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Original Research Article

Gender analysis of vulnerability of smallholder farming households to climate variability and change in North-central Nigeria

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Abstract

The frequency and intensity of climatic variables as indicators of climate change have been increasingly recognised as global crisis with significant impact on biodiversity, household food security and gender roles. This study therefore analysed gender vulnerability of smallholder farming households to climate variability and change in North-central Nigeria. A multi-stage random sampling technique was used to select 768 respondents from the study area. Indicator-based approach was adopted for this study and a structured questionnaire was used to elicit data from 3, 6, and 8 indicators of three components of vulnerability: exposure, sensitivity and adaptive capacity. Data obtained were subjected to linear normalisation, non-weight vulnerability index, and both descriptive and inferential statistics. Results show that both male- and female-headed households were vulnerable to changing climate and the female-headed ones were more vulnerable (0.410) compared to their male counterparts with an index of 0.321. The high vulnerability of female-headed households was due to their extent of exposure (0.839) and sensitivity (0.658) to climate change with low adaptive capacities (0.189). Also, there was a positive and significant difference between male (t = 5.142) and female (t = 5.079) headed households' in their level of vulnerability to climate change ($p \leq 0.05$). This study recommends access to technology that helps farmers receive timely information on climate variables, and farmers' access to agricultural insurance scheme would help improve adaptive capacity and reduce their vulnerability. Also, gender-sensitive framework that could bridge the gaps between male- and female-headed households are needed to form a policy development agenda by the government in order to encourage more female households' to participate in climate change mitigation.

Keywords: gender; index-based approach; vulnerability index; exposure; sensitivity; adaptive capacity; farming household

INTRODUCTION

Climate change is an environmental issue that is impacting negatively on farming households, communities and economies at large. The possibility of climate change to undermine economies and public finances is real and can no longer be ignored at any level. According to Menike and Arachchi (2016), agriculture appeared to the most sensitive to changing climatic variables which affect production and rural farming communities. The impact of climate variability and change on agriculture vary by crop, region and season, but the overall impact on the sector is net negative. Climate change is already affecting agriculture production by ruining crops through increased drought and flooding – it has already led to reduction yields by 1–2 percent in the last century and the prediction is that this will get worse (Wiebe et al. 2015). Climate variability and change in the amount and time of rain has resulted in declining crop yields and also force farmers to abandon their traditional crops for those that can withstand the change in climate. Key climate change impacts include increases in the intensity and/or frequency of natural-hazard induced disasters such as prolonged dry spells and associated droughts, intense rainfall, snow avalanches and severe dust storms. However, there is a significant variance across geographies and demographics with regard to vulnerability to these impacts.

Climate change impacts have the potential to increase the vulnerability, and threaten the livelihoods of millions of poor people across the world, many of whom already face exposure to a diversity of challenges, including disasters, hunger, susceptibility to disease outbreaks and loss of livelihoods. Climate change vulnerability can be analysed from world level (IPCC, 2014) to regional level (Acheampong et al., 2014) and household level (Opiyo, 2014). The choice of vulnerability analysis scale depends on the aim of the research, available data and the methodology of the study. The Third and Fourth Assessment Reports of the IPCC (2014) defined vulnerability as the level to which a system is susceptible to, or incapable of coping with the adverse effects of climate change, climate variability and extremes. In other words, vulnerability is an embodiment of the character, magnitude and degree of exposure of a system to climate change and variability, its sensitivity and adaptive capacity. Vulnerability is key to understanding the gender differential in climate change especially among the smallholder farmers. Though both male and female farmers within the same geographical location are exposed to the same climatic conditions, the extent of effect of the climatic stresses varies between men and women, because of differences in their levels of adaptive capacities and sensitivity. These effects, impact on gender differently including the gender roles and coping strategies (Guloba, 2014). Studies have shown that climate variability and change influence changes in normal gender (men, women and children) roles within a household (e.g. IPCC, 2014).

Gender issue pertaining to this study relates to vulnerability of male and female smallholder farmers to climate variability and change and with potential impact on agricultural activities in their farm households. To address gender differences in climate change adaptation and mitigation, planning is crucial to reduce the vulnerability of farmers, given the gendered nature of climate change vulnerabilities (Alston, 2014). Smallholder farmers are one of the most vulnerable social groups to climate change impact (Lindoso et al., 2012), especially in sub-Saharan Africa countries due to their heavy dependence on climate sensitive agro-economic sectors. In view of correlates between agricultural production and household income of both male and female smallholder farmers, the undesirable impact of climate change on agricultural productivity increases the vulnerability of farmers. Therefore, the changing climate not only has an impact on agricultural production of smallholder farmers but it also puts their household subsistence and food security at risk (Alam et al., 2017).

Gender-differentiated impacts of climate change are also largely attributable to gender-differentiated relative powers, roles and responsibilities of men and women at the household and community levels. Socially constraining norms and values often lead to increased vulnerability to climate change for women and girls. Recent work on gender implications of climate change in agrarian settings highlights how gender-specific patterns of labour and responsibility result in differential vulnerability (Carr and Thompson, 2014). In spite of growing recognition of the differential vulnerabilities as well as the unique experiences and skills exhibited by men and women bring to development and environmental sustainability efforts, women still have less economic, political and legal clout and are hence less able to cope with and are more exposed to the adverse effects of the changing climate. Climate change impacts can exacerbate existing gender inequalities. Consequently, men and women have different adaptive strategies and spatial perceptions that reflect their activities, social positions, and differential access to and control over resources (Villamor et al., 2015).

Many studies in the climate change literature in the study area have focused more attention on gender perception, adaptation and mitigation with little or no emphasis on the gender dimension of vulnerability to changing climate. Therefore, there is need to seek better understanding of the vulnerability of male and female smallholder farmers, with view to targeting adaptation strategies towards key vulnerabilities and to monitor their exposure to climatic stresses. Based on the aforementioned scenario, it is the focus of this study to map out the gender vulnerability of smallholder farmers to changing climate in North-central states of Nigeria. The specific objectives were to: examine farmers' level of exposure, sensitivity and adaptive capacity to climate variability and change using index-based approach; and

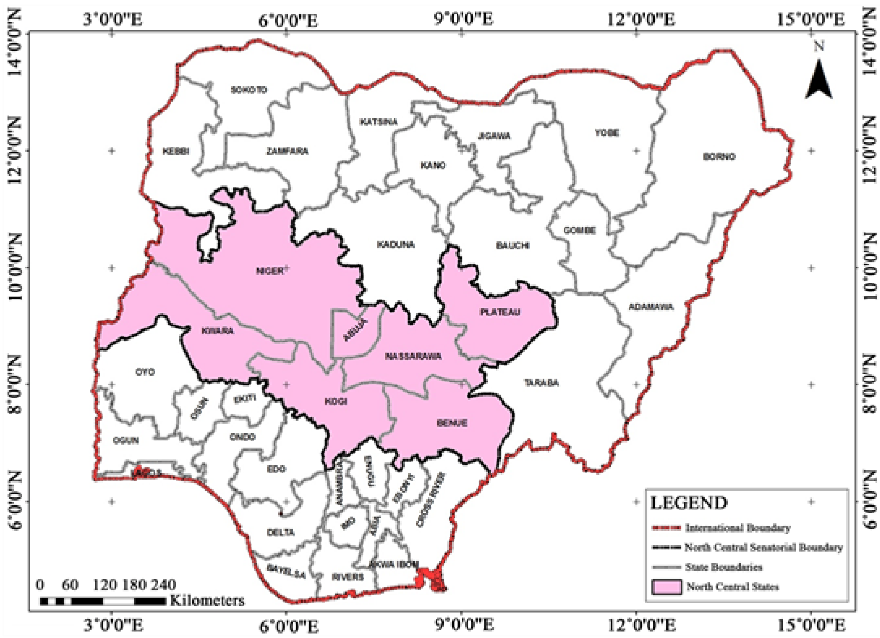

Figure 1. Map of Nigeria showing North-central states in colour
Source: Nigeria Metrological Agency, 2019.

determine if there is difference in the vulnerability of male and female smallholder farmers to climate change in the study area.

Hypothesis

H_{01} = There is no significant difference in the level of vulnerability of male and female respondents' to climate variability and change in the study area.

MATERIAL AND METHODS

This study was carried out in North-central States of Nigeria. There are six states in north-central Nigeria, namely Benue, Kwara, Niger, Plateau, Nassarawa, Kogi, and Abuja, the federal capital Territory and situated geographically in the middle belt region of the country, spanning from the west, around the confluence of the River Niger and the River Benue (See Fig. 1). It lies approximately between 3° and 14 °E and latitude 7° and 10°N. It constitutes the food basket of Nigeria covering about 730,000 km^2 or about 78% of the total land mass of Nigeria. The region is also home to many historical and colonial relics.

The climate of Nigeria's northern and southern areas has a strong influence on the North Central region. The research region is part of the Guinea Savannah vegetation belt, which includes grasses and shrubs as well as deciduous trees (Oladipo, 1993). The soil has a sandy surface horizon that is overlain by a weakly organized clay deposit. Agriculture is the backbone of the lower Benue basin's economy, with more than 70% of the working population involved in farming, fishing, cattle, and poultry, making the region the country's food basket.

Sampling procedure and samples

A four-stage random sampling technique was used for the selection of respondents from all the six states in the study area. Stage one: two agricultural zones were randomly sampled from each of the six states and making a total of 12 agricultural zones. In stage two; from each of the selected 12 agricultural zones, two local government areas (LGAs) were randomly selected making a total of 24 LGAs. Stage three: involved a random sampling of two (2) rural farming communities from each of the sampled 24 LGAs making 48 rural farming communities for the study. Lastly, stage four: from each of the selected farming communities, 16 smallholder (8 male- and 8 female-headed) farming households were randomly selected giving a total of 768 respondents. Effort to get equal number of male and female headed households for the study proof abortive as 384 male- and 372 female-headed households with a total sample size of 756 were eventually used for the study. Data were collected from respondents using questionnaire and analysed with both descriptive and inferential statistics such as frequency counts, percentages, charts and mean, standard deviation and vulnerability index and independent sample *t*-test.

Measurement of variables

Variables measured include both independent and dependent variables. The independent variables

Table 1. Indicators for the various components and subcomponents of vulnerability and functional relationship with vulnerability

Component	Sub-component	S/N	*Indicators (units of measurement)	**Relationship
Exposure	Climate variability	E_1	Change in temperature (as perceived and reported by households in the past 10 years)	+
	Climate disasters	E_2	Number of flood over the past 10 years	+
		E_3	Number of drought over the past 10 years	+
Sensitivity	Demographic	S_1	Number of family member directly involved in agriculture	–
	Vulnerable group	S_2	Total of number of vulnerable people in households	+
	Agricultural activity	S_3	Crop diversity index (inverse of the number of crops grown by a households + 1)	–
		S_4	Crop productivity (Yield in tons/ha)	–
	Land	S_5	Total farm land size owned (ha)	–
		S_6	% of land uncultivated (ha)	–
Adaptive capacity	Economical capability	AC_1	Amount of households income	–
		AC_2	% households having more than one source of income	–
	Technology Capability	AC_3	% households using drought tolerant crop varieties	–
		AC_4	% households using agrochemicals	–
		AC_5	% households practicing irrigation systems	–
	Institutional capability	AC_6	% households having access to climate information, extension services	–
		AC_7	% households having access to agricultural insurance scheme	–
	Human capability	AC_8	% of households who are able to read and write	–

*Household survey
**Functional relationship between indicator and vulnerability
+ denotes a positive relationship between the indicator and vulnerability
– denotes a negative relationship
Source: Field survey, 2019.

measured comprised age (in actual years), marital status (as single = 1, married = 2, divorced = 3, widowed = 4), level of education (as no formal education = 1, primary education = 2, secondary education = 3, and tertiary education = 4), household size (as the number of people living under the same roof and eating from the same pot), farm size (as in hectare under cultivation) and farming experience (in years) and income (in Naira).

The dependent variable which is the vulnerability of male- and female-headed households to climate variability and change was measured accordingly in term of their exposure, sensitivity and adaptive capacity to change in climate using index-based approach. The various components and sub-components of vulnerability as identified by Birkmann et al. (2013) were measured as follows (See Table 1).

Computation of vulnerability Indices

Since indicator approach is one of the methods that could be used to measure the vulnerability of farmers to climate change (Mbakahya and Ndiema, 2015). This method is thus, based on developing a set of indicators and selecting some of them through expert judgment. However, vulnerability of any system or household is frequently considered as a function of three components: exposure to a hazard, sensitivity to that hazard, and the capacity of the system or household to mitigate or cope with and adapt or recover from the effects of those conditions (Reed et al., 2013) which are mostly referred to as adaptive capacity. According to Sadiq et al. (2019) vulnerability therefore may be expressed mathematically as follows:

$$VI = f\left(\overset{+}{\hat{E}}, \overset{+}{\hat{S}}, \overset{-}{\widehat{AC}}\right) \quad (1)$$

where
VI = Vulnerability Index
E = Exposure
S = Sensitivity
AC = Adaptive Capacity

Using the non-weighted approach, normalisation of all indicators in the three sub-indices (sub-indices of exposure, sensitivity and adaptive capacity) was done to make all the indicator values comparable and congruent using standardisation method. The indicators were standardised to fit within the range zero (0) to one (1) using either linear normalisation or Z-score, depending on the type of data. In this study, the normalised scores for each indicator were computed using MS-Excel's MAX () and MIN () functions. Thus, the normalised value of an indicator (*Y*) for a household (*i*) is given by:

$$Z_{ij} = \frac{Max\{X_{ij}\} - X_{ij}}{Max\{X_{ij}\} - Min\{X_{ij}\}} \tag{2}$$

where
Z_{ij} = normalised value of indicator for a household *i*
X_{ij} = value of indicator for a household *i*
$Max\{X_{ij}\}$ = *highest value*
$Min\{X_{ij}\}$ = *lowest value*

Similarly, in this study every component and sub-component of vulnerability has a specific number of indicators (i.e. exposure has 3, sensitivity has 6 and adaptive capacity has 8 indicators). From Table 1 sub-index of exposure as determined by climate variability and climate extremes/disasters over a period of 10 years include: change in temperature, number of occurrence of flood and drought in the last 10 years and could be expressed as mathematically as:

$$E_i = \frac{1}{2}\left[E_1 + \frac{(E_2 + E_3)}{2}\right] \tag{3}$$

where
E_i = Exposure Index of a household *i*
E_1 = Change in temperature from 2008 to 2018
E_2 = Number of occurrence of flood from 2008 to 2018
E_3 = Number of occurrence of drought from 2008 to 2018

Also, for the sensitivity of male or female household to climate variability and change the sub-index of sensitivity were measured in terms of number of family member involved in agriculture, number of vulnerable people in the households, crop diversity index, crop productivity in form of yield/hectare, total farm land size owned in hectare and percentage of uncultivated land owned. These are therefore expressed mathematically as:

$$S_i = \frac{1}{4}\left[S_1 + S_2 + \frac{(S_3 + S_4)}{2} + \frac{(S_5 + S_6)}{2}\right] \tag{4}$$

where
S_i = Sensitivity index of a household *i*
S_1 = Number of family members involved in agriculture in household *i*
S_2 = Number of vulnerable group/people in household *i*
S_3 = Crop diversity index of household *i*
S_4 = Crop productivity (yield/ha) of household *i*
S_5 = Total farm land owned (ha) by household *i*
S_6 = Percentage of uncultivated land owned by household *i*

In terms of capacity of male or female household to ameliorate and adapt to changing climate, eight indicators were employed to measure their adaptive capacity to climate variability and change. These indicators include the amount of households' income (Naira), percentage of households having more than one source of income, percentage of households using drought tolerant varieties, percentage of households using agrochemicals, percentage of households practicing irrigation farming, percentages of households having access to agricultural information and extension services, insurance scheme and literacy rate. Adaptive capacity is thus, mathematically expressed as:

$$AC_i = \frac{1}{4}\left[\frac{(AC_1 + AC_2)}{2} + \frac{(AC_3 + AC_4 + AC_5)}{3} + \left(\frac{AC_6 + AC_7}{2}\right) + AC_8\right] \tag{5}$$

where
AC_i = Adaptive capacity index for a household *i*
AC_1 = Amount of income for a household *i*
AC_2 = % households having more than one source of income
AC_3 = % households using drought tolerant crop varieties
AC_4 = % households using agrochemicals
AC_5 = % households practicing irrigation
AC_6 = % households having access to weather forecast information and extension services
AC_7 = % households having access to agricultural insurance scheme
AC_8 = % households who are able read and write

However, from equation 1 the composite vulnerability index (CVI) for any male and female household *i*, as developed by Heltberg and Omolovskiy (2011) and adopted by Sadiq et al. (2019) using simple non-weighted average of all three sub-indices of exposure, sensitivity and negative of the adaptive capacity is therefore expressed as:

$$CVI = \frac{1}{3}\left[E + S(1 - AC)\right] \tag{6}$$

where
CVI = Composite vulnerability index for household *i*
E = Exposure index for household *i*
S = Sensitivity index for household *i*
AC = Adaptive capacity for household *i*

Thus, the vulnerability index so computed lies between 0 and 1, with 1 indicating maximum vulnerability and 0 indicating no vulnerability at all. For the purpose of categorisation, a simple ranking of

Table 2. Distribution of socioeconomic profile of respondents by gender (N = 756)

Socioeconomic profile		Male (n=384)			Female (n=372)		
Variable	**Group**	**(f)**	**(%)**	**Explanation**	**(f)**	**(%)**	**Explanation**
Age (years)	≤25	28	7.3	Ave: 50.8 SD: 21.5	13	3.5	Ave: 48.6 SD: 18.9
	26–50	149	38.8		222	59.7	
	>50	207	53.9		137	36.8	
Marital status	Single	65	16.9	Mode: Married	20	5.4	Mode: Married
	Married	304	79.2		254	68.3	
	Divorce	15	3.9		37	9.9	
	Widowed	0	0		61	16.4	
Level of education	Non formal	134	34.9	Mode: No Primary education	186	50.0	Mode: No formal education
	Primary	187	48.7		142	38.2	
	Secondary	44	11.5		44	11.8	
	Tertiary	19	4.9		0	0	
Household size No. of persons	1–5	61	15.8	Average: 12 SD: 7	129	34.7	Average: 8 SD: 5
	6–10	122	31.7		189	50.8	
	>10	201	52.5		54	14.5	
Farming experience (years)	1–10	24	6.2	Average: 26.2 SD: 18.5	39	10.5	Average: 21.4 SD: 15.3
	11–20	48	12.5		217	58.3	
	>20	312	81.3		116	31.2	
Farm size (hectare)	≤4	103	26.8	Average: 5.3 SD: 3.1	202	54.3	Average: 3.8 SD: 2.6
	4.1–8.0	192	50.0		111	29.8	
	>8.0	89	23.2		59	15.9	

Source: Field survey, 2019

the households based on the indices viz., $\overline{y_i}$ would be enough. Moreover, for a meaningful characterisation of the different levels of vulnerability, suitable fractile categorisation from an assumed probability distribution is hence needed. A probability distribution which is appropriate for this study is Beta distribution, and takes the values in the interval (0, 1), and this distribution is given by

$$f(z) = \frac{z^{a-1}(1-z)^{b-1}}{\beta(a,b)}, 0 < z < 1 \, and \, a,b > 0 \quad (7)$$

where $\beta(a,b)$ is the beta function defined by

$$\beta(a,b) = \int_0^1 x^{a-1}(1-x)^{b-1} \quad (8)$$

The Beta distribution is skewed. Assuming $(0,z_1)$, $(z_1 z_2)$, $(z_2 z_2)$, $(z_3 z_4)$ and $(z_4 z_1)$ be the linear intervals such that each interval the same probability weight of 20 percent. Therefore, the fractile intervals can be used to categorise the various level of vulnerability. Less vulnerable (if $0 < \overline{y_i} < z_1$), Moderately vulnerable (if $z_1 < \overline{y_i} < z_2$),Vulnerable (if $z_2 < \overline{y_i} < z_3$), Highly vulnerable (if $z_3 < \overline{y_i} < z_4$), and Very highly vulnerable (if $z_4 < \overline{y_i} < 1$).

Also, analytical tool such as independent sample t-test was used to compare the mean of male and female farmers based on their level of vulnerability to climate change in the research area. The tool or model is thus expressed as follows:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{S_1^2}{N_1} + \frac{S_2^2}{N_2}}} \quad (9)$$

where

$\bar{X}_1$ = the mean of group 1 (male)

S_1^2 = the mean of group 2 (female)

N_1 = Number of subjects in group 1 (male)

N_2 = Number of subjects in group 2 (female)

S_1^2 = Variance of group 1(male) = $\frac{\Sigma(X_1 - \bar{X}_1)}{n_1}$

S_2^2 = Variance of group 2 (female) = $\frac{\Sigma(X_2 - \bar{X}_2)}{n_2}$

Table 3. Gender distribution of respondents according to their exposure to climate variability and change (N = 756)

Component	Sub-component	Indicators (units of measurement)	Normalised Scores		Average of sub-indices	
			Male	Female	Male	Female
Exposure	Climate variability	Change in temperature (as perceived and reported by households in the past 10 years) E_1	0.734	0.882	0.734	0.882
	Climate disasters	Number of flood over the past 10 years, E_2	0.829	0.835		
		Number of drought over the past 10 years, E_3	0.781	0.754	0.805	0.795
Sum of sub-indices					1.539	1.677
Exposure Index					0.770	0.839

Source: Field survey, 2019

Table 4. Gender distribution of respondents' base on their sensitivity to climate variability and change (N = 756)

Component	Sub-component	Indicators (units of measurement)	Normalised Scores		Average of sub-indices	
			Male	Female	Male	Female
Sensitivity	Demographic	Number of family members directly involved in agriculture, S_1	0.622	0.563	0.622	0.563
	Vulnerable group	Total of number of vulnerable people in households, S_2	0.657	0.794	0.657	0.794
	Agricultural activity	Crop diversity index (inverse of the number of crops grown by a households + 1), S_3	0.792	0.717		
		Crop productivity (Yield in tons/ha), S_4	0.783	0.695	0.788	0.706
	Land	Total farm land size owned (ha), S_5	0.657	0.643		
		% of land uncultivated (ha), S_6	0.394	0.497	0.526	0.570
Sum of sub-indices					2.593	2.633
Sensitivity Index					0.648	0.658

Source: Field survey, 2019

RESULTS AND DISCUSSION

Socioeconomic characteristics of respondents

The results in Table 2 showed socioeconomic characteristics of the respondents. Average age of male respondents was 50.8 years and standard deviation of 21.5 years whereas average age of female respondents was 48.6 years with standard deviation of 18.9 years suggesting both categories of respondents are still in their active and productive age but male respondents were older than their female counterparts. Most (79.2% and 68.3%) of male and female respondents, respectively, were married with more married in male-headed households. The distribution of respondents' education level showed that only 4.9% of the male respondents had tertiary education and none in female category whereas about average (48.7%) of male respondents had primary education and half (50.0%) of female had no formal education. This suggests that male-headed households are more educated than their female counterparts in the research area. Therefore, a household with higher or reasonable level of education would likely understand and adopt best agricultural eco-friendly practices that would mitigate the impact of climate change. Also, in male-headed households the average household size was 12 persons whereas in the femal-headed ones the household size was 8 persons. This implies that a household with a relatively higher number of persons would have comparative advantage of family labour over their counterparts with smaller household size. In terms of farming experience, majority (81.3%) of the male respondents and only about 31.2% of their female counterparts had over 20 years of farming experience with the average of that was 26.2 and 21.4 years, respectively. The average farm size of male respondents was 5.3 hectares and standard deviation of 3.1 hectares whereas female respondents' average farm size was 3.8 hectares and standard deviation of 2.6 hectares. The results suggest that male-headed households cultivate more farm land than their female counterparts in the study area. The implication is that household that cultivate more farm land and grow more crops would have more yields which would likely translate into more household income.

Table 5. Gender distribution of respondents' base on their adaptive capacityused to combat climate variability and change (N = 756)

Component	Sub-component	*Indicators (units of measurement)	Normalised Scores		Average of sub-indices	
			Male	Female	Male	Female
Adaptive capacity	Economical capability	Amount of households income, AC_1	0.364	0.297		
		% households having more than one source of income, AC_2	0.258	0.246	0.311	0.272
	Technology Capability	% households using drought tolerant crop varieties, AC_3	0.382	0.129		
		% households using agrochemicals, AC_4	0.459	0.275		
		% households practicing irrigation systems, AC_5	0.347	0.186	0.396	0.197
	Institutional capability	% households having access to climate information, extension services, AC_6	0.206	0.112		
		% households having access to agricultural insurance scheme, AC_7	0.139	0.059	0.173	0.086
	Human capability	% of households who are able to read and write, AC_8	0.398	0.204	0.398	0.204
Sum of sub-indices					1.278	0.759
Adaptive capacity Index					0.320	0.189

Source: Field survey, 2019

Gender exposure to climate variability and change

In this study the gender exposure to climate change was assessed based onthe analysis of three indicators. These indicators are change in temperature as perceived and reported by the household head in the last ten years, number of flood occurrences, and number of drought occurrences in the last 10 years categorised in two subcomponents of climate variables and climatic disasters. Results in Table 3 show that female-headed households perceived higher change in temperature with exposure index of 0.882 than their male-headed households of 0.734. On the average of climate disasters, it was shown that male-headed households have a high exposure index of 0.805 compared to female-headed households (0.795). The overall exposure index showed that female-headed households have an exposure index of 0.839 and looked more exposed to climate variability and change than their male counterparts (0.770). This finding suggests that the impact of climate change would be felt more on female-headed households and vulnerable to changing temperature, floods and drought occurrences.

Gender sensitivity to climate change

The results in Table 4 showed the gender sensitivity to climate variability and change which was assessed based on six indicators and categorised in 4 subcomponents of demographics, vulnerable groups, agricultural activity and land issue. In terms of demographic, number of family member directly involved in agriculture was used as indicator and male-headed households were found to have a higher sensitivity index of 0.622 than female-headed households with 0.563. More vulnerable people are found in female-headed households (0.794) as compared to the male-headed households (0.657). This suggests that the higher number of vulnerable people in the household the higher the vulnerability level of such household. This finding is in agreement with research of Nkondze et al. (2013) that the number of sickmembers, employed members and dependants influence households to move from low vulnerability to moderate or higher level of vulnerability. In the agricultural activity sub-component, two indicators were used, i.e. crop diversity index and crop productivity. The average sub-indices of agricultural activity revealed that male-headed households with an index of 0.788 are relatively more sensitive to climate change than their female counterparts (index of 0.706). On land matters, average farm size owned by male-headed households us greater with less percent of uncultivated land than the female-headed households in the study area. The overall sensitivity index showed that both male- and female-headed households are sensitive to climate change with female headed-households relatively higher (0.658) than the male-headed households (0.648). This implies that the two categories of gender were sensitive to climate change but to varying degree.

Table 6. Overall vulnerability distribution of male and female respondents' to climate variability and change (N = 756)

Gender	Exposure Index	Sensitivity Index	Adaptive Capacity Index	Vulnerability Index CVI=1/3 [E+S(1-AC)]
Male	0.770	0.648	0.320	0.321
Female	0.839	0.658	0.189	0.410

Source: Field survey, 2019

Table 7. Gender distribution of respondents by their level of vulnerability to climate variability and change (N = 756)

Level of vulnerability	Vulnerability Index fractile	Male		Female	
		Frequency (%)	Percentage (%)	Frequency (%)	Percentage (%)
Very high	0.81–1.00	0	0	0	0
High	0.61–0.80	0	0	100	26.9
Moderate	0.41–0.60	43	11.2	218	58.7
Low	0.21–0.40	244	63.5	54	14.4
Very low	0.0–0.20	97	25.3	0	0
Total		**384**	**100**	**372**	**100**

Source: Field survey, 2019

Gender adaptive capacity to climate variability and change

The gender adaptive capacity of households was assessed based on 8 indicators and categorised into 4 sub-component, economical, technological, institutional and human capabilities. In term of economic capability of household, the amount of household income and percent of households having more than one source of income were assessed and Table 5 showed that both male- (0.311) and female-headed (0.272) households had low adaptive capacity which could make them more vulnerable. The implication is that the higher the level of adaptive capacity of household the lower their vulnerability to climate change. Technologically, use of drought-tolerant crop varieties, agrochemicals and practice of irrigation systems were analysed and the results revealed that male-headed households had a higher adaptive capacity index of 0.396 compared to their female-headed household counterparts in the study area. Averagely, in term of institutional capability both male- and female-headed households had low index values of 0.173 and 0.086, respectively, which was assessed based on their access to climate information, extension services, and agricultural insurance scheme. This implies that the low level of these indices of institutional capability of male- and female-headed households could not reduce their vulnerability to climate change. In a similar research conducted by Chinwendu et al. (2017) found that inadequate education, access to knowledge/information, poor local institutional capacity and services, and gender were the key factors that shape vulnerability. The overall adaptive capacity index in male-headed households was relatively higher (0.320) than in the female-headed households (0.189). This would subject female-headed households more to climate change impact. Also, Mallari (2016) in his study mentioned the importance of crop insurance, lectures on climate and agricultural information, the creation of plantingcalendar, monitoring of harvest seasons, and the climate field school program.

Overall gender vulnerability to climate variability and change

The results in Table 6 revealed the composite vulnerability of smallholder crop farmers to climate variability and change by gender. Results showed that female-headed households had high vulnerability index (0.410) compared to their male-headed counterparts with an index of 0.321. This finding suggests that both male- and female-headed households are vulnerable to change in climate but their vulnerability depends on level of exposure, sensitivity and adaptive capacity. Despite the fact that the two genders were exposed to the same climatic conditions, female-headed households were more exposed, sensitive and had the least adaptive capacities to climate variability and change variability thus, making them more vulnerable in terms of the contributory factors of vulnerability. This finding is supported by Suhiyini et al. (2019), who revealed that female-headed households were more vulnerable to climate change in Ghanadue to their low adaptive capacity.

Table 8. Results of independent sample *t*-test showing differences in the level of vulnerability of male and female respondents' to climate variability and change

Variable	N	Mean	SD	SE	MD	t-test	p-value	Decision
Male	384	13.012	0.862	0.019	0.043	5.142	0.040	Significant
Female	372	12.969	0.794	0.013		5.079	0.000	Significant

Source: Field survey, 2019
$p \leq 0.05$

Gender level of vulnerability of smallholder farmers to climate variability and change

Results in Table 7 present the gender distribution of smallholder farmers by their level of vulnerability to climate change in the research area. The computed vulnerability index lies between 0 and 1, with 1 indicating maximum vulnerability and 0 indicating no vulnerability at all. Our results showed that 11.2% of male-headed households are moderately vulnerable to climate change, 63.5% of them had low vulnerability while 25.3% had a very low vulnerability. Meanwhile, among female-headed households about 27% were highly vulnerable with more than half (58.7) having moderate vulnerability whereas only 14.4% had low vulnerability to change in climate. This implies that the vulnerability of male-headed households to climate change ranges from moderate to very low while in female category the vulnerability lies between high to low. To reduce households' vulnerability to climate change, their level of exposure and sensitivity should be reduced, while strengthening their adaptive capacity. Since climate change variability being the major stressor for both male- and female-headed households, it influenced their potential to respond to it, hence altered their gender roles. This could be therefore aggravated by the fact that that as long as agriculture continued to be rain-fed, its gender role vulnerability to climate shocks will vary in short, medium and long-term basis resulting in increased food insecurity and high poverty levels (FAO, 2018).

Relationship of male- and female-headed households' vulnerability to climate change

The results in Table 8 showed that there was a positive and significant difference between male- and female-headed households' level of vulnerability to climate change in the research area. The *t*-test values were 5.142 and 5.079 for male and female headed households, respectively, at a *p*-value of 0.04. Also, male-headed households had a mean value of 13.012and standard deviation of 0.862 whereas female-headed households had a mean value of 12.969 and standard deviation of 0.794. These findings suggest that male-headed households were less vulnerable to climate change compare to their female-headed household counterpart in the study area. Suhiyini et al. (2019) opined that female-headed households were significantly more vulnerable to socio-demographic profile, livelihood strategies, social network, water and food than male-headed households. This makes them more sensitive to climate variability and change and also more vulnerable in terms of adaptive capacity than male-headed households. Further result in Table 8 show that the mean difference for male and female headed households was 0.043 which may be accounted for the significant difference in their level vulnerability to change in climate.

CONCLUSION AND RECOMMENDATION

Based on this study, an indicator-based approach was used to compute non-weighted composite vulnerability of male- and female-headed households to climate variability and change. It was found that female-headed households were more vulnerable to changing climate than their male counterparts. The high vulnerability of female-headed households was due to their extent of exposure and sensitivity to climate change with low adaptive capacities. The level of vulnerability of male- and female-headed households to climate change was significant and varied depending on sub-indices of exposure, sensitivity and adaptive capacity. Climate variability and sub-indices of exposure appeared to be the major stressors for both male- and female-headed households that directly influenced their agricultural production. Since vulnerability among female households was relatively high and adaptive capacity low, the study recommends good access to technology that helps farmers receive timely information on climate variables and sustainable ways to improve agriculture would help improve adaptive capacity and reduce vulnerability. Also, farmers' access to agricultural insurance scheme should be strengthened and gender-sensitive framework that could bridge the gaps between male- and female-headed households are needed to form a policy development agenda by the government in order to encourage more female households' to participate in climate change mitigation.

CONFLICT OF INTEREST

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ETHICAL COMPLIANCE

The authors have followed the ethical standards in conducting the research and preparing the manuscript.

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