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Impact of Climate Variability and Food Security Assessment among Small and Emerging Maize Farmers in North West Province of South Africa

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Abstract: This study was conducted in Nkanga Modiri Molema District Municipalities of North West Province of South Africa. The objective of the study was to determine the implication of climate change on livelihood (Household Food security) and determinants among the small and emerging small-scale maize farmers in the province. A total number of 346 questionnaires were administered to the farmers in the district using stratified random sampling technique. Data were captured and analyzed using the Statistical Package for Social Sciences (SPSS) version 23 and household food insecurity access scale (HFIAS) was employed to categories the food insecurity level. Descriptive analysis was first used to define the data followed by correlation matrix to reveal the variables that are relevant which were used in Binary Logistic regression analysis. However, the results of the analysis expounded some variables that are determinants to the impact of climate change on food security. Furthermore, the HFIAS findings elucidated that about 28.0% are mildly food insecured, 34% are moderately food insecured, while 21% are severely food insecured. It was recommended that the determinants factors such as the source of income, type of farm, land acquired, source of climate change information, the channel of information received on climate change, support received on climate change should be given more attention and addressed. Climate-smart agriculture, as well as conservative agriculture, should be introduced and improved where it has been practiced in the study area.

Keywords: Binary Logistic Regression, Climate change, Maize farmers, HFIAS, North West.

INTRODUCTION

The impact of climate change on livelihood is seen to be devastated as it affects the farming household negatively. Todaro and Smith [1], posited that the worst impact of climate change would be felt by the less resourced which results in poor livelihood status. A study conducted by Deressa *et al.*, [2] revealed that Africa's agriculture is badly affected by climate change. This is also supported by Apata *et al.*, [3] who maintained that Africa is generally acknowledged to be the continent most vulnerable to climate change. Fischer *et al.*, [4] asserted that developing countries had been more vulnerable to climate change than developed countries because of the predominance of agriculture in their economies and scarcity of capital for adaptation measures. Climate change could be viewed as one of the severe environmental menaces to livelihood, food insecurity and low agricultural productivity. According to Ziervogel *et al.*, [5] climate change is attributable to the natural climate cycle and human activities, which have adverse effects on agricultural production in Africa. The impact of climate change on food security results into hunger and malnutrition. A substantial number of studies have been conducted to examine the influence of climate change on crop yields and on agriculture in sub-Saharan Africa [6-8] hence, all revealed a negative impact on agriculture, food security, and production.

Livelihood capitals and agriculture have a common relationship as the majority of the household in the developing countries depend on agriculture directly or indirectly. This threatens rural livelihood capitals especially in sub-Saharan African resulting into poverty. The natural capital livelihood of the farm household is most affected followed by the financial capital livelihood. Food security is an example of social livelihood capital. Climate change and food security cannot be detached from each other as the impact of climate change is seen on agriculture and food production. Food security is defined by the United Nations' Food and Agricultural Organization (FAQ) as (i) the availability of sufficient quantities of food of appropriate quality, supplied through domestic production or imports; (ii) access by individuals to adequate resources for acquiring appropriate foods for a nutrients diet; (iii) utilization of food through adequate diet, clean water, sanitation, and healthcare to reach a state of nutritional well-being where all physiological needs are met; and (iv) stability, because to be food secured, a population, household or individual must

have access to adequate food at all times [9]. According to the United Nations' Committee on World Food Security, food security is referred to as the condition in which all people, at all times, have physical, social and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. FAO [10] referred household food security as physical and economic access to adequate food for all household members without undue risk of losing such as access.

Problem statement

Climate change significantly affects rural communities particularly in Africa who depend on agriculture and natural forest resources for their livelihoods [11, 12]. Food and Agriculture Organization [13], reported that climate change is taking place in the context of other developmental stress such as poverty, low food production and many more. The challenge is that climate change threatens livelihood which gives rise to a high rate of unemployment as climate events destroy farm produce in the study area. In North West Province, poverty levels are high in the rural areas where most people depend on agriculture for their livelihoods. The proceeds from agriculture are a source of income to sustain and maintain a livelihood. The challenge here is that environmental and social consequences of climate change put livelihoods at serious risks of hunger, poverty, low farm income and makes it more difficult to reduce the proportion of people living in extreme poverty [12]. Changes in the rainfall pattern greatly affect biodiversity as well.

A noticeable gap and shortcomings were that rural livelihood is affected by climate change resulting in socio-economic problems such as poverty, hunger, low income, low food production, unemployment etc. However, a major focus has been on a national level, the lack of research findings to integrate activities, policies and agricultural practices to improve rural livelihood. This study is intended to fill in the gap by examining the impact of climate change on rural livelihood in the North-West province of South Africa, add to the existing literature, develop policy measures, agricultural practices and framework to improve rural livelihoods in response to climatic change and contribute to the body of knowledge.

Thus, there is a need to study the effect of climate change on livelihood, adaptation and mitigation strategies among small and emerging maize farmers. This will provide a sufficient reason to explore the effect of climate change on livelihood. The findings obtained will enable small and emerging scale maize farmers in the study area to understand better, the concept of climate change and livelihood. Policy makers and the stakeholders may also use the recommendation from the study to advice farmers about climate change effects and practices to improve farmers' livelihood.

METHODOLOGY

Data were collected using questionnaires, which consist of a logical flow of questions related to climate change and food security. Stratified sampling technique was used to administer the questionnaires to the farmers. The data were captured and analyzed using SPSS software and XLSTAT. Correlation matrix analysis was obtained to identify the variables that are associated with the study from the wide list of variables obtained from the questionnaires after which binary logistics regression model (BLRM) was used to determine if a household is food secured or not. Logistic regression is a multivariate technique used to study the relationship between a dichotomous dependent variable and one or more independent variables [14]. A dichotomous variable is a variable that takes only two values, 1 and 0 respectively.

Let Y be a binary response variable:

Y_i = 1 Household Food Secure i
Y_i = 0 Household Food Insecure i

$X = (X_1, X_2 \ldots\ldots X_k)$ be a set of explanatory variables which can be discrete, continuous, or a combination. x_i is the observed value of the explanatory variables for observation i. In this section of the notes, we focus on a single variable X.

Assuming that household food security is the function of household gender (x1), household age (x2), farming as a major income (x3), type of farm (x4) ….xn. The initial model will be given as:

$$\text{Logit}(\pi_i) = \log\left(\frac{\pi_i}{1-\pi_i}\right)$$
$$= \beta_0 + \beta 1 x_1$$
$$= \beta_0 + \beta 1 x_{i1} + \ldots\ldots + \beta k x_{ik}$$

Then the logistic regression model can be expressed as:

$$\text{Logit}(\pi i) = \log\left(\frac{\pi_i}{1-\pi_i}\right) = \beta 0 + \beta 1 X i \quad (1) \text{ or}$$

$$\pi i = \frac{exp\,(\beta 0+\beta 1xi)}{1+exp\,(\beta 0+\beta 1xi)} \quad (2)$$

$$Y= \alpha + \beta 1x_1 + \beta 2x_2 + \beta 3x_3 + \beta 4x_4 + \beta 5x_5 + \ldots\ldots + \beta kx_k + \varepsilon$$

Where,

The variable Ɛ is called the error term or disturbance. It is termed "noise" reflecting other factors that influence climate change awareness. It captures the factors other than x affecting y.

Y = dependent variable
×i = independent variables
βi = regression coefficients
α = is the constant term

The model for logistic regression analysis assumes that the outcome variable, Y, is categorical (e.g., dichotomous), taking on values of 1 (i.e., yes) and 0 (i.e., no). Hypothetically, population proportion of cases for which Y = 1 is defined as p = P (Y =1). Then, the proportion of cases for which Y = 0 is 1 - p = P (Y = 0). In the absence of other information, we can estimate p by the sample proportion of cases for which Y = 1. However, in the regression context, it is assumed that there is a set of predictor variables, X1...Xk, that are related to Y and, therefore, provide additional information for predicting Y.

Logit (Pi) = ln (Pi / 1-Pi) = α + β1×1 + …+βn ×n + Ut

Where,
ln (Pi / 1-Pi) = logit for farmers awareness choices (Yes or No)
Pi = Household food secure;
1 - Pi = Household food unsecure;
β = coefficient
×1 = covariates
Ut = error term

When the variables are fitted into the model, the model is presented as:
ln (Pi / 1-Pi) = α + β1×1 + β2×2 + β3×3 + β4×4…..+ Ut.

In other to determine the food security level or category, Household Food Insecurity Access Scale (HFIAS) Generic Questions were used, which consists of 9 questions as being listed below:

- In the past four weeks, did you worry that your household would not have enough food?
- In the past four weeks, were you or any household member not able to eat the kinds of foods you preferred because of a lack of resources?
- In the past four weeks, did you or any household member have to eat a limited variety of foods due to a lack of resources?
- In the past four weeks, did you or any household member have to eat some foods that you really did not want to eat because of a lack of resources to obtain other types of food?
- In the past four weeks, did you or any household member have to eat a smaller meal than you felt you needed because there was not enough food?
- In the past four weeks, did you or any household member have to eat fewer meals in a day because there was not enough food?
- In the past four weeks, was there ever no food to eat of any kind in your household because of lack of resources to get food?
- In the past four weeks, did you or any household member go to sleep at night hungry because there was not enough food?
- In the past four weeks, did you or any household member go a whole day and night without eating anything because there was not enough food?
- HFIA category variable is calculated for each household by assigning a code for the food insecurity (access) category in which it falls.

HFIA category	Calculate the Household Food Insecurity Access Category for each household. 1 = Food Secure, 2=Mildly Food Insecure Access, 3=Moderately Food Insecure Access, 4=Severely Food Insecure Access HFIA category = 1 if [(Q1=0 or Q1=1) and Q2=0 and Q3=0 and Q4=0 and Q5=0 and Q6=0 and Q7=0 and Q8=0 and Q9=0] HFIA category = 2 if [(Q1=2 or Q1=3 or Q2=1 or Q2=2 or Q2=3 or Q3=1 or Q4=1) and Q5=0 and Q6=0 and Q7=0 and Q8=0 and Q9=0] HFIA category = 3 if [(Q3=2 or Q3=3 or Q4=2 or Q4=3 or Q5=1 or Q5=2 or Q6=1 or Q6=2) and Q7=0 and Q8=0 and Q9=0] HFIA category = 4 if [Q5=3 or Q6=3 or Q7=1 or Q7=2 or Q7=3 or Q8=1 or Q8=2 or Q8=3 or Q9=1 or Q9=2 or Q9=3]

The Household Food Insecurity Access Prevalence was used to determine the percentage of household food security status. Food security levels were measured using the United States Agency for International Development Household Food Insecurity Access model. This study measures household food security by directly using the questionnaire-based techniques developed by Coates *et al.*, [15] for the United States Agency for International Development (USAID). These techniques and measurements are applied to the person most responsible for food and food provision in households. Indirect measures of food insecurity are: utilization of food security-related programs, income-based measurements of poverty, anthropometric measures, financial hardship indicators, dietary intake, and other nutrition and health parameters severely food insecure [16]. The HFIA categories households into four levels of household food insecurity (access): food secure, and mild, moderately and severely food insecure. Households are categorized as increasing food insecure as they respond affirmatively to more severe conditions and/or experience those conditions more frequently [15].

RESULTS AND DISCUSSION

Correlation analysis was used to find the relationship of a numerous number of independent variables that are related to the objective of the study as listed on the questionnaire. The result showed the following independent variable; household size, household gender, household age, the source of income, type of farm, land acquired, the source of information on climate change, channel of information received on climate change, support received on climate change are correlated to the dependent variable (food secure).

Source of income was statistically significant ($p<0.05$) and had a negative relationship to the objective of this chapter. Farmers who had no other job or extra source of income other than their farming activities (maize farming production) tend to be more knowledgeable, aware and adapt to climate change. They were concerned about their environment in relation to their farming activities because they needed to provide for their households and be food secured. They were, therefore, more conscious of the impact of climate change as an environmental factor responsible for low food production, unlike farmers who had other sources of income besides farming. Chigavazira [17] reported that household income is affected by climate change which results in low food production. In Indonesia [18], a decrease in rainfall in the 90-day period after the monsoon is associated with a 14 percent decline in per capita expenditures other than food. In the Philippines, climate variability, and in particular negative rainfall shocks, reduce household expenditures on food [19].

The type of farm from table 4, was significant ($p<0.05$) and showed a positive relationship on the impact of climate change on household food security. The result indicated that the type of farm was statistically significantly different to the impact of climate change on household food security. Various types of the farm such as individual farm, family farm, community farm, company farm and tribal farm were considered during the data collection, however irrespective of the farm type, the impact of climate change was observed which affect the household food security. This could be attributed to the fact that, a majority of the farmers' ranging from individual to tribal farm type depends largely on agriculture (maize production) to make their income. The majority of the farmers had no non-farm income, however, whatever type of farm they had, it's being maximized to realize an optimum profit.

The land is a fundamental factor of production in the agricultural sector. It has an essential role to play in increasing as well as sustaining agricultural production. Land acquisition was statistically significant ($p<0.05$) with a positive relationship to the objective of this chapter. The result showed how farmers acquire the land increased the probability of the impact of climate change on household food security by 20.7 percent. Farmers acquired lands through own finance, bond, LRAD, PLAS, restitution, inheritance, land affairs, and land hiring. Whatever land acquiring method used, it has an impact on food production in terms of quantity of food produced as a result of the availability of land space and its influence on the climate change and its variability. Cotula *et al.*, [20] reported that the issue of large-scale foreign land acquisitions is now a hot issue, especially in Africa. According to Kihwan Seo and Natalia Rodriguez [21] causal relationships among climate change, food security, and land grab make the current situation worse in Global South, where people already have been suffering from food shortages and severe weather events, and increase vulnerability to climate change. Each of these three elements adversely affects people in Global South in different ways that particularly threaten their livelihood, safety, and health.

Source of climate change information has a negative relationship on household food security and it was statistically significantly ($p<0.05$). It shows that source of information decreased the probability, or the likelihood decreased by 40.4 percent. There are different sources of information available for the farmers in the study area, which includes: flyers, magazine, radio, local newspapers, the internet, and the extension officers. The major source of information is the radio, farmer to farmer extension and extension officers. The source from which information is being received determined the effectiveness and farmers' adoption on adaptation which enhances food security. The same reported was made by Gabriel *et al.*, [22] farmers need information on the weather and climatic variations and extension agents are expected to be in regular contact with the farmers to disseminate information.

Information channel plays a crucial role in promoting *agricultural* productivity, increasing food security, improving rural livelihoods, and promoting *agriculture* as an engine of pro-poor economic growth. The channel of information on climate change increased the likelihood or the probability of food security by 32.9 percent and it was statistically significant ($p<0.05$). This could result from the fact that, extension officer works directly, hand in hand, visiting, assessing farmers' problems which become more effective and efficient for farmers to adopt innovations which can enhance their food production. Extension services provide an important source of information on the impact of climate change on household food security, as well as agricultural production and management practices. According to Nhemachena [23] better access to crop and livestock extension services has a strong and positive impact on climate adaptation strategies which has an influence on household food security. Benhin [24] noted that farmers' level of education and access to extension service are major determinants of adaptation measures to climate change. Improving access to extension services for farmers has the potential to significantly increase farmer awareness of changing climatic conditions as well as adaptation measures in response to climatic changes [25].

Institutional support received on climate change impact was statistically significant. The variable has a negative relationship with likelihood decreased by 17.8 percent. The support received by the farmers includes formal credit, insurance, farmer to farmer extension, relatives, subsidies. According to Gina and Ericksen [26] it was reported that institutional support for adaptation to food security is needed for rural farmers.

Table-1: Descriptive statistics of the variables

Description of Variables	N	Range	Minimum	Maximum	Mean		Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
Are you food secured Yes = 1; No = 0	346	1	1	2	01.72	0.024	0.451	0.204
Household Size 1-3 = 1, 4-6 = 2, 7-9 = 3, 10-12= 4, 13-15 = 5	346	4	1	5	2.13	0.058	1.073	1.151
Household Gender Male = 1, female = 2	346	1	1	2	1.16	0.020	0.366	0.134
Household Age 18-30 = 1, 31-40 = 2, 41-50 = 3, 51-60 = 4, 61-70 = 5, 71-80 = 6	346	5	1	6	3.45	0.077	1.432	2.051

Farming As Major Income Yes = 1; No = 0	346	1	1	2	1.29	0.025	0.457	0.208
Types of Farm Individual Farm = 1, Family Farm = 2, Community Farm = 3, Company Farm = 4, Tribal Farm = 5, Other = 6	346	4	1	5	2.06	0.075	1.386	1.921
How Do You Acquire the Farm Own Finance = 1, Bond = 2, LRAD = 3, PLAS = 4, Restitution = 5, Inheritance = 6, Land Affairs = 7, Land Hiring= 8	346	7	1	8	5.09	0.110	2.048	4.194
Source Of Information on Climate Change Flyers = 1, Magazines = 2, Radio = 3, Local Newspapers = 4, Internet = 5, Extension Officer = 6, None = 7	346	6	1	7	3.25	0.048	0.897	0.805
What Channel Information Is Being Received on climate change Formal extension =1, Farmer to Farmer = 2 Family support = 3, Neighbours = 4, Municipalities office =5, Other = 6, None =7	346	6	1	7	2.14	0.066	1.226	1.504
Support Received on climate change Impacts Formal credit =1, Insurance = 2, Farmer to Farmer extension = 3, Relatives = 4, Subsidies = 5, Other = 6, None = 7	346	6	1	7	4.87	0.125	2.316	5.366
Valid N (listwise)	346							

Size Sample = 346

Table-2: Distribution of respondents according to food security status in the study area

	Food Secured	Frequency	Percent
	Yes	98	28.3
	No	248	71.7
	Total	346	100.0

Parameter estimates of the binary logistics regression model on food security and its determinants

Variables		B	S.E.	Wald	df	Sig.	Exp (B)
Step 1[a]	Household Size	0.109	0.128	0.715	1	0.398	1.115
	Household Gender	-0.661	0.366	3.258	1	0.071	0.516
	Household Age	0.030	0.118	0.066	1	0.797	1.031
	Source of Income	-0.953	0.324	8.678	1	0.003	0.386
	Type of Farm	0.381	0.137	7.785	1	0.005	1.464
	Land Acquire	0.207	0.070	8.697	1	0.003	1.230
	Source of Climate Change Information	-0.404	0.137	8.716	1	0.003	0.668
	Channel of Information on Climate Change	0.329	0.157	4.412	1	0.036	1.390
	Support Received on Climate Change	-0.178	0.067	6.997	1	0.008	0.837
	Constant	2.526	0.991	6.493	1	0.011	12.497

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	332.235[a]	0.207	0.297

Source: Authors Computation, (2017).

Noted: $p < 0.05$; $p < 0.01$ is significant at 5% and 1% respectively.

Descriptive statistics to show what has happened in the past 30 days on Household Food Insecurity (Household Food Insecurity Access Scale (HFIAS) Generic Questions).

Table-3: Distribution of households worrying about not having enough food

	Households	Frequency	Percent
	Never	20	5.8
	Rarely	21	6.1
	Sometimes	173	50.0
	Often	132	38.2
	Total	346	100.0

Table-4: Distribution of households not eating preferred meal

	Households	Frequency	Percent
	Never	27	7.8
	Rarely	16	4.6
	Sometimes	189	54.6
	Often	114	32.9
	Total	346	100.0

Table-5: Distribution of households eating few kinds of food

	Households	Frequency	Percent
	Never	13	3.8
	Rarely	15	4.3
	Sometimes	200	57.8
	Often	118	34.1
	Total	346	100.0

Table-6: Distribution of households eating foods not preferred due to lack of resources

	Households	Frequency	Percent
	Never	41	11.8
	Rarely	30	8.7
	Sometimes	193	55.8
	Often	82	23.7
	Total	346	100.0

Table-7: Distribution of households eating smaller meals due to not having enough food

	Households	Frequency	Percent
	Never	46	13.3
	Rarely	51	14.7
	Sometimes	181	52.3
	Often	68	19.7
	Total	346	100.0

Table-8: Distribution of households eating fewer meals due to lack of food accessibility

	Households	Frequency	Percent
	Never	54	15.6
	Rarely	35	10.1
	Sometimes	151	43.6
	Often	106	30.6
	Total	346	100.0

Table-9: Distribution of households with no food due to lack of resources

	Households	Frequency	Percent
	Never	120	34.7
	Rarely	37	10.7
	Sometimes	124	35.8
	Often	65	18.8
	Total	346	100.0

Table-10: Distribution of households going to bed hungry due to lack of food

	Households	Frequency	Percent
	Never	124	35.8
	Rarely	35	10.1
	Sometimes	106	30.6
	Often	81	23.4
	Total	346	100.0

Table-11: Distribution of households spending the whole day without eating any food.

	Households	Frequency	Percent
	Never	117	33.8
	Rarely	48	13.9
	Sometimes	109	31.5
	Often	72	20.8
	Total	346	100.0

Household Food Insecurity Assess (HFIA) Category

Food and Nutrition Technical Assistance (FANTA) reported that a food secure household experiences none of the food insecurity (access) conditions, or just experiences worry, but rarely. A mildly food insecure (access) household worries about not having enough food sometimes or often, and/or is unable to eat preferred foods, and/or eats a more monotonous diet than desired and/or some foods considered undesirable, but only rarely. But it does not cut back on quantity nor experience any of three most severe conditions (running out of food, going to bed hungry, or going a whole day and night without eating). A moderately food insecure household sacrifices quality more frequently, by eating a monotonous diet or undesirable foods sometimes or often, and/or has started to cut back on quantity by reducing the size of meals or number of meals, rarely or sometimes. But it does not experience any of the three most severe conditions. A severe food insecure household has graduated to cutting back on meal size or a number of meals often, and/or experiences any of the three most severe conditions (running out of food, going to bed hungry, or going a whole day and night without eating), even as infrequently as rarely. In other words, any household that experiences one of these three conditions even once in the last four weeks (30 days) is considered.

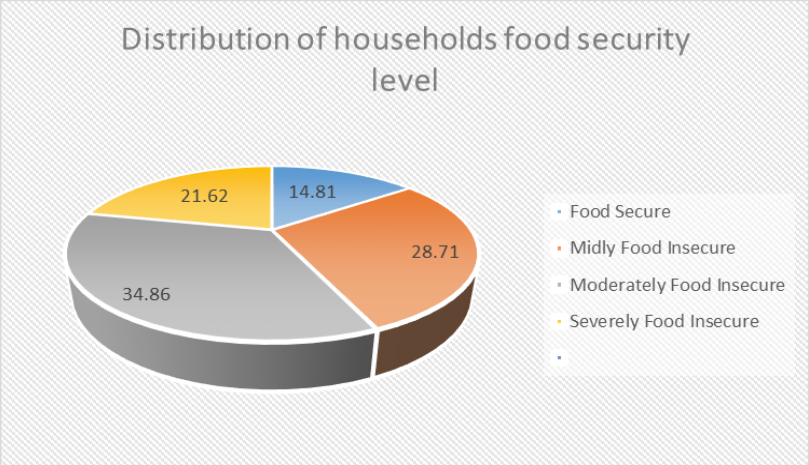

Fig-1: Percentage distribution of household food security level (HFIA Categories).

The findings from figure 1 above, indicated that 14.81 percent of households are food secure, 28.71 percent are mildly food insecure, 34.86 percent are moderately food insecure, while 21.62 percent are severely food insecure. This shows that majority of the household need to be food secured, several measures have to be put in place to increase food production and farmers' livelihood.

CONCLUSION

This study assessed the implication of climate change on livelihood, adaptation and mitigation strategies. However, the impact was observed on the household food insecurity as well as the factors responsible. It explored household food insecurity assess (HFIA) category and distribution of household food security level. In achieving these, correlation and binary logistics regression were used. Firstly, the correlation matrix helped to analyze independent variables that are related and correlated to the climate change and household food insecurity. Binary logistics statistics analysis revealed variables that determine the impact of climate change on household food insecurity among the small and emerging maize farmers in the study area. There was a statistically significant difference between the impact of climate change on household food insecurity and the following variables; source of income, type of farm, land acquired, the source of climate change information, the channel of the information on climate change, support received on climate change. This revealed that attention is much more needed on the variables that are significant in other to enhance and strengthen household food security in the face of climate change impact.

Descriptive statistics showed the Frequency distribution what has happened in the past 30 days on Household Food Insecurity. There were 9 questions which were asked from the households. The questions were referred to as Household Food Insecurity Access Scale (HFIAS) Generic Questions, which measured household food security by directly using the questionnaire-based techniques developed by Coates *et al.*, [15] for the United States Agency for International Development (USAID). Household Food Insecurity Access Prevalence was used to determine the percentage of household food security status. The HFIA categories households into four levels of household food insecurity (access): food secure, and mild, moderately and severely food insecure. However, the result of the HFIA showed the percentage distribution of household food security level in which 14.81 percent of households are food secure, 28.71 percent are mildly food insecure, 34.86 percent are moderately food insecure, while 21.62 percent are severely food insecure. This depicted that only a few of the household is food secured.

It is recommended that farmers should be taught, trained and educated on the different method of farming such as conservation agriculture (CA), climate-smart agriculture (CSA), sustainable farming (SA) and different adaptation measures as well as indigenous knowledge in other to adapt to climate change variability and events. The activities of extension services should be increased as many farmers claimed they are not well reached and supported. Farmers' support or group or cooperative should be encouraged among the farmers. The government should provide resources at the local level and endeavor the resources are channeled and received by the right people. The youth should also be encouraged in farming, perhaps through value-driven agricultural production in other to increase agricultural produce which as result can reduce the importation of food.

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