and Agricultural Organization of the United Nations (FAO) (2016). Diversification strategies and adaptation deficit: Evidence from rural communities in Niger, by Asfaw, s., Palma, A. and Lipper, L. ESA. *Working Paper No. 16-02*. Rome.

Food and Agricultural Organization of the United Nations (FAO) (2019). Food and agriculture data. Available at: www.fao.org/faostat/en/. Accessed on 1st July, 2019.

Garba, B. I. (2018). Determinants of climate change adaptation strategies used by rice farmers in Kontagora local government area, Niger State. Unpublished B.Tech project submitted to Department of Agricultural Economics and Extension Technology, Federal University of Technology Minna, Nigeria.

Inayatullah, J., Munir, K. K., Khan, M. A., Shakeel, H. and Tariq, R. (2012). Factors affecting rural livelihood choices in Northwest Pakistan. *Sarhad Journal of Agriculture, 28*(4): 681-688.

Intergovernmental Panel on Climate Change (IPCC) (2001). Contribution of working Group II. Climate

change impacts, adaptation and vulnerability. *Third Assessment Report*. (Eds). McCarthy, J. J., Canziani, O. F., Leary, N. A., Dokken, D. J. and White, K. S. New York: Cambridge University Press.

Intergovernmental Panel on Climate Change (IPCC) (2007). Working Group II. Impacts, adaptation and vulnerability. Intergovernmental Panel on Climate Change. *Fourth Assessment Report*. (Eds). Parry, M. L., Canziani, O. F., Palutikof, J. P., Linden, P. J. and Hanson, C. E. New York: Cambridge University Press.

Intergovernmental Panel on Climate Change (IPCC) (2014). Climate variability, Impacts, Adaptation, and Vulnerability. Working Group II, *Fifth Assessment Report Phase I Report* Launch, 31 March 2014.

Jamshidi, O., Ali, A., Khalil, K., Hossein, A. and Jurgen, S. (2018). Vulnerability to climate change of smallholder farmers in the Hamadan province, Iran. *Climate Risk Management,* 23(1): 146-159.

Joshua, E. (2018). Climate change and gender equality in developing states. *World Development*, 107(1): 289–305.

Krejcie, R. V. and Morgan, D. W. (1970). Determining sample size for research activities. *Educational and Psychological Measurement*, 30(1), 607-610.

Majahodvwa S. N., Micah B. M. and Absalom, M. (2013). Factors affecting households vulnerability to climate change in Swaziland: A case of Mpolonjeni Area Development Programme (ADP). *Journal of Agricultural Science*, 5(10): 1-15.

Narayanan, K. and Sahu, S. K. (2016). Effects of climate change on household economy and adaptive responses among agricultural households in Eastern Coast of India. *Current Science*, 110(1): 1-12.

National Population Commission (NPC) (2006). Population data in Nigeria. Retrieved on February 20, 2017 from http://www.population.gov.ng/population-data-in-Nigeria.

Nigerian Meteorological Agency (NIMET) (2019). E-Library. Available at: www.nimet.gov.ng. Accessed on 3rd August, 2019.

Ozor, N., Madukwe, M. C., Onokala, P. C., Enete, A., Garforth, C. J., Eboh, E., Ujah, O. and Amaecchina, E. (2010). A framework for agricultural adaptation to climate change in Southern Nigeria. A development partnership in higher education (DelPHE) 326 *Project Executive Summary*. Supported by DFID and implemented by the British Council, Enugu: African Institute for Applied Economics.

Parry, M. L., Rosenzweig, C. and Livermore, M. (2005) Climate change, global food supply and risk of hunger. *Philosophical Transactions of the Royal Society B*, 360(1): 2125 – 2136.

Rahman, S. A. (2014). Climate Change and Trends in Agricultural Production. In (eds). Amos, T. T., Imoudu, P. B., and Oseni, J. O. Proceedings of the 14th Annual National Conference of the Nigerian Association of Agricultural Economist. *Climate Change, Agriculture and Food Security in Nigeria*. Held at the Federal University of Technology, Akure, Nigeria between 24th-27th, February, 2014.

Slater, R., Peskett, L., Ludi, E., and Brown, D. (2007). Climate change, agricultural policy and poverty reduction–how much do we know? *Natural Resource Perspectives,* 109(7): 1-6.

Stern, N. (2009). Managing climate change and overcoming poverty: Facing the realities and building a global agreement. Centre for Climate Change Economics and Policy Grantham Research Institute on Climate Change and the Environment, U.K., pp. 1-28.

Tun, A., Huylenbroeck, G. V. and Speelman, S. (2018). Assessment of climate change vulnerability of farm households in Pyapon District, a delta region in Myanmar. *International Journal of Disaster Risk Reduction*, 28(1): 10-21.

Value Chain Development Programme (VCDP) (2016). *Value Chain Development Programme Supervision Report. West and Central Africa Division Programm*e. Report No. 4217-NG. Federal Republic of Nigeria, Retrieved from www.supervisionmissionreport_vcdp_pat_0006-1-1136 on 24th March, 2019.

Wickham, H. (2016). *ggplot2: Elegant Graphics for Data Analysis*. Springer-Verlag New York.

Yohe, G. and Tol, R. S. J. (2005). Indicators for social and economic coping capacity-moving toward a working definition of adaptive capacity. *Global Environmental Change*, 12(1): 25-40.

Table 1: Components and indicators of vulnerability to climate change

Components of indicators of Vulnerability	Sub-indicators	Indicators	Description
EXPOSURE	Extreme event	Frequency of flood in last 10 years	Number of flood event from 2009-2019
			Number of drought events from 2009-2019
	Climatic variables	Frequency of drought in last 10 years	Mean annual precipitation
		Average annual precipitation	
SENSITIVITY	Demography		Number of unemployment of family aged 15-65 / total number of family members
		Unemployment in family	Number of family directly involved agriculture/total number of family member
		Family involved in agriculture	Number of family's child below 15 years old / total number of family member
		Number of child	Number of family's child below 5 years old / total number of family member
	Vulnerable social group land	Child under 5 years old	
		Adults above 65 years old	Number of family above 65 years old / total number of family member
		Average land size	
		Farm size of each family member	Total farm size owned / number of land pieces
	Land		Total farm size owned / numbers of family members
		Crop diversity index	CDI= 1 / number of crops grown by a household + 1
	Agricultural productivity	Chemical fertilizer consumption	Consumption of chemical fertilizer in hectare
ADAPTIVE CAPACITY		Land cultivated by drought resistance varieties	% of land cultivated by drought resistance varieties to whole owned land
		Net farm income	Net income obtained from the farm
		Crop insurance	% of farm land covered by crop insurance / or credit
		Livestock unit	Ownership of number of livestock unit
		Irrigated to rain-fed land	Rate of irrigation to land-fed under cultivation land
	Economical capability		% of income from agriculture to all income
		Income from agriculture	Household farmland ownership (ha)
		Land ownership	Number of family member involve in agricultural activity
		Family member involved in agriculture	The level of taking technical advice consulting
		Technical advice consulting	
		Family member participating in social communities	% of family members participating in social communities
	Social capability	Adult family members	Ratio of family members aged 15-65 years to all
		Household head education	Household numbers of years education
		Highest number of year education	Highest numbers of years education in household
	Human resources capability	Access to nearest health center	Distance to nearest health center (km)
		Access to main road	Distance to nearest main road-asphalt (km)
		Access to healthy drinking water	Access to healthy drinking water (yes = 1, no = 0)
		Access to market	Distance to nearest city (km)
	Institutional capability	Access to infrastructure	Access to road (road, electricity, gas and telephone)
		Access to educational facilities	Access to educational facilities such as school, high schools and library
		Access to governmental credit	Access to governmental credit (yes = 1, no = 0)
		Access to communication channels	% of access to communication channel (radio, TV, satellite, phone)
		Access to agricultural impute	% of access to agricultural impute (machinery, irrigation system, pesticide, fertilizer)

Adopted from Jamshidi *et al*. (2018) and modified.

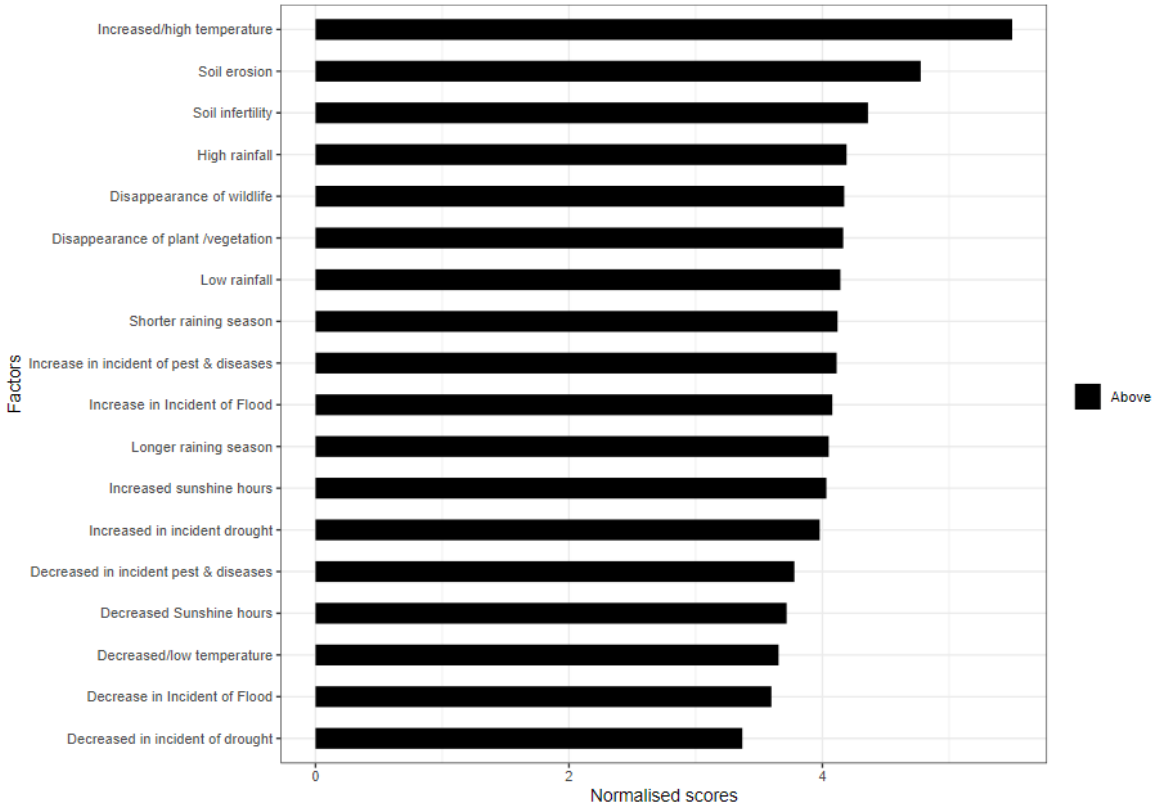

Figure 1: Awareness of climate change variables by IFAD farmers in North Central Nigeria.
Source: Field survey, 2019.

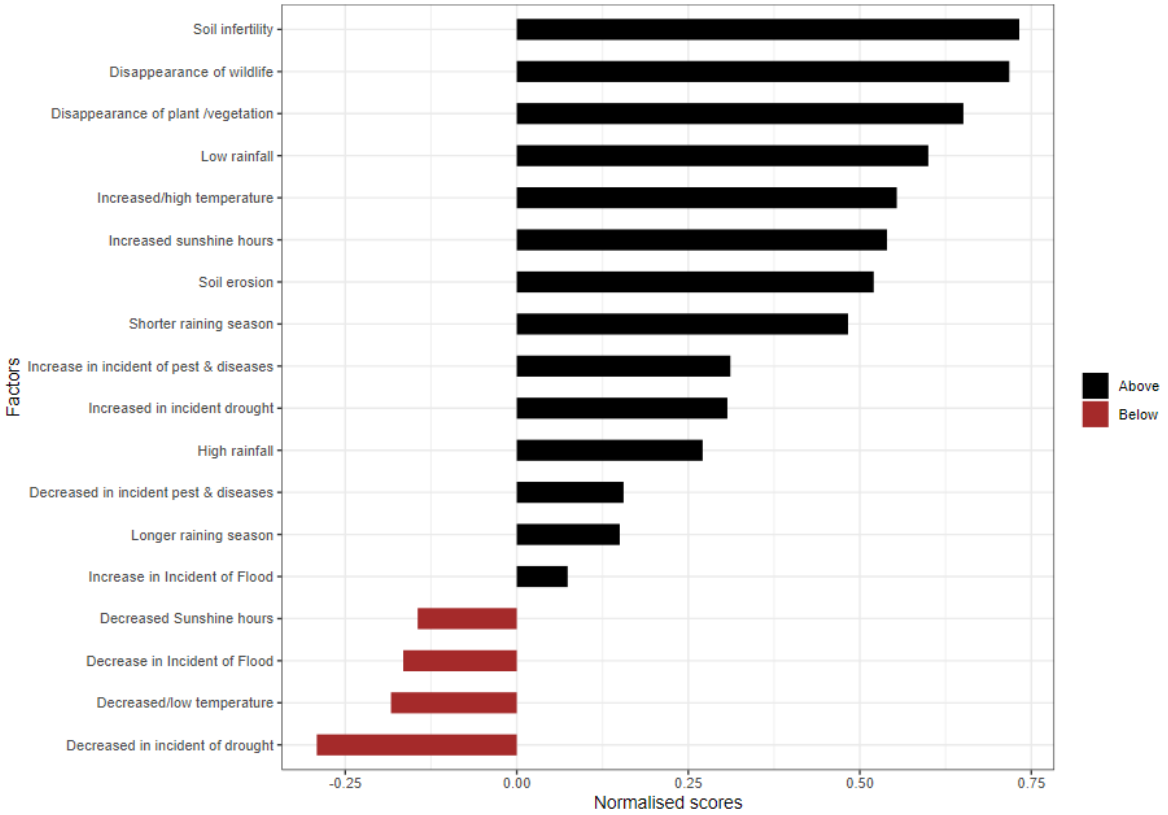

Figure 2: Awareness of climate change variables by IFAD farmers in Benue State.
Source: Field survey, 2019.

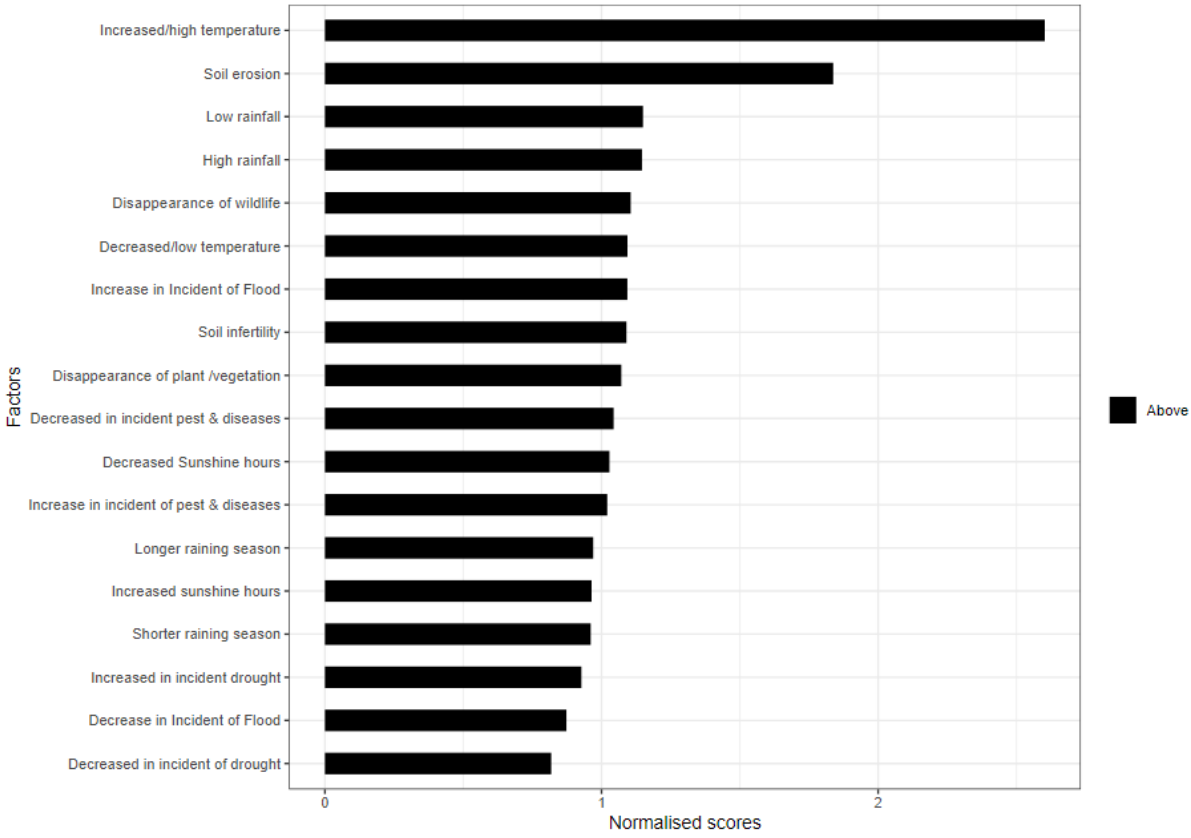

Figure 3: Awareness of climate change variables by IFAD farmers in Niger State.
Source: Field survey, 2019.

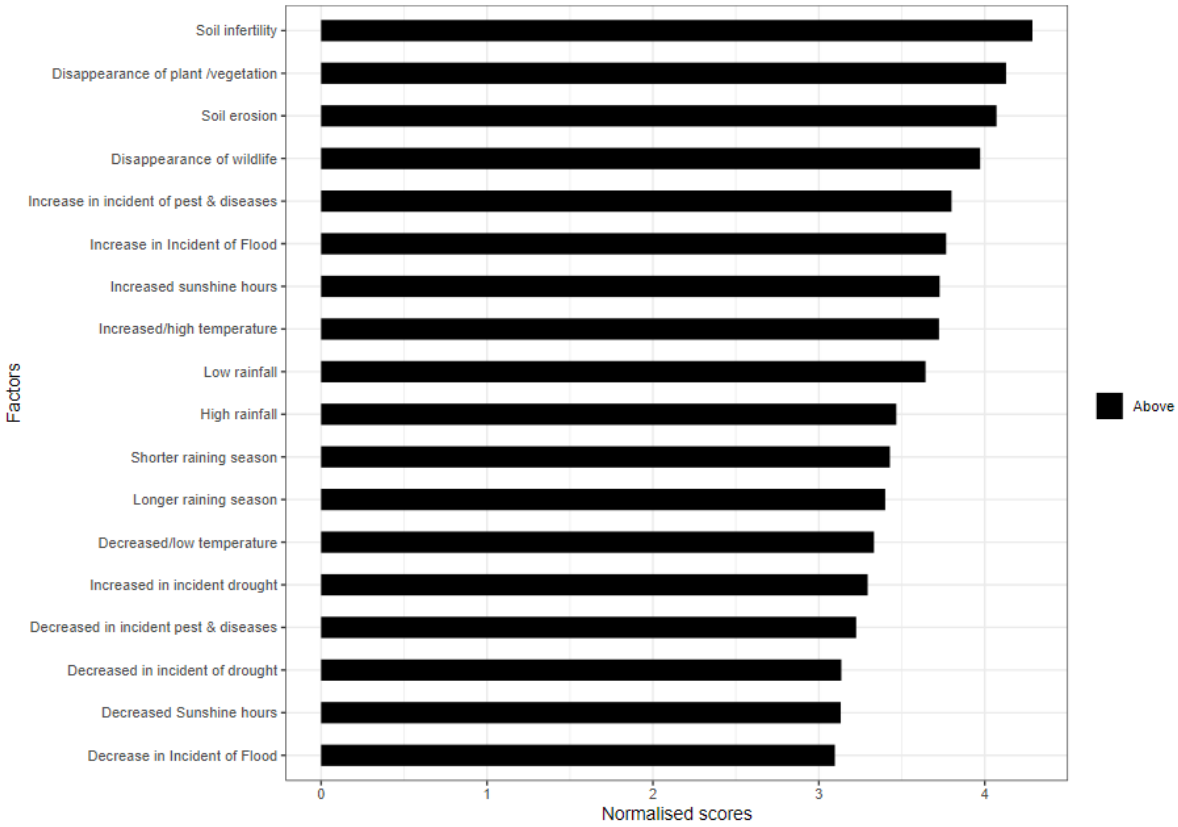

Figure 4: Frequency of occurrence of the various climate change variables as expressed by the respondents in North Central Nigeria.
Source: Computed from field survey, 2019.

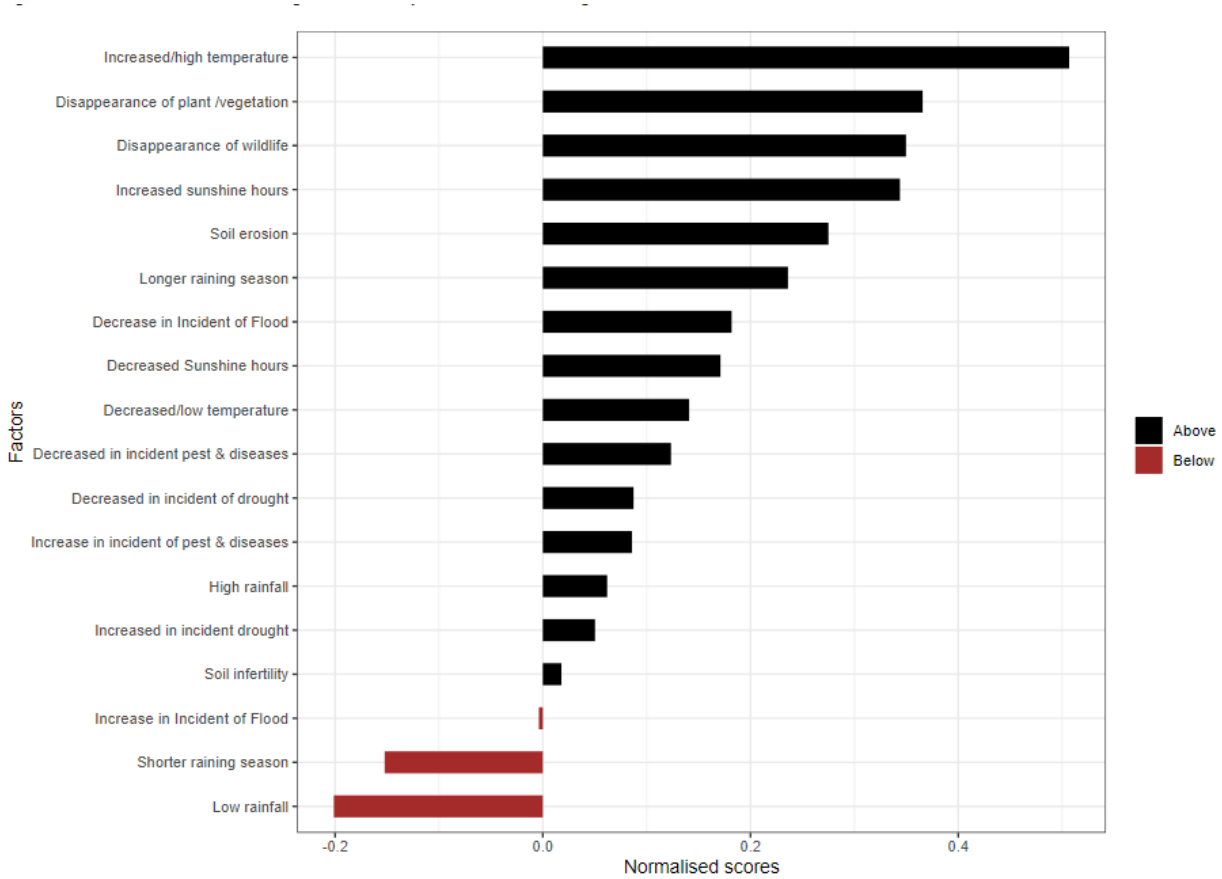

Figure 5: Frequency of occurrence of the various climate change variables as expressed by the respondents in Benue State.
Source: Computed from field survey, 2019.

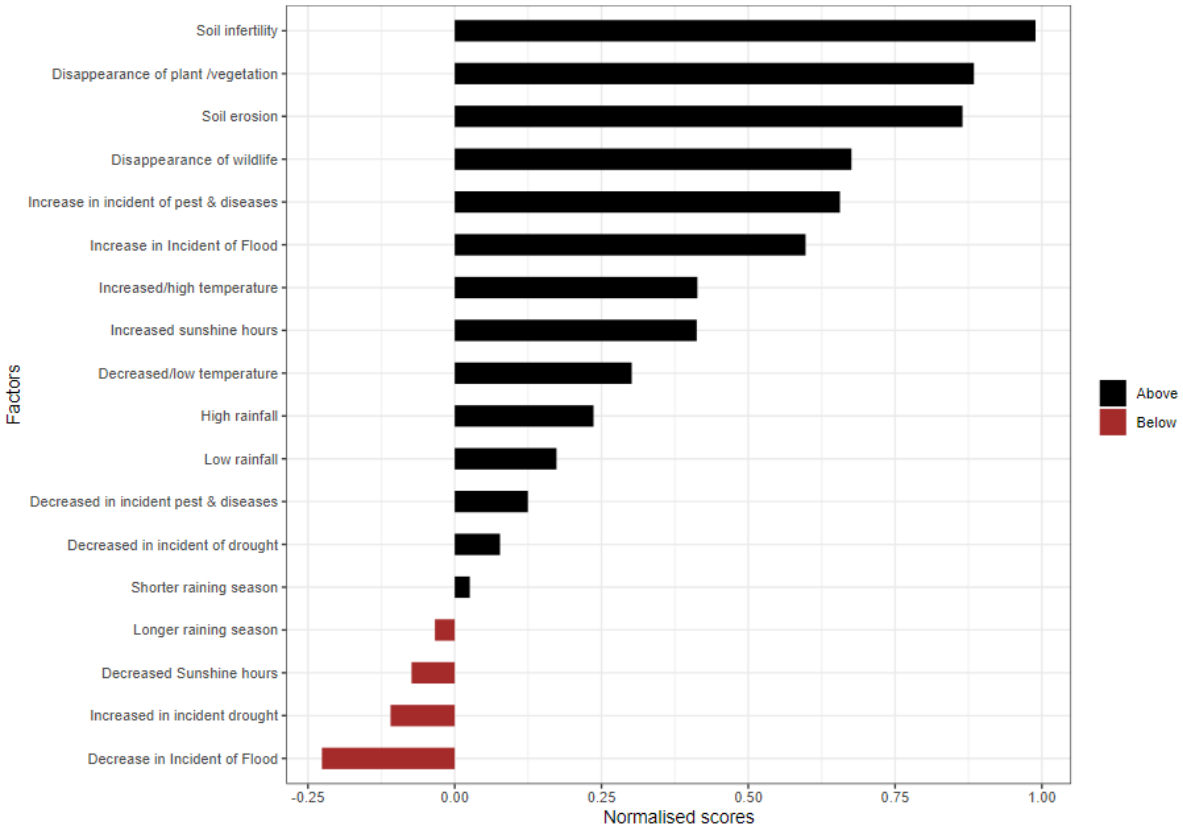

Figure 6: Frequency of occurrence of the various climate change variables as expressed by the respondents in Niger State.
Source: Computed from field survey, 2019.

Table 2: Level of vulnerability of farm households to climate change in North Central Nigeria

Level of vulnerability	Pooled data Freq (%)	Benue State Freq (%)	Niger State Freq (%)
Low > 0 < 0.33	67(13.87)	11(4.58)	56(23.05)
Moderate ≤ 0.33 < 0.66	245(50.73)	88(36.67)	157(64.60)
High ≥ 0.66 ≤ 1.0	171(35.40)	141(58.75)	30(12.35)
Mean vulnerability	0.653	0.689	0.656

Source: Field survey, 2019.

Table 3: Beta regression estimates on factors affecting vulnerability to climate change in North Central Nigeria

Variables	Coefficients	Standard Err.	Z-value	P>|z|
Adaptive capacity	-1.325 ***	0.425	-3.12	0.002
Age of household head	-0.007**	0.004	-1.96	0.050
Level of education	-0.044***	0.008	-5.17	0.000
Gender	-0.156*	0.088	-1.76	0.079
Distance to market	-0.009**	0.004	-2.11	0.035
Non-farm income	0.002	0.010	0.25	0.800
Credit	-0.006	0.007	-0.89	0.373
Livestock ownership	-0.026***	0.004	-5.43	0.000
Household size	0.007	0.009	0.84	0.400
Poverty status	0.171*	0.095	1.79	0.073
Social amenities	-0.106***	0.037	-2.87	0.004
Total livelihood act.	-0.138**	0.066	-2.09	0.036
Membership of ass.	-0.214***	0.065	-3.27	0.001
Constant	3.071***	0.594	5.17	0.000
Scale constant (phi)	2.356***	0.634	37.16	0.000
LR Chi^2 (13) =	485.73			
Prob > Chi^2 =	0.0000			
Log likelihood =	367.62003			

Source: Computed from field survey, 2019.

Table 4: Estimates of marginal effect on factors affecting vulnerability to climate change in North Central Nigeria

Variables	δy/δx	Standard Err.	Z-value	P>|z|
Adaptive capacity	-0.238***	0.076	-3.13	0.002
Age of household head	-0.001*	0.001	-1.96	0.050
Level of education	-0.007***	0.001	-5.18	0.000
Gender	-0.028*	0.015	-1.76	0.079
Distance to market	-0.001**	0.001	-2.11	0.035
Livestock ownership	-0.004***	0.001	-5.48	0.000
Poverty status	0.030*	0.017	1.79	0.073
Social amenities	-0.019***	0.006	-2.88	0.004
Total livelihood activities	- 0.024**	0.119	-2.09	0.036
Membership of associations	-0.038***	0.011	-3.28	0.001

Source: Field survey, 2019.