CLIMATE-SMART AGRICULTURAL PRACTICES, PRODUCTIVITY AND FOOD SECURITY STATUS OF ARABLE FARMING HOUSEHOLDS IN NORTH-WESTERN NIGERIA

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CERTIFICATION

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DEDICATION

This thesis is dedicated to the Almighty God for His benevolence, grace and mercy given to me all through this programme. He has been my very present help at all times.

To my wife (Charity) and children (Lincoln, Christabel, Dorathy and Reinhard) for their unending love, support and care that kept me going. Thanks for always being there for me.

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ABSTRACT

The challenge of food insecurity still persists irrespective of the various climatic adaptation strategies adopted by arable farming households to improve crop productivity. Climate-Smart Agricultural Practices (CSAP) are vital tools for curbing the menace on agriculture. There are scanty empirical results on CSAP, its effect on productivity and food security among arable farming households. Hence, the effect of CSAP on productivity and food security status of arable farming households in North-western Nigeria were investigated.

A four-stage sampling technique was adopted. Katsina and Sokoto States were randomly selected. Ten Local Government Areas (LGAs) were randomly selected from Katsina (six) and Sokoto (four) proportionate to size. Additionally, 30 villages were randomly selected from all the LGAs proportionate to size. Thereafter, 577 households were randomly selected from all the villages. Using structured questionnaire, data were collected on socio-economic characteristics (age, household size, sex, marital status and education), enterprise characteristics (farm size, farming experience, livestock ownership and land ownership), level of use of CSAP and farmers' perception of climate change impact. Farming households were categorised into levels of use of CSAP using composite score [low-user (0-3), medium-user (4-6) and high-user (7-10)]. Data were analysed using descriptive statistics, adaptation strategy use index, ordered probit, Total Factor Productivity - TFP [deteriorating level (<1) and progressive level (≥ 1)], ordinary least square regression, cost-of-calorie measure and binary logit model at $\alpha_{0.05}$.

Age of household heads was 48.4±9.8 years with household size of 10.9±5.7 persons. Most of the household heads were male (91.0%), married (92.2%) and acquired quaranic education (45.1%). Farm size and farming experience were 4.2±3.3 hectares and 25.6±10.9 years, respectively, with majority owning livestock (84.9%) and inherited land (77.5%). The low-user, medium-user and high-user households were 18.4%, 57.5% and 24.1%, respectively. Farmers' perception of climate change impact were increasing temperature (74.5%), decreasing rainfall (74.2%), negative impact on crop yield (72.3%), short duration of rainfall (61.9%) and severe impact of drought (12.3%). Use of organic manure (2.316), conservation agriculture (1.902), crop diversification (1.878), planting of cover crops (1.863) and crop rotation (1.731) were the most used CSAP. High-user of CSAP were influenced positively by age of household head (β=0.09), sex of household head (β=0.49), farming experience (β=0.02), livestock ownership (β=0.28) and membership of a social group (β=0.41). The TFP of most household heads were at deteriorating level (63.0%), while 37.0% were at progressive level. Seed (β=0.01), organic manure (β=0.0002) and being a high-user of CSAP (β=0.60) increased TFP, while labour (β=-0.01) and inorganic fertiliser (β=-0.001) decreased TFP. Food insecurity line was estimated as ₦79.06/day. About 44.0% of the arable farming households were food secure, while 56.0% were food insecure. Food security status increased with being a male headed household (ME=0.15), education (ME=0.01), non-farm income (ME=2.11e-06) and being a high-user of CSAP (ME=0.23), but decreased with household size (ME=-0.07).

High level of use of Climate-Smart Agricultural Practices improved productivity and food security status of arable farming households in North-western Nigeria.

Keywords: Arable crop farmers, Climate change, Total factor productivity, Food security.

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CHAPTER ONE

INTRODUCTION

1.1. Background to the study

In most of the developing countries, the agricultural sector offers the primary source of livelihood as well as jobs for majority of its populace and also donates a very significant portion to Gross Domestic Product (GDP) (Olajide *et al*., 2012). Consequently, when climate change reduces production in agriculture, it affects the food security status of the rural poor seriously and likewise worsens their livelihood conditions (Commission for Africa, 2005). In the definition of Nwosu (2012), climate change is seen as any alteration in the normal weather condition of a place over time. This could be caused by natural circumstances or human operations leading to environmental degradation. In the opinion of Onu and Ikehi (2015), climate change is concerned with changes in weather, which brings about a digression from the usual rainfall regime (pattern or intensity), temperature, relative humidity wind as well as solar radiation over a period of 30 years and above. There are five key factors reported by World Bank (2007) by which climate change affect agricultural crops production. These factors include temperature, precipitation change, climate variability, fertilisation by carbon dioxide (CO_2) and surface water overflow.

Climate change remains a serious danger to agricultural productivity and likewise affects the poverty alleviation programmes in poor and vulnerable parts of the universe, that rely mainly on rain fed agriculture. Although climate change has strong impact on health, water resources and land use, coastal infrastructure and environment, the most affected is agriculture especially in a growing economy like that of Nigeria where irrigation is seldom practiced. This is because agriculture is greatly predisposed to weather extremes like floods, droughts and storms (Onu and Ikehi, 2015). The research work of Singh *et al*. (2013) revealed that agricultural production activities could be significantly impacted by a rise in temperature, changing pattern of rainfall, deviations in regularity of occurrence and degree of extreme climatic event.

Deressa *et al*. (2005) also noted that agricultural activities are usually more susceptible to climate change effect than other sectors of the economy and that developed nations have attempted to compute the magnitude of its economic impact as it affects agriculture as compared with the developing countries that are more adversely impacted.

Ajetomobi *et al*. (2010) reported that policy makers have been concerned about the susceptibility of the Nigerian agricultural sector to climate change, since this sector is the main stay in Nigeria's economy that accounts for a little above 60% of our workforce as well as contributes 30-40% of Nigeria's GDP, which is now 24.7% as at 2020 after the rebasing (NBS, 2020). They also reported that this sector provides raw materials and likewise foreign exchange income for Nigeria. The extent to which climate change would be held responsible for modifications in Nigeria agricultural production would stay on as a research topic for long, provided other variables interact in determining agricultural productivity (Ajetomobi *et al*., 2010).

Climate-Smart Agriculture (CSA) was the key concept discussed during the first International Convention on Agriculture, Food Security as well as Climate Change in 2010, which took place at the Hague. At this conference, CSA was defined as agriculture that sustainably improves agricultural productivity and income, adapts to climate change by building resilience, removes Greenhouse Gas (GHG) emission and add to the realisation of the national food security and developmental goals (FAO, 2010). CSA has helped to direct our attention to the climate change–agriculture link and has also unified agriculture and climate change with developments as one component. After the second conference in Hanoi in 2012, the CSA sourcebook was published. This has helped to further advance the idea of Climate-Smart that would benefit first and foremost, the smallholder farmers and those who are exposed to danger in developing countries (FAO, 2013). Thus, farming households that use Climate-Smart Agricultural Practices (CSAP) will be better-off than households which did not practice it (Elizabeth and Sophie, 2014).

WHO (2013) stated that food security is achieved when all people at all times have access to sufficient, safe and nutritious food to maintain a healthy and active life. It therefore has four dimensions, which include food availability, accessibility, stability and utilisation (Ziervogel and Ericksen, 2010). According to Fadare *et al*. (2019), food and nutritional insecurity is ubiquitous in Nigeria in spite of its favourable environmental endowments. It has a total land area of 92.4 million hectares, out of which only about 35 percent are being cultivated. Nigeria therefore is deficient in capacity as well as the capability to provide for the food and nutritional requirements of its teeming populace. As such, food insecurity and the prevalence of under-nutrition in Nigeria are among the worst globally. The picture of Nigeria's food and nutrition insecurity has been on worsening trend. This is in accordance with the report of FAO *et al*. (2019), who stated that between 2004 and 2006, the total number of undernourished Nigerians was 9.1 million. This number increased to 25.6 million people or 281.32 percent between 2016 and 2018.

In the light of the above assertions, there is the need to expose our rural farming households to practices and technology that would curb the menace of climate change and improve their crop productivity to bring about food security, since the agricultural sector provides most of the food we eat. This is what CSAP tends to achieve via its 'triple win' benefits of improving food security, increasing resilience against climate change and reducing GHG emissions, if farmers are enlightened of its benefits and encouraged to practice it.

1.2. Problem Statement

Ogbuabor and Egwuchukwu (2017) reported that lower precipitation, higher temperatures, desertification and droughts reduce farmlands, lower agricultural production and affect crop yields. They also stated that increased rainfall intensity in the coastal region, sea level rise, flooding and erosion of farmland will also lower agricultural production. Northern regions of Nigeria, which have higher degrees of rurality, are more vulnerable to climate change (Madu, 2016).

Idowu *et al*. (2011) opined that climate change effects on crop production are numerous, some of which included rainfall trend variation that results in floods, high temperatures that asphyxiate crops, pest and diseases migration, irregular sunshine hours that bring about low harvest, with a record of 2.5% reduction of harvests per year. There is also an uncontrollable incidence of pest and disease under extreme weather. Flood extremes and drought feature prominently north wards of Nigeria, which affects crops production and harvests and likewise livestock production, the feed of which are mostly crop-based.

A minimum of 22% of cultivated area of significant crops around the world is predicted to have adverse effect of climate change by 2050 and 56% of these lands are in sub-Saharan Africa (SSA) (Campbell *et al*., 2011). Also, predicted estimates for 2050 showed that the joint impact of rising temperatures, reduced rainfall, droughts and frequent floods could lead to an average decrease in the crop yields for major crops like rice (14%), wheat (22%) and corn (5%), and Sub Saharan Africa's food availability will decrease on the average by 500 calories per individual, translating into 21% decline in food availability (IFPRI, 2009). The impacts may not be much up to 2050, but higher impacts are expected beyond 2050.

Boyd *et al*. (2009) pointed out that the certainty of climate change cannot be doubted anymore and proof have emerged showing that climate change portend as a major danger for developments in developing countries. They also opined that climate change has distorted both physical and human geography with significant effects on humans and that the consequences of climate change on impoverished communities in Africa is becoming more and more outstanding. Bunce *et al*. (2010) stated that Africa is turning to a significant global food crisis epicentre if the problems surrounding climate change stay unresolved. Elevated rates of poverty, rising temperatures and low rainfall have worsened African communities' exposure to climate change and trends of almost all elements of weather have become less predictable in Sub-Saharan Africa (Holmgren and Oberg, 2006). Available facts showed that with agriculture as the core source of revenue in many rural areas in SSA, any unfavourable developments that affects agriculture, would negatively affect the lives that rely on it (Biggs *et al*., 2008).

There are evidences that Nigeria is already being plagued by a variety of ecological problems directly related to climate change and the report from Elisha *et al.* (2017) on Nigeria's susceptibility to climate change confirms this. Southern Nigeria that is mainly recognized for high precipitation is facing irregularities in rainfall pattern currently, whereas the Guinea savannah conversely is facing rise in temperatures gradually. The Northern zone is facing the menace of desert intrusion yearly (Madu, 2016). This has led to the exploitation of previously undisturbed lands resulting to forest cover depletion in Nigeria's Northern zone (Odjugo, 2010). Consequently, the resourceful peasant farmers face dreadful challenge of crop failures that definitely reduces agricultural output, increase poverty as well as malnutrition (Zoellick and Robert, 2009).

Kaptymer *et al*. (2019) opined that climate change is pounding on smallholder farmers very hard, especial in Sub-Saharan African, which is most susceptible to the impacts of climate change. Therefore, Climate-Smart Agriculture works towards enhancing crop productivity in an environmentally and socially sustainable way, strengthen farmers' resilience to climate change, and reduce agriculture's contribution to climate change by reducing GHG emissions and increasing carbon storage on farmland. In spite of the potential of Climate Smart Agriculture in improving resilience and enhancing agricultural production and rural livelihoods, it is still very limited in Africa due to lack of practical understanding of the approach; lack of data and information and appropriate analytical tools at local and national levels; inadequate coordinated, supportive and enabling policy frameworks; and poor physical and social infrastructure to mention few.

This research work fills the knowledge gap in literature by investigating CSAP and its effect on crop productivity and food security in order to provide adequate data and information for policy makers and farmers at local levels (rural household level) with evidence from North-Western Nigeria.

In the light of the above challenges of climate change on crop productivity and the benefits of climate-smart agriculture on food security, this research work is thus addressing the following stated empirical research questions:

1. What is the level of use of Climate-Smart Agricultural Practices by arable farming households in the study area?
2. What are the factors influencing the level of use of Climate-Smart Agricultural Practices by arable farming households in the study area?
3. What is the effect of using Climate-Smart Agricultural Practices on crop productivity among arable farming households in the study area?
4. What is the effect of using Climate-Smart Agricultural Practices on food security status of the arable farming households in the study area?

1.3. Objectives of the study

The main objective of the study was to determine the effect of using Climate-Smart Agricultural Practices on productivity and food security status of farm households in North-western Nigeria.

The specific objectives are to:

1. Profile the level of use of Climate-Smart Agricultural Practices by arable crop farming households in the study area.
2. Determine the factors influencing the level of use of Climate-Smart Agricultural Practices by arable crop farming households in the study area.
3. Examine the effect of using Climate-Smart Agricultural Practices on crop productivity among arable crop farming households in the study area.
4. Examine the effect of using Climate-Smart Agricultural Practices on food security status of arable crop farming households in the study area.

1.4. Justification of the study

The benefits of CSAP cannot be underestimated in the face of challenges created by climate change. CSAP is a very imperative developmental approach in agriculture aimed at achieving the national goal of food security. Many countries are yet to adopt Climate-Smart Agriculture approach and its applicability has not been well studied nor been assessed in terms of its sustainability, in Nigerian and Africa, in general (Fanen and Olalekan, 2014). It is a strategy that is upcoming, which would assist rural farmers in adapting to climate change by diversifying their livelihood, and decrease their susceptibility to climate change (FAO, 2013).

Studies such as Lawal and Leo (2007), Ajewole and Iyanda (2010) and Idowu *et al*. (2011), focused on farmers' adaptation and the effect of climate inconsistency on yields of crops. Fanen and Olalekan (2014) also studied the role of CSA in combating climate change in Northern Nigeria, but this study deviated from the above stated studies and contributed to knowledge by looking at the effect of CSAP on crop productivity and food security status of farm households.

The need to carry out a research on CSAP and its effect on crop productivity and food security of rural farm household at micro level cannot be overlooked, since previous studies showed that the effect of climate change is a menace to agricultural activities in Northern Nigeria **(**Ekpoh, 2010; Sawa, 2010; Damin *et al*., 2011**)**. Also, there is scarcity of studies from micro level (rural farming household level) on CSAP and this has made it difficult to downscale existing CSA studies from regional level. This was what this study has done by filling the gap in literature with evidences from North-western Nigeria and this will be a reference material for policy makers, researchers and academicians.

In terms of methodology, various studies like Key and Mcbride (2003), Fakayode *et al*. (2008) and Umar *et al*. (2011), used the inverse of average variable cost to estimate Total Factor Productivity (TFP); Coelli and Rao (2005) and Domanska *et al*. (2014) used the malmquist index to estimate total factor productivity. Otitoju (2013) used Multinomial Logit (MNL) to determine how climate change adaptation strategies affect food crop productivity, whereas this study distinguished itself by using Fisher index to estimate TFP for its productivity measurement. As far as theoretical and test properties are concerned, the Fisher index does better and it is easier to understand. It is recommended because of its extra self-dual property and the capability to accept zero in a data set (Ogundele and Okoruwa, 2014; Diewert (1992) as cited by Fuglie *et al*., 2016). TFP as a productivity measure consists of all the factors of production. It is a measure of agricultural productivity that remedied the shortcomings of the partial measures of productivity (Adeola *et al*., 2011).

This study also distinguished itself from Omonona and Agoi (2007) and Obisesan and Omonona (2013), who used Foster and Greer Thorbecke (FGT) household food expenditure model for food security measurement, by adopting Cost-of-Calorie food security measurement as used by Ramakrishna *et al*. (2014) and Ahmed *et al*. (2015). Cost-of-calorie food security measurement goes beyond food availability and accessibility to food utilisation by giving values close to the minimum calorie requirement of the farming households. This study decomposed and disaggregated the arable farming households who were food insecure by level of CSAP used by estimating the degree of food insecurity in terms of the incidence (F_0), depth (F_1) and severity of food insecurity (F_2) as carried out in the research work of Orewa and Iyangbe (2009) and Kuwornu *et al*. (2013).

In terms of policy direction, a better understanding and assimilation of the type of CSAP operational in the area under study and likewise its effect on crop productivity and food security status of the arable farm household would facilitate the effective development of programmes that would bring about improved productivity and strengthen climate change resilience using approaches that are community driven. Furthermore, along the lines of the Sustainable Development Goal (SDG) number thirteen, which is concerned with taking urgent steps to curb climate change impacts and the Paris club agreement on climate change, which the Nigerian government is a signatory to (UNDP, 2016; Lofts *et al*., 2017), this study will enlighten policy maker and assist them in developing relevant policies that would combat the menace of climate change impact as it affects crop yield. This would go far to provide sustainable and appropriate policy solutions that would boost food security in Nigeria.

1.5. Plan of the study

This Thesis is divided into five chapters. The first chapter comprised the background to the study, problem statement, research questions, objectives and justification of the study. All these have been highlighted. The remaining chapters of this thesis are as follows.

Chapter two is composed of literature review and theoretical framework. Chapter three includes research methods, which comprises the scope of the study, collection of data and analytical framework and tools employed. Chapter four presents the results and discussion, while chapter five concludes with presentation of the summary, conclusion and policy recommendations.

CHAPTER TWO

LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1. Theoretical review

2.1.1. Theory of utility

The decision of whether or not to use any Climate-Smart Agricultural Practice (CSAP) option falls within the framework of utility (satisfaction derived) and profit maximisation (income derived) (Pryanishnikov and Katarina, 2003). Every economic agent (including subsistence rural farmers), are presumed to only use Climate-Smart Agricultural Practice if the perceived satisfaction or profit that would be derived from it, is considerably higher than what the situation would have been without using it. Even though utility is not observed directly, all economic agents detect it by the choices they make. Take for instance, any rational farmer who expects to get the best out of the present value of the future benefits of production for a specified period of time, such a rational farmer is obliged to choose wisely among a set of *k* Climate-Smart Agricultural Practice options. The i^{th} farmer will choose to use k^{th} Climate-Smart Agricultural Practice option, if he perceives that the benefits from using such option *k* far outweighs the utility derived from choosing another option (say, *p*) given as:

$$U_{ik} = (\beta_k^{'} \mathrm{X}_i + \varepsilon_k) > U_{ip}(\beta_p^{'} \mathrm{X}_i + \varepsilon_p), p \neq k \qquad (1)$$

Where: U_{ik} and U_{ip} represents the perceived satisfaction derived by the i^{th} farmer from the use of Climate-Smart Agricultural Practice options *k* and *p*, respectively; X_i represent vector of independent variables influencing the choice of the CSAP option; β_k and β_p are estimated parameters; while ε_k and ε_p are error terms that are presumed to be independent and distributed identically (Green, 2000).

Under the revealed preference assumption that a farmer would practice a Climate-Smart Agricultural Practice option that produces better profits and would not accept something else, the relationship between the observable discrete choice and the latent continuous net profit is as shown below:

$Y_{ik} = 1$, if $U_{ik} > 0$ and,

$Y_{ik} = 0$, if $U_{ik} < 0$. (2)

Y stands for the dichotomous dependent variable that take the value of 1 and 0, when the ith farmer selects a Climate-Smart Agricultural Practice option and otherwise, respectively. Therefore, the probability given that the ith farmer would prefer CSAP option *k* from the options available to him is given as:

$$P(X = 1/X) = P(U_{ik} > U_{ip}/\mathrm{X}) \quad (3)$$
$$= P(\beta_k^{'}\mathrm{X}_I + \varepsilon_k - \beta_p^{'}\mathrm{X}_i - \varepsilon_p > 0/X)$$
$$= P((\beta_k^{'} - \beta_p^{'})\mathrm{X}_I + \varepsilon_k - \varepsilon_p > 0/X)$$
$$= P(\beta^{*}\mathrm{X}_I + \varepsilon^{*} > 0/X) = F(\beta^{*}\mathrm{X}_I)$$

P stands for probability function, ε*= $\varepsilon_k - \varepsilon_p$ is the error term, whereas β*= $(\beta_k^{'} - \beta_p^{'})$ is the unknown parameters vector construed as the influencing vector of the explanatory variable influencing the choice of CSAP, and F(β*X_i), is a cumulative distribution of ε* evaluated at β*X_i. Numerous qualitative choice models (for example, logit, probit model or linear probability) can be estimated, but logit and probit models are commonly used (Green, 2003).

2.1.2. Production theory

According to Otitoju, (2013), production involves a process by which a set of inputs are transformed into output. Therefore, production economic theory gives the logical framework for researches carried out on productivity as well as efficiency. This efficiency implies achieving a production goal without waste. Most economists have developed an array of efficiency theories with the basic idea of "no waste". However, the basic idea behind every efficiency measures is the quantity of goods and services one derives from the input used. Thus, it can be considered unproductive technically, if the output derived is too small from the bundle of inputs utilised.

Two fundamental approaches for measuring efficiency exist, these are classical and frontier approach. The former is called partial productivity measure, because it focuses on output ratio to a given input. Economists have developed superior econometric techniques for evaluating productivity as well as efficiency, because they are dissatisfied with the limitations of this approach. The frontier measure of efficiency on the contrary, looks at the efficiency of firms from a different perspective. It classifies competent firms as those ones operating at the frontier of production, while the inefficient ones are those that lies beneath its production frontier (Farrell, 1957 as cited by Otitoju, 2013).

Climate-Smart Agricultural Practice (CSAP) is an input in the production process; therefore, the use of this technology would bring about improved crop yield and consequently higher income, which is the output the farmers get from their crop production activities (Elizabeth and Sophie, 2014).

2.1.3. Food security model

Food security is a difficult concept to measure as it deals in very broad terms with the production, distribution as well as consumption of food, but food insecurity on the other hand focuses more readily on measurement and analysis. It should be stressed that food security and famine and hunger are not to be confused: food security refers to the availability of food whereas famine and hunger are the consequence of the non-availability of food, that is, as a result of food insecurity. Factors that may lead to a situation of food insecurity include non-availability of food, lack of access, improper utilisation and instability over a certain time period (Napoli *et al*., 2011).

The food security model as used in this study was developed from the production and consumption behaviour of rural dwellers as stated by Kidane *et al.* (2005). The model as used by these researchers is stated as follows:

$$\Psi_i = F\left(\lambda_i = \frac{1}{\chi_i}\right) = \frac{1}{1+\omega^{-\left(\beta_i + \sum_i^k \beta_p \chi_i\right)}} \quad (4)$$

Ψ_i is probability of a farm household (i) that is food secure, while λ_i stands for food security status observed in the i^{th} household. χ_i are determinants of the i^{th} household's food security status and β_P the estimated parameters. If $\beta + \sum_{i}^{k} \beta_P \chi_i$ represent Z, then equation (4) can be stated as shown below:

$$\Psi_i = F\left(\lambda_i = \frac{1}{\chi_i}\right) = \frac{1}{1+\omega^{-Z_i}} \tag{5}$$

Looking at equation 5, the probability of a food insecure household is denoted by (1- Ψ_i), resulting to equation 6, stated as:

$$(1-\psi_i) = \frac{1}{1+\omega^{Z_i}} \tag{6}$$

Thus, the odd ratio ($\Psi_t/(1-\Psi_t)$) is represented by equation 7:

$$\left(\frac{\Psi_i}{1-\Psi_i}\right) = \frac{1+\omega^{Z_i}}{1+\omega^{-Z_i}} = \omega^{Z_i} \tag{7}$$

The natural logarithm of equation 7 above is given as:

$$Ln\left(\frac{\psi_i}{1-\psi_i}\right) = \beta + \sum_{p=1}^{k=n} \beta_{ip} + \varepsilon_i \tag{8}$$

If we rearrange equation 8, making the dependent variable to be in log odds, then the logit regression can be used to estimate the conditional probabilities as:

$$\Psi_i = \frac{\omega^{\left(\overline{\beta_0} + \sum_{i=1}^{k=n} \overline{\beta_p} \chi_{ip}\right)}}{1+\omega^{\left(\overline{\beta_0} + \sum_{i=1}^{k=n} \overline{\beta_p} \chi_{ip}\right)}} \tag{9}$$

Once the above is estimated for each sampled household, partial effect of the continuous variables on the household's food security could be derived using:

$$\delta\psi_i \big/ \delta\chi_{ip} = \psi_i (1-\psi_i) \beta_p \tag{10}$$

The discrete variable's partial effects can also be derived by calculating the estimated probability differences, as $\chi_i = 0$ and $\chi_i = 1$. In this research work, this food security situation is conceptualized in terms of the calories available to the farm households in the area studied.

2.2. Review of Literature

2.2.1. Methodological Review

This section entails the review of the models used for analyzing the objectives of this study and other relevant models used for the same purpose.

2.2.1.1. **Ordered Probit Model**

This model is the choice for the ordinal ranking of dependent variable just like the likert scale. It is considered the polytomous models and differs from the nominal (multinomial) models when the dependent variables are unordered or can assume any order (Gujarati, 2009). It is the extension of the binary choice or dichotomous models- the probit and logit models. Binary choice models are models with dummy dependent variable that take only two values which denotes a 1 or 0 (Reagle and Salvatore, 2000). Their basic framework is:

$$Y_i^* = b_0 + b_1X_1 + b_2X_2 + u_i \tag{11}$$

So that the latent (unobservable) variable (Y^*) becomes an underlying propensity for the dummy variable to take the value of 1 and likewise a continuous variable given that:

$$Y_i = 1, \text{ if } Y_i^* \geq 0 \tag{12}$$

$$Y_i = 0, \text{ if } Y_i^* \leq 0$$

Therefore;

$$\text{Prob } (Y=1 \,|X) = K(x,\beta) \text{ and} \tag{13}$$

$$\text{Prob } (Y= 0 \,|X) = 1- K(x,\beta)$$

Their extension, the ordered probit model is thus expressed:

$$Y_i^* = x'\beta + \varepsilon_i \tag{14}$$

It describes a hidden discrete random variable that underlies the ordinal response and it is a linear combination of explanatory variables, x, in addition to the error term, which has a standard normal distribution (Greene, 2008): Y_i, is the observed ordinal variable, which takes on values from 0 through ∞.

Therefore:

$$Y_i = 0, \text{ if } Y_i^* \leq 0 \tag{15}$$

$$Y_i = 1, \text{ if } 0 < Y_i^* \leq \mu_1$$

$$Y_i = 2, \text{ if } \mu_1 < Y_i^* \leq \mu_2$$

$$Y_i = k, \text{ if } \mu_{k-1} < Y_i^*$$

μ_1 and μ_2 are threshold variables in the probit model referred to as the cut points. Since μ_s (unknown parameters) are computed with b and there is an assumption of normal distribution, the model is associated with the probabilities shown below:

$$\text{Prob } (Y= 0|x) = \phi - x'\beta \tag{16}$$

$$\text{Prob } (Y= 1|x) = \phi\ (\mu_1 - x'\beta) - \phi(x'\beta)$$

$$\text{Prob } (Y= 2|x) = \phi\ (\mu_2 - x'\beta) - \phi(\mu_1 - x'\beta)$$

$$\text{Prob } (Y= k|x) = 1 - \phi(\mu_{k-1} - x'\beta)$$

This model was utilised to estimate the factors influencing the level of use of CSAP among the farming households in the study area. The three levels of CSAP used derived from the composite score estimate would form the dependent variable for the model.

2.2.1.2. **Productivity Measurement**

Increasing productivity in agriculture can enhance economic wellbeing, build up food security as well as preserve environmental resources. Productivity in agriculture is heavily affected by socio-economic forces, institutions, policies and environmental factors, therefore, agricultural productivity metrics is a better means of quantifying the impacts emanating from these factors. Partial Factor Productivity (PFP), Total Factor Productivity (TFP) and Total Resource Productivity (TRP) are the main productivity metrics categories that are measured in a production process. The PFP computes output per unit of the input, TFP estimates the ratio of all outputs to the whole inputs in the production process, which offers a better and a richer economic efficiency than

Partial Factor Productivity. TRP on its own part expands TFP by taking into consideration the non-marketable environmental goods and services that are useful in agricultural production (Fuglie *et al*., 2016)

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(i) Partial Factor Productivity (PFP)

Measures for Partial Factor Productivity **(**PFP) are easier to estimate and are easier to comprehend. However, they are inadequately used to summarize the total productivity performance in a production process. For instance, yield measures productivity for each unit of plot used. If we hold land constant, the yield would increase as other factors of production are increased. But PFP estimates would not give a comprehensive and clear picture of the effects of these other inputs put together. The PFP measures could be misleading in its evaluation of productivity performances. Hence, statistical agencies have preference for TFP, since it takes all key inputs into consideration in the process of production (Fuglie *et al*., 2016).

(ii) Total Factor Productivity (TFP)

The TFP was developed to evaluate the efficiency by which economic resources are utilised to produce economic outputs, either at the firm level or the economy as a whole. It is measured as an index that is relative to a certain base period, while the percentage difference from the base can also be computed. The TFP rate of growth can also be computed. The index for agricultural TFP offers a better accessible means for evaluating national or regional level progress toward sustainable agricultural productivity. The TFP indices for the agricultural sector have been determined for most countries, but making cross-country comparisons is difficult due to variations in the methodologies and quality of data used. TFP contrasts the growth in cumulative output quantity, with the collective quantity of land, labour, capital and other inputs in the process of production. It enlarges if output from a specified quantity of input is increased, or when less input is used to produce a specified quantity of output (Fuglie *et al*., 2016).

(iii) Total Resource Productivity (TRP)

Most current agricultural productivity metrics do not completely take into consideration the importance of using environmental goods and services in agriculture and none of these metrics deals with the significant aspects of ecological sustainability, such as resilience. This therefore, provides only a partial method for evaluating the sustainability of agricultural productivity in the long-run. Thus, TRP expands TFP to consist of non-traded environmental goods and services used for production in agriculture. The Organisation for Economic Cooperation and Development (OECD) considers TRP as an environmentally-familiar TFP, which linked TRP with green growth accounting, with the aim of adding these estimations in the statistics of national economic development (Fuglie *et al*., 2016). The benefits derived from TRP are explicitly considered. However, there are no all-inclusive group of agricultural environmental indicators and total resource productivity indices and it is still uncertain how these goods and services would be incorporated and how it can be assessed (Fuglie *et al*., 2016).

2.2.1.3. **Total Factor Productivity (TFP) Measurements**

Parametric and non-parametric approaches are the two key approaches used for measuring TFP (Griliches 1996 as cited by Fuglie *et al*., 2016). The parametric approach entails the econometric model in the production function, which usually utilizes the regression methods in estimating the link that exist between total input and total output. Once this attributable is determined, the unexplained output that emanate from the regression is considered as a TFP measure. Also, Growth accounting, which is a major non-parametric approach, is the foundation on which "Törnqvist" and "Fisher" indices were built. Here, output and input prices are used to estimate the total output-input ratio, termed TFP (Diewert 1992 as cited by Fuglie *et al*., 2016). Directional distance function is also a non-parametric method used, when information on price is not available. This involves linear programming solutions, which uses data based on quantity to mark out the productivity frontier. An example of this is the Malmquist index (Coelli and Rao, 2005).

(a) The Malmquist Index

Mathematical programming methods, such as Data Envelopment Analysis (DEA) or Stochastic Frontier Analysis (SFA) can be used to estimate the Malmquist Index without using price data (Coelli and Rao, 2005). It is described using distance functions. A distance function shows how far the present productivity of a country is from a productivity frontier (when comparing productivity among countries), in which the frontier is characterized by the most productive countries (Coelli and Rao, 2005). The gap between a country and the frontier indicates relative efficiency of a country.

Due to technical change over time, the frontier shifts out. A development in TFP can be achieved by either improving efficiency (closing the gap between a country and the frontier) or by technical change. Practically, in order to trace the productivity frontier, a Malmquist index needs data on numerous countries. Countries used for the analysis are situated in accordance with how far they are from the frontier, depending on what has been achieved by those on the productivity frontier (Coelli and Rao, 2005).

(b) The Törnqvist Index

Törnqvist index is referred to as the "gold standard" for TFP measurement among many index formulae available in practice, since the Törnqvist index has some desirable properties relative to other index formulae. First, the index is connected to an elastic production function and its interpretation is clear economically (Diewert, 1992 as cited by Fuglie *et al*., 2016). Secondly, it works better for constructing productivity index and likewise accomplish 21 logical axiomatic tests (like the Fisher index), which makes it better than other indices (Fisher, 1922 as cited by Fuglie *et al*., 2016). Thirdly, it gives a better functional form in which the TFP growth is estimated, the estimation process is simplified and the cross-country as well as the cross-region evaluations are facilitated.

Therefore, TFP is estimated by the Törnqvist index as:

$$TFP_t = \frac{Y_t}{X_t} \tag{17}$$

$$\frac{\Delta TFP_t}{TFP_t} = \frac{\Delta Y_t}{Y_t} - \frac{\Delta X_t}{X_t} \tag{18}$$

Where $T\text{FP}_t$ implies TFP level, Y_t quantifies total output, and X_t computes all the inputs utilised at time t. These three terms, $\Delta T\text{FP}_t$, ΔY_t, and ΔX_t depict magnitude of change for each term over time. Technological progress and efficiency enhancement are determined by TFP level and TFP growth. However, TFP levels is complex than TFP growth, as it involves a greater concentration on what makes up the input used and output realised from the production process as well as their quality (Fuglie *et al*., 2016). To compute agricultural levels of TFP level and TFP growth with the help of equations (17) and (18), it is necessary to consistently add up the inputs and outputs using their respective prices as weights based on an index formula. Therefore, an index measure will be created for cross-sectional or trans-temporal comparison, when a benchmark is selected (Diewert 1992 as cited by Fuglie *et al*., 2016).

However, one of the shortcomings of the Törnqvist index in measuring the TFP levels and growth in the agricultural sector is its need for annual statistics on both the quantities and prices of all the outputs and inputs in adequate details in order to make these measures comparable. Other shortcoming is inadequate data on prices of commodities and inputs. One way to handle this is to compute data on price obtained from other countries as it relates to agricultural system (Fuglie *et al*., 2016).

(c) The Fisher Index

According to Diewert (1992) as cited by Fuglie *et al*. (2016), Fisher index has a very good performance in both theoretical and test properties. Another issue that favours Fisher index is that it exhibits the self-dual property, which suits the factor-reversal test. Fisher index is described in terms of Laspeyres and Paasche indices and it is a geometric mean generated from the Laspeyres and Paasche indices. Thus, it is simpler to comprehend and has the ability to handle zero quantities in a data set. The Fisher index fulfils the conditions of the factor-reversal test that ensures a correct breakdown of the change in price and quantity. This is the reason why the Fisher formula is labelled the "ideal index". This factor-reversal quality indicates that direct Fisher quantity index is not different from indirect quantity index obtained by collapsing the value index using Fisher price index and that this index is precise and superlative.

The decision on which of the TFP indices is the best to be used for measuring TFP is fundamentally between the Fisher and Tornqvist indices. This is because the two indices have significant properties that suit numerous axioms. If both indices are worked out for similar periods, the difference in their estimations is likely to be relatively minimal in terms of numerical values (Ogundele and Okoruwa, 2014).

(d) Determinant of Total Factor Productivity (TFP)

Hussain and Perera (2004) reported that factors that determine productivity in agriculture included socio-economic factors, climatic factors, agronomic factors, land and water related factors, farm management factor, etc. Other factors accountable for agricultural productivity change as reported by Fakayode *et al*. (2008) included technology, labour employment, land ownership rights, fund, education and agroenvironmental conditions. Adeola *et al*. (2011) used variables such as farm size, fertiliser, labour, seed and insecticide in their research work as determinants of Total Factor Productivity.

2.2.1.4. **Ordinary Least Square (OLS) Regression Model**

Multiple regression analyses are used to test hypotheses on the link that exist between continuous dependent variable and two or more explanatory variables (Reagle and Salvatore, 2000). The OLS multiple regression technique, when run on statistical packages like STATA, give the regression coefficients (β_i) for the explanatory variables, coefficient of multiple determination (R^2), F-statistics, standard errors and the t-values. The best fit equation will then be selected base on the signs of the coefficient, t-value, coefficient of determination (Adjusted R^2) and number of significant variables as lead equation (Gujarati, 2009).

The OLS regression model can be stated as:

$$Y_i = \alpha + \beta_i X_i + e_t \qquad (19)$$

Where, Y_i = dependent variable

X_i = explanatory variables

α = constant term

β_i = parameter estimates

e_t = error term

The model is expressed as:

$$Y_i = f(X_1, X_2, \ldots\ldots\ldots, X_7, e_t) \qquad (20)$$

OLS regression model can be expressed in any of the following functional forms. These include linear, semi-logarithm, reciprocal and double-logarithm functional forms:

Linear:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots + \beta_7 X_7 + e_t \qquad (21)$$

Semi-log (Lin-Log):

$$Y = \beta_0 + \beta_1 \log X_1 + \beta_2 \log X_2 + \ldots\ldots + \beta_7 \log X_7 + e_t \qquad (22)$$

Semi-log (Log-Lin):

$$\text{LogY} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots. + \beta_7 X_7 + e_t \quad (23)$$

Reciprocal:

$$Y = \beta_0 + \beta_1 1/X_1 + \beta_2 1/X_2 + \ldots\ldots. + \beta_7 1/X_7 + e_t \quad (24)$$

Double-log:

$$\text{LogY} = \beta_0 + \beta_1 \text{log}X_1 + \beta_2 \text{log}X_2 + \ldots\ldots. + \beta_7 \text{log}X_7 + e_t \quad (25)$$

2.2.1.5. Measurement of food security

The food security or insecurity level in a household could be computed by acquiring data on a number of behavioural pattern, detailed conditions and experiences that constantly illustrates the observable fact of the household's food security or insecurity, as recognized by researchers. The information needed (which could be on food generated by the household themselves or purchased) is obtained from the survey of households. These can then be used in estimating the food security status of the surveyed households (Sikwela, 2008).

(i) Coping Strategy Index (CSI)

According to Senefelds and Polsky (2005), the CSI spelt out a variety of coping strategies that is consumption-related and frequently adopted by the populace. There are four broad coping types measured, each with a particular location and culture specified strategies:

a). Dietary change (for example, eating less preferred food)

b). Increase short-term access to food (gifts, borrowing, consume seed stock and wild fruits)

c). Reduction in number of people to be fed

d). Rationing strategies (limit portion size; skip eating for a whole day; skipping meals; prioritizing children).

Data on the rate of occurrence (frequency) of each strategy would be assembled and a score is assigned to it (which, ranges from 0 to 7 on a weekly evaluation). A severity score is assigned to each strategy on the basis of the perception of the community focus groups. Both the frequency and severity scores are put together to determine the CSI. When the number of coping strategies being used is high and the frequency of usage is high, the value of the CSI will be high, implying a more food insecure household and vice versa. CSI had been discovered as a true expression of household's food insecurity situation in several studies in Africa. But it must be noted that CSI only expresses a relative measure of food insecurity (Senefelds and Polsky, 2005).

(ii) The Household Food Insecurity Access Scale (HFIAS)

The HFIAS as created by USAID can be employed to study the liability of households to food insecurity. Two main sub-questions are used in gathering information for this analysis. The first set are referred to as the occurrence questions (with two response option of 'yes' or 'no'; where no = 0 and yes =1). The second set is the frequency-of-occurrence questions (used as follow-up to the first). In the event that interviewee answer 'no' to an occurrence question, he/she would be asked to omit the related frequency-of-occurrence question. There are nine frequency-of-occurrence questions, which is used to compute the HFIAS score (Ndobo and Sekhampu, 2013). The scale takes a value of 0 (lowest score) to 27 (highest score), which can be utilised to categorize households as food secure or food insecure. Higher scores infer higher likelihood of a household being helpless against food insecurity (Knueppel *et al*., 2009 as cited by Ndobo and Sekhampu, 2013).

(iii) Foster-Greer Thorbecke (FGT) Household food expenditure model

The FGT food security measure is used to access the food security status of households by estimating the household food insecurity line, which is drawn as two-third of the Mean Per Capita Household Food Expenditure (MPCHFE). Households whose MPCHFE is above or equal to the line is categorized as food secure, while households whose MPCHFE is below the line is classified as food insecure.

Following Kuwornu *et al*. (2013), the FGT measure is mathematically derived as:

$$P_\alpha = \frac{1}{F}\sum_{i=1}^{F} M_i = \frac{1}{F}\left(\sum_{i=1}^{F}\frac{L-R_i}{L}\right)^{\alpha} \qquad (26)$$

Where $M_i = \dfrac{L-R_i}{L}$

Where:

P_α = FGT index

F = number of food insecure households;

M_i = per capita calorie intake deficiency of the i^{th} household;

R_i = the i^{th} households' per capita calorie consumption;

L = recommended daily energy level of 2900Kcal as recognized by USDA and FAO; and

α = the FGT food insecurity index, which takes the values of 0,1,2, for α = 0 is food insecurity incidence; α = 1 is food insecurity depth and α = 2 is food insecurity severity.

(iv) Food Security Index

This index is employed to classify households into food secure households or food insecure households group as used by Omonona and Agoi (2007). The formula for deriving the index is given below:

$$F_i = \frac{\text{Per capita expenditure on food for the } i^{th} \text{ household}}{\text{2/3 mean per capita food expenditure of all households}} \qquad (27)$$

Where F_i = food security index

$F_i \geq 1$, implies the household is food secure

$F_i < 1$, means the household is food insecure

A household is said to be food secure when its per capita monthly spending on food is more than or equivalent to two-third (2/3) of the mean per capita food expenditure, and vice versa for a food insecure household.

(v) Cost-of-calorie measure

The supply of calorie is a function of diet quantity and energy supply. This provides a good signal of the whole food security status of a household, thus, household not meeting up with the minimum calorie intake are considered as food insecure (Smith *et al*., 2006). This method was proposed by Greer and Thorbecke, (1984) as adapted by Sultana and Kiana (2011), Ramakrishna *et al*. (2014) and Ahmed *et al*. (2015).

The cost-of-calorie function is given as:

$$\text{Ln } X = a + bC \qquad (28)$$

Where:

X = cost-of-calorie per adult equivalent (in Naira)

C = actual calorie consumed per adult equivalent in the household (in kilocalories)

a and b = parameters estimated

Food insecurity line (Z) will then be estimated using:

$$Z = e^{(a+bL)} \qquad (29)$$

Z = food insecurity line (threshold)

L = approved daily energy level in Kcal recognized by USDA and FAO as 2900Kcal (Ayantoye, *et al.*, 2011)

a = intercept

b = coefficient of the actual calorie consumed

e = 2.718

(vi) Food insecurity gap indices

On the basis of the Z estimated, the food insecurity gap index as well as headcount index can be estimated for a sampled household. The food insecurity gap (P) therefore, is a measure that estimates the amount by which households that are food insecure lie beneath the food security line, on the average, whilst the food surplus gap (S) estimates the degree by which households that are food secure exceeds the food security line. Headcount index (H) is the estimates of the percentage surveyed household that were food secure/insecure.

Orewa and Iyangbe (2009) explained food insecurity indices as follows:

(i) **Food insecurity incidence (F_0)**: a measure of the percentage of individuals within a household with calorie intake level less than the minimum requirement.

(ii) **Food insecurity depth (F_1):** an estimate of the mean shortfall of calorie intake less than the food insecurity threshold as a share of the food insecurity line.

(iii) **Food insecurity severity (F_2):** Rather than adopting equal weighting system for the food insecure, this measure applies a greater weight for those who are more food insecure, in determining the depth of food insecurity.

2.2.1.6. Determinants of food security

Sikwela (2008) opined that the factors that influenced household food security include plot size, household size, fertiliser application, per capita cumulative production, ownership of cattle and irrigation access. Beyene and Muche (2010) used socio-economic characteristics, dependency ratio, farm size, farm income, household size, livestock ownership, off-farm income, access to market and credit, whereas, Zakari *et* *al*. (2014) computed high food prices, drought, poverty, disease and insect attack and soil infertility as the determinants of food security.

Ndobo and Sekhampu (2013) included socio-economic variables, household's income and the household head's employment status as determinant of vulnerability to food insecurity in their research work, while Osei *et al*. (2013) also used socio-economic variables, credit access, farm size, off-farm income, remittance and fertiliser application as factors that determined household food security in Ghana.

2.2.2. Evidence of the existence of Climate Change in North-Western Nigeria

Ekpoh (2010) in his work on how rural farmers adapt to the shock of climatic variability in North-western, Nigeria reported that most of the droughts in this region were associated with a late beginning and untimely cessation of the rains, which has brought about a dramatic decline in rainy season duration. He also found out that there is a trend of false onset, a situation whereby the rainy season begins normally and then ends abruptly, resulting to a dry phase between the false onset and the true onset, which results in a sharp decrease in annual rainfall.

Rafindadi (2011) worked on the perception of farmers on climate variability and the strategies used for adaptation in Katsina State and reported that 79.44% and 84.44% of the farmers alleged that precipitation levels had declined, and temperature increased, respectively. Abaje *et al*. (2014) also examined climate variability, its impacts and the coping strategies used by farmers in Dutsinma area of Katsina State. Their result showed that 52%, 65%, 56% of the respondents disclosed that precipitation had decreased, drought occurrences had risen and there is increased variability, respectively, for a period of 30 years. The major consequences as reported by the farmers include a fall in crop yields, decreased soil fertility, water shortages, crop pest and diseases as well as migration from rural to urban areas.

Atedhor (2015) studied the liability of agriculture to climate change in Sokoto State and discovered that while there were downward trends in annual precipitation and rain-days in Sokoto State, Nigeria, annual mean temperatures indicated upward trend, whereas annual droughts showed slight and moderate intensities during the period under review. The findings also showed unreliable rainfall, desertification, rising temperatures, pasture scarcity and inaccessibility to loan facilities are the primary determinants of climate change susceptibility in the studied area. Abaje *et al*. (2016), also examined the impact of climate change and the framework for adaptation among rural households in Northern Nigeria and found out that 73% and 63.4% of the respondents perceived increased temperatures and erratic rainfall pattern with decreased length of rainy days that resulted in drought over the past few decades, respectively.

Ismail and Oke (2014) examined the trend and frequency of rainfall in North-Western Nigeria from 1905 to 2008 and reported a downward pattern in rainfall for the period under study in Sokoto, Kano, Kebbi, Kaduna and Katsina States. Dogara *et al*. (2017) also examined the temperature and solar irradiance trend for Zaria, which is located in North-Western, Nigeria from 1986 to 2015 and reported an average rise in temperature and solar radiation over Zaria for the period under study, which confirms global warming caused by climate change impact. Abdussalam (2015) also agrees with the trend above. He examined the changes in daily temperature and precipitation in Northwest Nigeria from 1971 to 2010 for six synoptic weather stations in the zone and reported that temperature significantly increased, but a weak and not very significant change in precipitation.

2.2.3. The concept of Climate-Smart Agricultural Practices (CSAP)

Food and Agricultural Organisation (FAO) defines CSA as agriculture that increases productivity sustainably, increase resilience (adaptation), reduces Green House Gases (mitigation), to improve the achievement of food security and developmental goals (FAO, 2013). This merely implies that it is possible to use distinct, more climate-friendly farming methods to grow agricultural products. CSA has the potential to provide a ‘triple wins’: which are (a) improved food security, (b) increased resilience, and (c) reduced Green House Gas (GHG) emissions. An approach that could provide these three advantages at the same time for agricultural production would therefore, be preferable to any other strategy (Meybeck and Gitz, 2013).

Meybeck and Gitz (2013) stated that this strategy has the potentials to address the issues stated below:

- **Need for increased global food production:** CSAP have suggested potential for improved productivity and adaptation; in which crops are more resilient to climate change and can help meet increasing worldwide food demand.

- **Need to manage the land wisely:** It also has the ability to decrease the pressure to change land (e.g. using forests land for agriculture).

- **Political sensitivity of agricultural sector:** It should be less contentious than other submissions for decreasing worldwide agricultural emissions, since one of its 'pillars' is improving food security.

- **Support for sustainable agriculture globally:** CSAP also have the potential to contribute to global political obligations to enhance sustainable agriculture and at the same time, present a strategy that addresses climate change.

Examples of some CSAP as opined by Pye-Smith (2011) are:

- Conservation agriculture, involving modified ploughing techniques that decrease the extent to which the soil is bothered or ploughed in addition to spreading crop residue in the farm, which reduces soil erosion;

- Planting resilient crop variety that may boost productivity or carrying out crop rotation, which will improve climate change adaptation;

- Agro-forestry and cover crop increases the nutrient in the soil and reduces soil exposure to wind as well as water erosion; and

- Fertilising the soil with livestock manure can improve the soil biomass, which would lead to a better carbon sequestration of the soil, improved water retention and replenishment of soil nutrients (Bryan *et al.*, 2010). This can consequently improve the functionality of the soil, thereby reducing inorganic fertiliser application, which leads to environmental degradation and the production of emissions when manufacturing and applying them.

Three benefits of CSAP which could play vital roles in sustainable agriculture and national food security, according to Elizabeth and Sophie (2014) include:

- **Adaptation benefits**: Adaptation to heavy rainstorms could be achieved from increased soil cover and roots that prevents erosion. The resistance of drought can also be increased by enriching soil organic matter and covering the soil to aid moisture retention.

- **Food security benefits**: Intercropping can lead to the production of more food from the same plot, while composting in addition to intercropping will boost crop yields through enhanced fertility of the soil.

- **Mitigation benefits**: The quantity of chemical fertilisers applied to the soil could be reduced with the application of organic manure and legumes, which could decrease the emissions of GHG that results from the manufacture and application of chemical fertilisers. In addition, crop diversification and compost manure can improve both the underground and top-soil biomass, thus promoting sequestration of soil carbon.

Elizabeth and Sophie (2014) therefore opined that almost any agricultural practice that would improve productivity, reduce farmers' vulnerability to climate change variability (like mulching, water harvesting, planting drought-tolerant crops and terracing), sequester/get hold of carbon in the atmosphere (through agro-forestry), reduce emissions from agriculture and improve efficient use of resources (farming highly productive crop and livestock breeds and improved crop management), could be considered climate-smart.

The examples and benefits of CSAP are presented in Table 2.1, derived from FAO (2013); Pye-Smith (2011); Meybeck and Gitz (2013); Elizabeth and Sophie (2014).

Table 2.1: **Benefits and examples of CSAP**

The "Triple Win" of CSAP	Issues addressed by CSA	Benefits of CSAP	Examples of CSAP
• Increased resilience to climate change • Reduced GHG emissions • Improved food security	• Need for increased global food production • Need to manage the land wisely • Political sensitivity of the agricultural sector • Global support for sustainable agriculture	• Adaptation benefits • Mitigation benefits • Food security benefits	• Conservation Agriculture (minimum tillage, leaving crop residue on the field), • Agro-forestry, • Use of organic manure, • Crop rotation, • Crop diversification (cereal/legume intercropping), • Mulching, • Use of wetland (Fadama), • Planting of heat and drought tolerant crops, • Planting of cover crop and • Soil conservation techniques.

Sources: FAO (2013); Pye-Smith (2011); Meybeck and Gitz (2013); Elizabeth and Sophie (2014)

2.2.4. Review of empirical literature on Climate Change and Climate-Smart Agriculture

Ajewole and Iyanda (2010) did a study on how climate change affects cocoa yield in Nigeria. The study showed a weak negative correlation between precipitation and the yield of cocoa. They also reported a strong correlation that is positive between yields and temperature. The research therefore conclude that when optimal temperature is combined with minimal rainfall, it would produce better yields and boost the income of the cocoa farmers and that of the nation in general. Lawal and Leo (2007) also carried out similar research on cocoa and reported a negative relationship linking cocoa yield and rainfall as well as relative humidity, but with a positive relationship for temperature. They also discovered that occurrence of black pod disease is positively influenced by temperature and relative humidity.

The study carried out by Sawa (2010), where rainfall data for a 30 years period in Northern Nigeria was used, reported that different locations in these areas are now suffering the effect of climate change. Farmers in this region experienced increased numbers of dry spells during rainy time, which causes drought and desertification. Damin *et al*. (2011) researched on adaptation strategies that farmers around the Lake Chad Basin used and reported that decrease in the volume of the lake's water is linked to climate change.

van Marrewijk (2011) carried out a research on CSA in Mutale basin of South Africa and found out that due to lack of access road, water, relevant data, fund, infrastructure and farm inputs, the Basin has no capacity for climate-smart investments and that in the near future the Basin would undergo greater amount of drought, which would negatively affect their immediate ecosystem and will further restrict community's access to water. But with Climate-smart investments, the vulnerability will reduced, thereby providing opportunities to sustainably improve food security. Apata (2011) also researched on the determinant of the perception and choice of adaptation measures in Southwest, Nigeria using Heckman probit model and reported that 53.4% of surveyed farmers perceived increased temperature over the period that was studied, while 58% observed a decrease in precipitation in the same period.

Greg *et al*. (2011) examined the financial implication of the impact of climate change on food production and security in SSA. Their research revealed that the supposed "greenhouse fertilisation effect" generates favourable impacts in which higher atmospheric CO_2 stir up the growth of plants. This happens mainly in temperate regions, where yields for C3 crops (low photosynthetic rate) and C4 crops (high photosynthetic rate) were predicted to rise by 10-25% and 0-10%, respectively. Increased storm concentration and frequency, modified the hydrological cycles, and the variability in precipitation. This also has a long-run effect on both the practicability of the world's agro-ecosystems as well as future availability of food. They described Climate change to be the major important threat environmentally in the 21st century, which would hamper crop output in Latin America, Asia and Africa. Projecting into 2050, they predicted a rise in the world's average temperatures and weather variability, with consequences on agricultural production worldwide. In meeting up with the world's demand by 2050, based on food consumption and population growth trend, they projected that agricultural production would have to be enhanced by at least 70%.

Jokastah *et al*. (2013) noted in their research work on the views of rural farmers on climate change impact on rain-fed agriculture in Kenya for a period of 30 years, using descriptive statistics and temperature analogue approach, that farm households in Africa are not fully notified about this impacts, in line with the debate on climate change effects. Their findings indicated that in almost all of the selected agricultural practices, most of the farmers at the drier sites have a perception of more changes within the period studied.

Thulani and Keith (2013) assessed climate change impact on livelihoods in Zimbabwe revealed a frightening impact on livelihood in the community. It has distorted the topography in the community, contributing to the loss of plants and animals, including other natural surroundings that make up the people's livelihoods. Decreasing rainfall and temperature rise are increasingly hampering farming, thus exacerbating food insecurity. Therefore, they suggested immediate adaptation programmes that must be implemented to avert a livelihoods calamity in the region.

Also according to Fanen and Olalekan (2014), in their study to assess climate-smart's role in fighting climate change and desertification for improving rural livelihood in

Northern Nigeria, discovered that small-holder farmers in their numbers are unintentionally practicing CSA as some of their conventional farming operations and that a consistent climate mitigation approach is lacking with poor institutional structure. They therefore recommended that disadvantaged people's needs should be integrated into the CSA policy prior to its final acceptance in Nigerian society, where the disadvantaged poor are repeatedly deprived of developmental programs.

Aluko *et al*. (2008) as cited by Onu and Ikehi (2015) opined a significant effect of climate change on fragile soil and traditional farming operations. They went further to reveal that farmers in rural communities are not producing adequate quantity of food required to sustain their teeming population as a result of crop failure resulting from extreme weather. They concluded that flooding would be disastrous to storage infrastructures and transporting of food from the farms to the markets, thus, discouraging farmers who could produce more food. Likewise, climate change affects livestock especially in dry weather conditions or desert-prone zones/regions where longer periods of drought adversely affect the fodder availability.

2.2.5 Review of Empirical Studies on Climate Change and Crop Productivity

Ekpoh (2010) in his study on adaptation of peasant farmers in North-Western, Nigeria to climatic variation impacts reported that rainfall significantly affect crop production, while evaporation negatively affect crop yield. While, Ajetomobi *et al*. (2010) opined a fall in net revenue for rice farms on dry land, but increased revenue for irrigated farms, because of temperature increment and precipitation, in their investigation on rice cropping in Nigeria. Also, Edeh *et al*. (2011) who studied the risk factors in terms of environment that affects rice yield in Ebonyi State, Nigeria revealed that rainfall variability in terms of intensity, duration, and relative humidity affected rice yield. While, Ayinde *et al*. (2011) who worked on climate change effect on agriculture in Nigeria using a co-integration model, stated that temperature change brought about negative impact, while rainfall changes exerted a positive effect on crop yield.

Audu *et al*. (2013) reported that climate change is inimical to farming activities in Nigeria. They pointed out that this is because of over dependence on rain-fed agriculture and that production has been distorted by drought, desertification and flooding among others. Eregha *et al*. (2014) who researched on crop production and climate change in Nigeria opined that the types of crop planted, seasonality properties and the duration of the crop determines the effect of climatic variables on its production. Their report also showed that rising temperature and CO_2 in the air results in decline of the output of crops. Ajetomobi *et al*. (2015) also discovered that the productivity of most crops sown in Nigeria is threatened by climate extremes nationwide. The economic impact showed that extreme temperature caused a considerable annual loss in value for most crops studied in this research.

Porter *et al*. (2014) also reported the estimated effects that climate change has on cereal crop yield. They reported that yield loss reached as much as 35%, 13%, 50%, 20% and 60% for rice, barley, sorghum, wheat and maize, respectively, which was influenced by factors like location and the climatic situation in the study area. To solve this problem, the findings of Khatri-Chhetri *et al*. (2016) recommended the adoption of CSAP, which will boost crop yields, enhance net income, increase input use efficiency as well as reduce GHG emissions. But despite these outstanding benefits of CSAP, the rate of adoption by farmers in most part of Nigeria is somewhat low (Fanen and Olalekan, 2014).

2.2.6. **Review of Empirical Studies on Climate change and Food Security**

Gregory *et al*. (2005) conducted a research on the manner in which climate change affected food security and opined that it is one of several changes having effect on the food systems and that this differs from one region to another. They classified the effect as direct effect on crop yield, changes in market, changing food price and the supply chain infrastructure. The capacity of the food systems to adapt through implementation of the four food security dimensions is feasible irrespective of the level of climate change.

In analysing the food security condition amidst urban dwellers in Lagos, Nigeria, Omonona and Agoi (2007) discovered that index of food insecurity amplified, with upward movement in the age of the household heads, but least for those at the lower age range. They also claimed that food insecurity incidence in households that were headed by females was higher than those headed by males and food insecurity incidence increased as household size enlarges. The rate of food insecurity incidence decreased as income rose, but rises with increase in dependency ratio. They therefore concluded that age, price, per capita food consumed, household size as well as household head's educational level, were the essential predictors that affected the households' food security level.

Schmidhuber and Tubiello (2007) opined that climate change exerted its impact on all the four dimensions of food security. The influence of this dimension varies across countries and this will in due course rely on a nation's socio-economic status as climate change effects take root. They went on to state that it would increase reliance of developing nations on imports and amplify food insecurity in Africa. Nonetheless, in the long run, it is possible that variations in the path of socio-economic development would be the key determining factor for food utilisation. Also, FAO (2009) in its study that looked at how the agriculture sector in developing nations alleviate the consequences of climate change, revealed that two major challenges confronting mankind today results from alterations in overall food system and climate. They also reported that farmers will be feeding a predicted population of about 9.1 billion people in 2050 and to meet this demand, there is need to change the production system in agriculture, especially among smallholder farmers. These developments in the agricultural sector also have consequences for adaptation and mitigation.

Obisesan and Omonona (2013) investigated the effect of Root and Tuber Expansion Program (RTEP) on food security levels of households that cultivate cassava in Southwest, Nigeria, and reported that the food insecurity incidence among the beneficiaries of RTEP technology were lesser as compared with non-beneficiaries, which showed that the program enhanced production technology and had the ability to enhance food security. Also, food insecurity indices of the beneficiary reduced by a significant percentage, when compared with non-RTEP beneficiaries, as a result of their participation in the program.

Jabo *et al*. (2014) in their research work to examine the three indices of food insecurity amidst rural dwellers in Nigeria, revealed the existence of transitory food security based on the temporal rather than the chronic food shortages, which are more severe during the post-planting season. Also, high food prices and recurrence of droughts in rural Nigeria were seen as the main causes of food shortages. Nevertheless, the study revealed that rural farm households were the worst hit by food insecurity due to shortage of available inputs. The research also reported that nearly half of Nigeria's rural households are food insecure and manage to survive on less than the Recommended Daily Food Allowance (RDA). However, the disaggregation of households based on geographical areas and certain vital socio-economic traits suggested further that higher rate of food security during post-harvest season results from the failure of rural farmers to make good use of their time for off-farm proceeds generating jobs because of demand for labour for farm work. Consequently, they suggested that government should implement policies that would guarantee the regular supply of basic infrastructure which will boost food production among the rural households.

2.3. Conceptual Framework

The conceptual framework in this study illustrates what we expect to find throughout the research work. It clearly defines the significant variables for this study and maps out how they might relate to each other. This is clearly shown in the diagram in Fig. 2.1.

2.3.1 Climate-Smart Agricultural Practices (CSAP) and Food Security in Nigeria

Climate change is concerned about the observable variations that exist within the climate system for a period of 30 years and above, which are caused by human activities, most especially the ones which modify the earth's atmospheric composition and eventually results into global warming. It therefore has negative impacts on all aspects of food security (Idowu *et al*., 2011). Therefore, productivity in agriculture is altered by climate variability both directly (poor yield, pests and diseases outbreaks and inadequate soil nutrient) and indirectly (impacts on income distribution, economic growth and the demand on agriculture). Climate variability has also brought about alterations in food production structure (which include production, processing, storage, distribution and consumption), which adversely affect the productivity of food crop (Smit *et al*., 2001). It also affect the farming environment where agricultural activities are been carried out through climate variability like rainfall, temperature, water supply, duration of rainfall and drought, thereby resulting in low crop output and thereafter, food insecurity (Smit *et al*., 2001).

Farmers' perception of these negative impacts would determine their decision to use Climate-Smart Agriculture Practices (CSAP) to curb this menace exerted by these impacts on their food production system. The use of CSAP is expected to therefore bring about increased crop productivity by curbing the negative impact, which will consequently increase the income of the farmer and also make more food available for consumption, that is, increase food availability, thereby improving the rural farm households' food security status, since they depend mainly on their own production for food. The use of CSAP by farm households has 'triple-win' benefits, which include food security benefits, adaptation benefits and mitigation benefits (Elizabeth and Sophie, 2014). In the long run, all these benefits of CSAP will bring about the achievement of national food security, which is the ultimate goal of Climate Smart Agriculture.

The schematic conceptual framework of Climate-Smart Agricultural Practices (CSAP), Productivity and Food Security is presented in Figure 2.1.

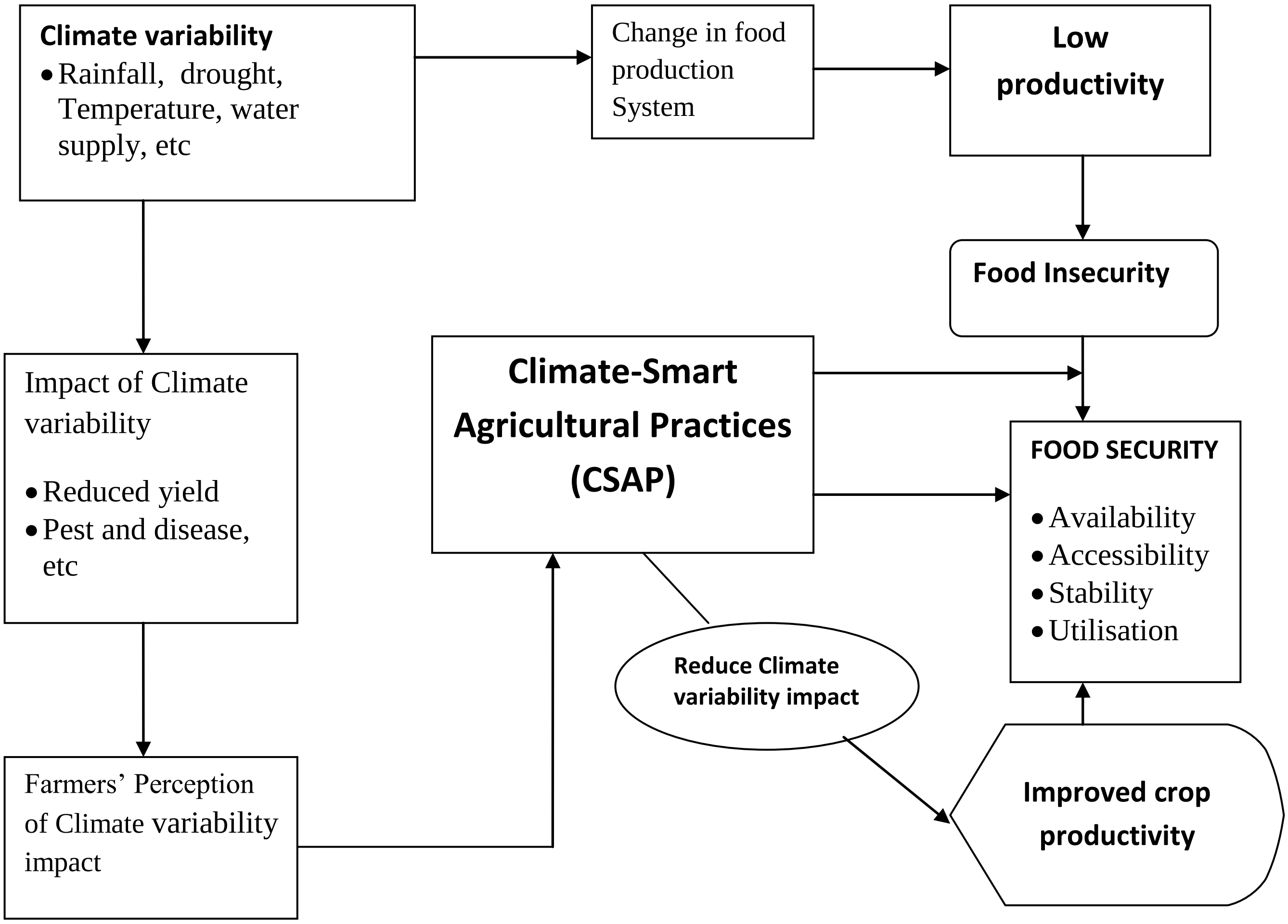

Figure 2.1: Conceptual framework: Climate-Smart Agricultural Practices (CSAP), Productivity and Food Security.

Source: Author's conceptual design (adapted from Smit *et al*., 2001 and Belaineh *et al*., 2012).

CHAPTER THREE

RESEARCH METHODOLOGY

3.1. Study area

This study was carried out in North-western, Nigeria, which falls within the Sudano-sahelian agro-ecological zone (Abaje *et al*., 2015). The zone is composed of seven States, which are Kano, Kaduna, Katsina, Sokoto, Zamfara, Jigawa and Kebbi states. North-western Nigeria lies between latitude 14° to the North and 10° to the south and longitude $4^{\circ}2^{1}$ to the West and $10^{\circ}15^{1}$ to the East. It has boundaries with Niger Republic in the North, Bauchi, Yobe and Taraba States in the East, FCT, Niger and Nasarawa States in the South and Benin Republic in the West (Adefila and Madaki, 2014; Abaje *et al*., 2015). The climate has distinctive wet and dry seasons with relatively low humidity. Dry season exists from October to April, whereas the rains commence in May and stop in September. The annual mean rainfall ranges from less than 500mm (northern part) to 1800mm (southern part), with mean minimum temperature of 15-17°C in the harmattan period and 35-38°C in dry season. North-West Nigeria covers approximately an area of 216, 065 km^2 in Nigeria and the vegetation is typically Sudan and Northern Guinea Savannah (Abaje *et al*., 2015). The total estimated population of North-Western Nigeria as at 2020 is about 54,276,570 persons (projected from NBS (2017) data using the Nigeria population growth rate) and they are predominantly agrarian. The climatic condition of the zone supports farming of crops such as millet, maize, rice, sorghum, groundnut, cotton, beneseed, potato, cowpea, water melon, etc.

Fig. 3.1 below presents the map of Nigeria showing the study area covered by this research.

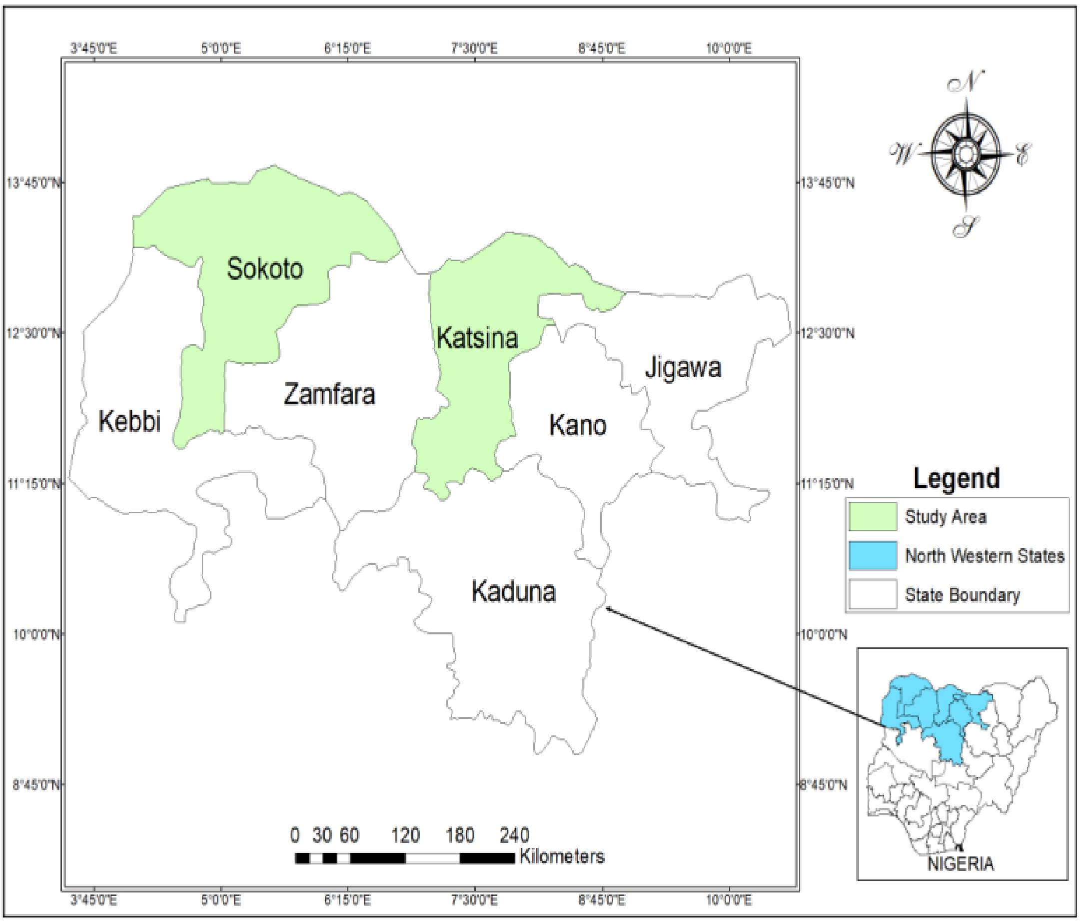

Figure 3.1: Nigeria map showing the study area covered by the survey

3.2. Method of data collection

The data employed for this study were primary data, gathered from the sampled arable farm households, who engaged in farming, during a survey conducted between February and April, 2016. The cross-sectional data was obtained by means of structured questionnaire administered to rural farmers with the aid of trained enumerators, who were staff of International Fund for Agricultural Development (IFAD) and Agricultural Development Program (ADP) in Sokoto and Katsina States, respectively, who already had an established rapport among the arable farmers living in the area. These enumerators were trained and the aim of the study explained to them during the course of the training.

Data for this research work were collected on the following information:

1. Household socioeconomic characteristics

2. Climate variability and CSAP

3. Cropping activities (inputs and output)

4. Food expenditure and consumption patterns

3.3. Sampling procedure and Sample size

A four-stage sampling procedure was used in this study. The first stage includes a simple random selection of two states out of the total of seven states in North-Western Nigeria, which were Katsina and Sokoto States. The second stage entails a random selection of ten (10) Local Government Areas (LGAs) from the two states selected proportionate to sizes. In Katsina State, 6 LGAs were selected out of 34 LGAs and in Sokoto State, 4 LGAs were selected out of the 23 LGAs, using the proportionality formula following Ibrahim (2011) as shown in equation 30:

$$S = \frac{n}{N} \times q \qquad (30)$$

Where:

S = number of LGAs to be selected
n = total number of LGAs in a particular State
N = sum of LGAs in the two (2) States selected
q = sample size (10 LGAs)

For the third stage, thirty (30) villages were selected using convenient sampling from the Ten (10) selected LGAs, while the last stage entailed the use of convenient sampling to select three hundred and sixty (360) respondents from the villages selected in Katsina State and two hundred and forty (240) respondents from the villages selected in Sokoto State, making a total of 600 arable farming households. A total of 600 well-structure questionnaire were administered. However, information from 577 respondents was finally used for the analysis (see Appendix I, Annex II). The remaining 23 questionnaire were either poorly filled or contained contradictory entries.

3.4. Method of data analysis

This section describes the various analytical tool utilised to satisfy the different objectives of this study and empirical specification of model used. Descriptive as well as inferential statistics were both used to analyse the data collected. The first objective was achieved using composite score, descriptive statistics and Adaptation Strategy Use Index (ASUI); objective (ii) was realised using ordered probit model; objective (iii) was realised using TFP index and OLS regression model, whilst objective (iv) was accomplished using Cost-of-calorie food security measure and binary logistic model.

3.4.1. Composite score

To measure and compute the level of use of CSAP by the farm households, composite score was used. Respondents were asked to answer questions concerning their level of use of CSAP. These practices included conservation agriculture (minimum tillage, leaving crop residue on the field), agro-forestry, crop diversification (cereal/legume intercropping), crop rotation, mulching, use of organic manure, use of wetland (Fadama), planting of heat and drought resistant crops, planting of cover crop and soil conservation techniques. Binary scale (Yes=1 and No=0), regarding the use of any of these Climate-Smart Agricultural Practices was employed in classifying the farmers. Using 10 items; a respondent scores 10 points as maximum score and minimum of 0 points. The categorisation into low, medium and high-user was then accomplished using the composite score as described below (Salimonu, 2007 and Adepoju *et al.*, 2011).

Low-user = from 0 point to (Mean – S.D) points.
Medium-user = in-between the lower and upper limits
High-user = from (Mean + S.D) points to 10 points

3.4.2. **Descriptive statistics**

This included frequency, percentages, graphs and means to illustrate the socioeconomics and enterprise characteristics as well as the perception of the farm households on the basis of their level of usage of CSAP.

3.4.3. **Adaptation Strategy Use Index (ASUI)**

This was used to analyze the frequency to which the farming households used CSAP in coping with the climate change impacts. This index was adapted from Adesoji and Famuyiwa (2010) as cited by Umunna *et al*., (2013) and Mohammed *et al*., (2014). The frequency of use of CSAP was explained with the aid of a four-point Likert scale, designated as 3, 2, 1, and 0 for frequently used, occasionally used, rarely used and not used, respectively. Below is the formula for the computation:

$$ASUI = \frac{[(N_1 \text{ x } 3) + (N_2 \text{ x } 2) + (N_3 \text{ x } 1) + (N_4 \text{ x } 0)]}{M} \qquad (31)$$

Where:

N_1 = number of farming household that frequently used a particular CSAP.

N_2 = number of farming household that occasionally used a particular CSAP

N_3 = number of farming households that rarely used a particular CSAP

N_4 = number of farming households that did not use a particular CSAP

M = total number of respondents

The Climate-Smart Agricultural Practices considered in this research included conservation agriculture (minimum tillage, leaving crop residue on the field), organic manure usage, agro-forestry, crop diversification (cereal/legume intercropping), crop rotation, mulching, use of wetland (Fadama), planting of heat and drought tolerant crops, planting of cover-crop and other soil conservation techniques. The ASUI was adopted to reveal the relative ranking (position) of each of the CSAP identified, in terms of their usage and frequency of use in the area of this research.

3.4.4. **Ordered probit model**

This model was utilised to estimate the factors determining the level of use of CSAP among the farm households. The three levels of CSAP usage derived from the composite score above formed the dependent variable for this model. This model is commonly used in analysing this type of discrete data and it is thus expressed:

$$Y_i^* = x_i\beta + \varepsilon_i \qquad (32)$$

Where Y_i^* is the unobserved discrete random variable, x_i stands for explanatory variable vector, β is vector of regression parameter that would be computed and ε_i is the vector of the error term (Greene, 2008). Thus, Y_i, (observed ordinal variable) takes on the following values:

$$Y_i = 0, \text{ if } Y_i^* \le 0 \qquad (33)$$
$$Y_i = 1, \text{ if } 0 < Y_i^* \le \mu_1$$
$$Y_i = 2, \text{ if } \mu_1 < Y_i^* \le \mu_2$$
$$Y_i = k, \text{ if } \mu_{k-1} < Y_i^*$$

μ_1 and μ_2 are threshold variables in the probit model, referred to as the cut points.

In line with the studies carried out by Elizabeth and Sophie (2004); and Deressa *et al*. (2008), the following variables were used:

The dependent variable is Y_i = level of use of CSAP (2=High-user, 1=medium-user, 0=low-user).

Explanatory variables included:
X_1 = age of household head (years)
X_2 = age squared (number)
X_3 = sex of household head (D =1 if male; 0 = otherwise)
X_4 = education of household head (years)
X_5 = household size (number)
X_6 = farm income (Naira)
X_7 = non-farm income (Naira)
X_8 = farming experience (years)
X_9 = farm size (hectares)

X_{10} = membership of farmers' association (D =1, if member; 0 = otherwise)

X_{11} = access to agricultural credit (D =1, if yes; 0 = otherwise)

X_{12} = Number of extension contacts per year (number)

X_{13} = Livestock ownership (D =1, if owned; 0 = otherwise)

The expected signs associated with the variables that influence the level of use of CSAP by the farm households are:

i. X_1 (age): It is anticipated that the coefficient sign for age (in years) on the use of CSAP should be positive or negative. Household heads become more experienced in their farm management practices for greater productivity as they advance in age, but in contrast, one would expect the younger farmers to be more energetic in exerting more energy into the farming activities.

ii. X_2 (age squared): The sign of the coefficient of age squared (standing as proxy for old age) is expected to be negative. The reason being that, at old age, the farmers may not be so productive and would therefore be unwilling or uninterested in using CSAP.

iii. X_3 (sex): This is captured as a dummy (male = 1, and female = 0). A positive sign is anticipated in relation to the use of CSAP, which implies that male household head would more likely use CSAP than a female household head. Since, they are more exposed to agricultural innovations and are more involved in agricultural activities.

iv. X_4 (years of education): The coefficient is anticipated to be positive for education. Expectations are that, with education, access to information is expected to increase and farmers are enlightened on the benefits of using CSAP and its aptitude to curb climate change menace.

v. X_5 (household size): The coefficient of household size is anticipated to be either negative or else positive. Large household size could hinder the use of CSAP, as the income available to the farmer for CSAP farming activities would be channeled to feeding the large household members, thereby reducing the money needed to invest in the use of CSAP. But on the other hand, if the household members are composed of working/productive members, income would be available to invest on the use of CSAP.

vi. X_6 (farm income): It captures the summation of income derived by the farming households from farm activities measured in Naira. The assumed sign of the coefficient is positive. The more the income derived from the farming activities, the greater the financial capability of the farming households to use CSAP.

vii. X_7 (non-farm income): These are earnings from sources outside the farming activities also measured in Naira. A positive or negative coefficient is anticipated. Higher non-farm income acquired by the farming households is expected to give rise to more finance available for investment in farming activities, but on the other hand, involvement in non-farm activities withdraws labour out of agriculture, thereby reducing production.

viii. X_8 (farming experience): This is assumed to have a positive sign for its coefficient with respect to the use of CSAP. Farming experience is measured in years. More years of farming experience predisposes an experienced farmer to making better informed decision in relation to the use of CSAP.

ix. X_9 (farm size): The sum of all the plots/land area used by the farmers. The coefficient is assumed to be positive or negative. Larger farm size (measured in hectare) is likely to lead to higher production level and vice versa.

x. X_{10} (membership of farmers' association): The expected sign on the coefficient of membership of farmers' association, expressed as a dummy variable (if member=1 and 0, otherwise) is positive. A membership of farmers' association will give the farming households opportunity to get information that will help boost crop productivity and likewise an opportunity for joint collaboration in securing agricultural credit.

xi. X_{11} (access to agricultural credit): A positive sign for its coefficient is expected. It is expressed as a dummy (assuming value of 1, if yes and 0 if no). This will increase the financial capability of the farming households for investment in CSAP.

xii. X_{12} (Number of extension contacts): This is expressed as a number. The coefficient of extension contacts is expected to be positive. Contacts with extension agents will expose the farming households to new technology and other farming methods that will help to improve crop productivity. It can also serve as an avenue for educating farmers on the significance of investing in CSAP.

xiii. X_{13} (Livestock ownership): The expected sign on the coefficient of livestock ownership, expressed as a dummy (assuming 1, if owned and 0, otherwise) is positive. It serves as an asset to the farmer; which can be a source of income to the farmer for investment in CSAP.

Table 3.1: presents the summary of the *a priori* expectation of independent variables considered in the ordered probit model.

Table 3.1: **Summary of *a priori* expectation of independent variables considered in the ordered probit model**

Variables	Measurement of the variables	Expected Sign	References
Age of household head	In years (discrete)	+/-	Deressa, *et al*., 2008 Robert *et al*., 2013
Age squared	In number (discrete)	-	Deressa, *et al*., 2008 Robert *et al*., 2013
Sex of household head	Dummy (female=0, male=1)	+	Gladwin *et al*., 2001 Ali and Erenstein, 2017
Education of household head	In years (discrete)	+	Padhy and Jena, 2015 Saguye, 2016
Household size	In number (discrete)	+/-	Thapa, 2007 Robert *et al*., 2013
Farm income	In Naira (discrete)	+	Deressa, *et al*., 2008 Belaineh, *et al*., 2012
Non-farm income	In Naira (discrete)	+/-	Babatunde, 2013 Egyei and Adzovor, 2013
Farming experience	In years (discrete)	+	Belaineh, *et al*., 2012 Adefila and Madaki, 2014
Farm size	In hectares (discrete)	+/-	Gladwin *et al*., 2001,
Membership of farmers' association	Dummy (no =0, yes =1)	+	Deressa, *et al*., 2008 Ali and Erenstein, 2017
Access to credit	Dummy (no =0, yes =1)	+	Belaineh, *et al*., 2012 Robert *et al*., 2013
Number of extension contacts	In number (discrete)	+	Deressa, *et al*., 2008
Livestock ownership	Dummy (no=0, yes=1)	+	Deressa, *et al*., 2008 Ali and Erenstein, 2017

3.4.5. **Total Factor Productivity (TFP) analysis**

TFP index was utilised for computing productivity levels of the farming households. All the crop output from the respondents were converted to Maize Grain Equivalent using the Nigerian Food Balance Sheet prepared by NISER, Ibadan (see Appendix II, Annex I). The approach used by Key and Mcbride (2003) as well as Fakayode *et al*. (2008) is as stated below:

$$\text{TFP} = \frac{Y}{TVC} \qquad (34)$$

Y = output quantity (in Kg of maize grain equivalent)

TVC = total variable cost (₦)

$$\text{TFP} = \frac{Y}{\sum P_i x_i} \qquad (35)$$

P_i = unit price of the i^{th} variable input.

x_i = quantity of the i^{th} variable input.

The method sets aside the function of the total fixed cost (TFC) as TFC has no effect on both profit maximisation as well as resource use efficiency. TFC is thus set as a constant.

Cost theory indicates that:

$$\text{AVC} = \frac{\text{Total Variable Cost (TVC)}}{\text{Output quantity (Y)}} \qquad (36)$$

AVC = average variable cost (₦)

Therefore, from equation 34 and 36, $\text{TFP} = \frac{1}{AVC}$ (37)

Partial productivity estimation, which represents the marginal products (MP) is stated as

$$\text{MP} = \frac{\Delta TFP}{\Delta X_I} \qquad (38)$$

The TVC (₦/ha) used included fertiliser cost (both organic and inorganic) (Kg/ha), quantity of seeds sown (Kg/ha), labour used (man-days/ha), pesticides (litre/ha) and herbicide (litre/ha) based on the views of Latruffe (2010) and Umar *et al*. (2011).

The TFP Index Program (TFPIP) version 1.0 was used in this study for computing the indices for input as well as output quantities, in addition to the resultant TFP index calculated using the Fisher index formula. The inputs and output quantities and their prices were normalized to per hectare. The benchmark TFP was 1.00 as reported by Ball *et al*. (2001). Therefore, TFP less than one (TFP < 1) indicates deterioration, while TFP greater than or equal to one (TFP ≥ 1) implies progress, with the difference from one indicating percentage deterioration and percentage progress respectively (Latruffe, 2010).

3.4.6. Estimating the effect of use of CSAP on crop productivity using OLS regression

Ordinary Least Square (OLS) regression was employed to examine the effect of using CSAP on crop productivity among the arable farm households. Other regression models were used for this analysis, but gave spurious results, but the OLS regression model gave a better and robust result. Therefore, it was used for this analysis.

Linear, semi-log, reciprocal and Cobb-Douglas (double-log) functional forms were analysed, but the semi-log model was selected as the lead equation. The choice was anchored on the coefficient of determination (R^2), signs of the coefficient and number of significant explanatory variables.

The linear function is specified as follows:

$$TFP = \beta_0 + \beta_1 K_1 + \beta_2 K_2 + \beta_3 K_3 + \beta_4 K_4 + \beta_5 K_5 + \beta_6 K_6 + \beta_7 K_7 + \beta_8 K_8 + \beta_9 K_9 + \beta_{10} K_{10} + \beta_{11} K_{11} + U \quad (39)$$

TFP= Total Factor Productivity; β_0= constant; β_1- β_{11} = coefficients to be estimated and U= error term

The value of TFP gotten from the Fisher index analysis was utilised as the dependent variable in this model.

On the basis of the works of Hussein and Perera (2004) and that of Fakayode *et al*. (2008), the variables stated below were used as determinants of the Total Factor Productivity model: Seeds in kilogram (K_1), Inorganic Fertiliser in kilogram (K_2), Organic manure in kilogram (K_3), Farming experience in years (K_4), Farm size in hectare (K_5), Education in years (K_6), Labour in man-days (K_7), Farm income in Naira

(K_8), Non-farm income in Naira (K_9), Household size (number) (K_{10}) and CSAP measured as reference/baseline category variable (K_{11}).

The assumed signs of variables influencing Total Factor Productivity (TFP) in the area under study are as follows:

i. K_1 (seed): The anticipated sign for the coefficient of the quantity of seed sown (measured in Kg) on crop productivity would be positive. Seed as an input, when planted, yields output. It is therefore expected that when viable seeds are planted, output will increase.

ii. K_2 (Inorganic fertiliser): The assumed sign for the coefficient of inorganic fertiliser would either be positive or negative, since inorganic fertiliser though positively affect crop productivity at the onset, becomes detrimental with continuous usage, which results in soil acidity.

iii. K_3 (Organic manure): Organic manure on the other hand is anticipated to have a positive relationship with crop productivity; therefore, the expected sign of its coefficient would be positive. Organic manure improves soil characteristics; such as soil biomass and soil structure and it also replenishes soil nutrient.

iv. K_7 (Labour): The anticipated sign of the coefficient of labour (measured in man-days) on crop productivity would be positive. Labour, as an input in crop production, contributes to increased productivity of the farm enterprise. Labour here represents both family labour and hired labour measured in man-days.

v. K_{11} (CSAP): It is also assumed that the sign of the coefficient of CSAP on crop productivity would be positive. CSAP is used to curb the menace of climate change, thereby curtailing its negative impact.

Table 3.2: gives the summary of the *a priori* expectation of explanatory variables considered in the OLS regression.

Table 3.2: **Summary of *a priori* expectation of explanatory variables considered in the OLS regression**

Variables	Measurement of the variables	Expected Sign	References
Seeds	In Kilogram (discrete)	+	Umar *et al*., 2011
Inorganic fertiliser	In Kilogram (discrete)	+/-	Gupta and Hussain, 2014 Usman *et al*., 2015
Organic fertiliser	In Kilogram (discrete)	+	Uzoma *et al*., 2011 Usman and Kundiri, 2016
Farming experience	In years (discrete)	+	See section 3.4.4
Farm size	In hectare (discrete)	+/-	See section 3.4.4
Education of household head	In years (discrete)	+	See section 3.4.4
Labour	In man-days (discrete)	+	Adeola *et al*., 2011
Farm income	In Naira (discrete)	+	See section 3.4.4
Non-farm income	In Naira (discrete)	+/-	See section 3.4.4
Household size	In number (discrete)	+/-	See section 3.4.4
CSAP	Dummy (base = medium-user)	+	Meybeck and Gitz, 2013 Gwambene *et al*., 2015

3.4.7. **Cost-of-calorie food security measure**

This measure was adopted to quantitatively classify the respondents into food security groups by measuring their average cost of daily calorie consumed. The measure gives a good clue of the overall status of a household, thus, households not meeting up to the minimum calorie intake were considered as food insecure (Smith *et al*., 2006). The method was suggested by Greer and Thorbecke, (1984) and adapted by Sultana and Kiana (2011). This was employed to compute the food insecurity threshold in this study.

The cost-of-calorie function is given as follows:

$$\text{Ln } X = a + bC \qquad (40)$$

Where:

X = cost-of-calorie per adult equivalent (in Naira)

C = actual calorie consumed per adult equivalent (in kilocalories)

a and b = parameter estimates

The food insecurity threshold (line), Z, was computed using:

$$Z = e^{(a+bL)} \qquad (41)$$

Z = food insecurity line

L = recommended daily energy level in Kcal recognized by USDA and FAO as 2900Kcal (Ayantoye, *et al.*, 2011)

a = intercept

b = the coefficient of the actual calorie consumed

On the basis of the calculated Z, farming households were grouped as being food secure or insecure. Households were classified as food secure, when their mean cost of daily calorie consumed is greater than or equivalent to Z, while households with values less than Z were categorized as food insecure. Household’s calorie intake for this study was estimated for each food group using the Proximate Composition of Foods table prepared by Oguntona and Akinyele (1995) (See Appendix II, Annex III).

In estimating the per capita household calorie intake, all the household members were transformed to adult equivalent (using the adult-equivalent conversion factors table), taking into consideration, their age and gender, as computed by Claro *et al*. (2010) (see

Appendix II, Annex II). The total calorie intake already calculated was divided by the adult equivalent household's size, which gives the household's per capita calorie intake.

To get the per capita expenditure on food consumed, values of food eaten by each household (total values of purchased food, food received as gifts and the value of own production consumed) were estimated. The value of food purchased was gotten by multiplying the quantities of different food types consumed by their unit prices. The total expenditure on food consumed, when divided by adult equivalent household size gave the per capita expenditure on food consumed. These were then utilised together with the per capita household calorie intake, to estimate the food insecurity line (Z). The estimated line was the minimum amount paid to acquire 2900Kcal (recommended daily energy level in Kcal) (Ayantoye, *et al.*, 2011).

Following Kuwornu *et al*. (2013), the food insecurity gap indices, which include, head count ratio, incidence, depth and severity of food insecurity of the respondents was determined using:

• Food insecure households' head count index (Hf_i) = $\frac{F}{J}$ (42)

• Food secure households' head count index (Hf_s) = $\frac{S}{J}$ (43)

• Food insecurity gap index (P_α) = $\frac{1}{F}\sum_{i=1}^{F} M_i = \frac{1}{F}\left(\sum_{i=1}^{F}\frac{L-R_i}{L}\right)^{\alpha}$ (44)

Where $M_i = \frac{L-R_i}{L}$

Where:

F = number of households that are food insecure;

S = number of households that are food secure;

J = total number of surveyed households;

M_i = per capita calorie intake deficiency of the i^{th} household;

R_i = the i^{th} households' per capita calorie consumption;

L = recommended daily energy level of 2900Kcal as recognized by USDA and FAO; and

The values of P_α = food insecurity aversion degree; $\alpha = 0$ (incidence); $\alpha = 1$ (depth) and $\alpha = 2$ (severity), were computed (Orewa and Iyangbe, 2009; Obisesan and Omonona, 2013).

3.4.8. Binary logit model

The binary logit estimation was utilised to examine the effect of using CSAP on food security status of the farming household. A Binary (dummy) variable developed from the relative food security line (Z_i) served as the dependent variable, while variables relating to CSAP and other determinants of food security as predictor variables.

Following Bogale and Shimelis (2009), the logistic model is econometrically defined as:

$$P_i = F(Z_i) = \frac{1}{1+e^{-(\alpha+\sum \beta_i X_i)}} \qquad (45)$$

P_i = probability of a food secure farmer, given X_i

X_i = vector of independent variable

α and β = parameter estimates

e = natural logarithm base

Logit models are stated in terms of log of odd, for an easier way of interpreting the coefficient (Hosmer and Lemeshew, 1989 as cited by Bogale and Shimelis, 2009). The odd ratio means the ratio of probability (P_i) of a food secure household to the probability ($1 - P_i$) of the food insecure household.

$$\frac{P_i}{1-P_i} = e^{Z_i} \qquad (46)$$

If we take the natural log, the above equation becomes:

$$Ln\left(\frac{P_i}{1-P_i}\right) = Z_i = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \dots + \beta_w X_w \qquad (47)$$

Taking the error term, e_i, into consideration; we have:

$$Z_i = \alpha + \sum_{i=0}^{w} \beta_i X_i + e_i \qquad (48)$$

Z_i will then be 1, food secure farming household and 0, if otherwise.

Explanatory variables used in this research work were related to the works of Belaineh *et al*. (2012) and Robert *et al*. (2013):

X_1 = household head's age (years)

X_2 = age squared (number)

X_3 = sex (D = 1, if male; 0 = otherwise)

X_4 = education (years)

X_5 = household size (number)

X_6 = farm income (Naira)

X_7 = non-farm income (Naira)

X_8 = farming experience (years)

X_9 = farm size (hectares)

X_{10} = membership of farmers' association (D = 1, if member; 0 = otherwise)

X_{11} = access to agricultural credit (D = 1, if yes; 0 = otherwise)

X_{12} = livestock ownership (D =1, if owned; 0 = otherwise)

X_{13} = CSAP (reference/baseline category variable)

Table 3.3 presents the summary of the *a priori* expectation of explanatory variable considered in the binary logit model.

Table 3.3: **Summary of *a priori* expectation of explanatory variable considered in the binary logit model**

Variables	Measurement of variables	Expected Sign	References
Age of household head	In years (discrete)	+/-	See section 3.4.4
Age squared	In number (discrete)	-	See section 3.4.4
Sex of household head	Dummy (0 = female, 1=male)	+	See section 3.4.4
Education of household head	In years (discrete)	+	See section 3.4.4
Household size	In number (discrete)	+/-	See section 3.4.4
Farm income	In Naira (discrete)	+	See section 3.4.4
Non-farm income	In Naira (discrete)	+/-	See section 3.4.4
Farming experience	In years (discrete)	+	See section 3.4.4
Farm size	In hectares (discrete)	+/-	See section 3.4.4
Membership of farmers' association	Dummy (0 = no, 1= yes)	+	See section 3.4.4
Access to credit	Dummy (0 = no, 1= yes)	+	See section 3.4.4
Livestock ownership	Dummy (0 = no, 1= yes)	+	See section 3.4.4
CSAP	Dummy (base = low-user)	+	See section 3.4.6

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1. Profiling the level of use of CSAP by arable farm households in the study area

4.1.1. Categorisation of farming households into levels of use of CSAP

The categorisation of the farming households on the basis of their level of use of CSAP was achieved using responses to 10 items that represent different CSAP used in the study area. The division of the farmers into various groups on the basis of their level of use of CSAP is shown in Table 4.1. The mean score was estimated as 5.21, while the standard deviation was estimated as 1.89. On the basis of these values, the farm households were grouped into three groups as shown below:

Low-User category = from 0 to (Mean – SD) = 0 to 3.32

Medium-User category = in-between lower and upper limits = values in-between 3.32 and 7.1

High-User category = (Mean + SD) to 10 = 7.1 to 10

Table 4.1 showed the percentage of farm households that belonged to each of the categories. From the Table, 57.5% of the respondents were in the medium-user category, 24.1% were high-user of CSAPs, while 18.4% were low-user of CSAP. This showed that a large portion of the farmers here were in the medium-user category. The calculated mean value which is estimated as 5.21, suggest that the farmers in the study area practised an average of five CSAP. This means that most of the farmers still need enlightenment on the benefits of using CSAP in their cropping activities to curtail the menace of climate change. This will help to increase their level of use of CSAP and consequently boost their crop yield.

Table 4.1: Categorisation of the arable farmers into the three (3) CSAP categories

Categories	**Number of CSAP used**	**Frequency**	**Percentage (%)**
Low-User	0 – 3	106	18.4
Medium-User	4 – 6	332	57.5
High-User	7 – 10	139	24.1
TOTAL		**577**	**100**

Source: Field Survey, 2016

4.1.2 Description of socio-economic characteristics of the farming household by level of use of CSAP

Table 4.2 showed the socio-economic characteristics of the farming households profiled by their level of use of CSAP. The results indicated that on the average, age of household heads across the three categories of CSAP were 46, 50 and 47 years for the low-user, medium-user and high-user categories, respectively. The pooled average ages was 48 years, showing that most household heads were still in their active age and thereby are strong enough to engage in farming activity. Also from the pooled results, 91.0% of the respondents were males, with only 9.0% being female, while across the three CSAP groups, 80.2%, 92.8% and 95.0% of the respondents were of the male gender for the low, medium and high-user categories, respectively, but only 19.8%, 7.2% and 5.0% constitute the female gender in the same order. This result indicated that across all the three categories, the male gender were the major players in terms of farming in the area studied. This is a clear indication of what is obtainable in Northern Nigeria, where most farmers are men, while women basically engage in farming activities like planting, threshing and winnowing (Annon, 2006 as cited by Mohammed and Abdulquadri, 2012**)**.

The educational level of the household heads indicated that Quranic education (45.1%) was the most acquired form of education, and this was applicable across the various CSAP groups, for the low-user (47.2%), medium-user (48.5%) and high-user (35.3%) categories. Quranic education is the type of education that is more prevalent among the rural dwellers in Northern Nigeria **(**Goodluck and Juliana, 2012). In terms of the percentage of household heads that acquired post primary education, the high-users of CSAP were 32.4%, while medium-user and low-user are 31.3% and 19.8%, respectively. The high level of education of the high-user might be the reason why they practice CSAP more. This confirms the fact that education is a vital tool in the adoption of innovation or new strategy (Ali and Erenstein, 2017).

Results of the household heads' marital status showed that majority were married, and this was similar across the various CSAP groups. Across the various level of usage of CSAP, the result showed that 87.7%, 91.6% and 97.1% of the low-user, medium-user and high-user were married. From the pooled results, 92.2% of the household heads were married, 2.6% single, 0.9% divorced and 4.3% widowed. Marital status is vital in accessing time available for farming engagements as married people with children are likely to carry out division of labour for household chores as well as farm activities, thereby having more time for their farm work (Sikwela, 2008).

Table 4.2 also showed that household size among the farm households was 11 persons, on the average. Low-user category had 10 persons as their average household size, while medium-user and high-user categories both have 11 persons on the average as their household size. Large household size constitute more family labour for the rural farmers, but alternatively it implies more food demand, more consumption and consequently more expenditure on food on the part of the household head (Osei *et al*. (2013). The average size of dependants across the three groups indicated that low-user had an average of 6 dependants, while medium and high-users had average of 7 dependants. On the whole, the average numbers of dependants among the arable farming households were 7 persons in the study area. Large number of dependants, who are unproductive, constitutes a burden on the family, since it leads to more expenditure on food and non-food commodities (Okon *et al*., 2017). Table 4.2 also indicated that most of the farmers (52.9%) belonged to at least one social group or the other, while 47.1% did not belong to any social group. Membership of farmers' association has immense benefits for the farmers as it is an avenue for enlightenment, education; awareness, having access to incentives and obtaining vital information that can help the farmers boost his/her farming activity (Saguye, 2016; Ali and Erenstein, 2017).

Extension services are also vital to the farming enterprise as it plays a vital function in assisting the farmers to develop their farming business. From Table 4.2, 15.1% of the respondents stated that they had contacts with extension agents very often, 39.7% had contacts often, while 31.5% and 13.7% had contacts with extension officers seasonally and not at all, respectively. Comparing the results across the three categories, a higher proportion (63.3%) of high-users of CSAP had more contacts often with extension agents, as compared with medium-user (55.7%) and low-user (40.6%). These contacts must have exposed the household heads to acquiring more information on climate change menace and subsequently adopting more CSAP to curb its effect and reduce the impact on their cropping activities.

Table 4.2: Socio-economic characteristics of the arable farm households by their level of use of CSAP

Characteristics	Low-User of CSAP (n=106)	Medium-User of CSAP (n-332)	High-User of CSAP (n=139)	Pooled (N = 577)	Difference test
Age of household head					
(average)	46.19	49.62	46.98	48.35	12.64***
Sex of household head					
Male (%)	80.2	92.8	95.0	91.0	19.04***
Female (%)	19.8	7.2	5.0	9.0	
Marital Status of household head					
Single (%)	1.9	3.6	0.7	2.6	
Married (%)	87.7	91.6	97.1	92.2	19.59***
Divorced/separated (%)	3.8	0.3	0.0	0.9	
Widowed (%)	6.6	4.5	2.2	4.3	
Education					
No formal education (%)	8.5	4.8	1.4	4.7	
Quranic education (%)	47.2	48.5	35.3	45.1	29.66***
Primary education (%)	24.5	15.4	30.9	20.8	
Secondary education (%)	17.0	20.8	20.1	19.9	
Tertiary education (%)	2.8	10.5	12.2	9.5	
Household size (average)	10.42	10.92	11.40	10.94	1.91
Dependants (average)	6.07	6.75	6.76	6.63	3.75
Membership of farmers' association					
Yes (%)	42.5	48.5	71.2	52.9	25.96***
No (%)	57.6	51.5	28.8	47.1	
Contacts with extension agents					
Very often (%)	5.7	19.9	10.8	15.1	34.08***
Often (%)	34.9	35.8	52.5	39.7	
Seasonally (%)	34.9	31.6	28.8	31.5	
Not at all (%)	24.5	12.7	7.9	13.7	

Source: Field Survey, 2016

Kruskal-wallis difference test: ***** =10% level of significance, ****** =5% level of significance, ******* =1% level of significance

4.1.3 Description of farming household enterprise characteristics by level of use of CSAP

The enterprise characteristics of the arable farm households are as revealed in Table 4.3. The results point out that on the average, the household heads had 26 years of farming experience, but across the three CSAP categories, the low-user had an average farming experience of 22 years, medium-user an average of 26 years and high-user an average of 27 years. Farming experience is very vital in agricultural activities as it goes along with skill acquisition, which is fundamental to effectiveness and efficiency in farming activities and this will have a positive impact on agricultural development. Farmers having experience are more disposed to accepting innovative ideas and techniques that would improve productivity in agriculture (Adefila and Madaki, 2014).

Access to agricultural credit (soft loans) is an imperative factor that helps farmers to expand their farming activities, but most of the farmers (71.6%) were not having access to agricultural credit, only about 28.4% stated that they had access to agricultural credit. This implies that most of the households sourced for finance from other sources apart from agricultural credit to perform their farm activities. Livestock ownership was also a common practice among the farm household as about 84.9% of the respondents kept livestock together with their farming activities, while 15.1% did not keep livestock. Livestock ownership is an asset to the farmer as sales of it serves as additional source of income (Ali and Erenstein, 2017).

Average monthly farm income acquired by the household heads was ₦204,202.08 per year. Average yearly farm income among the various CSAP categories were ₦195,033.84 per year (cropping season) for the low-user category, while the medium-user and the high-user categories earned ₦205,074.84 per year and ₦209,109.24 per year, respectively. Whereas the average non-farm income earned was ₦372,606.48 per year, while across the three CSAP categories, the household heads earned non-farm income of about ₦293,140.80, ₦392,268.60 and ₦386,243.16 per month for the low, medium and high-user categories, respectively, from activities such as petty trading, artisanship, blacksmithing, barbing, mechanical works, motorcycle (okada) transportation, butchering, food selling, carpentry, vulcanizing, brick laying and tailoring. These results showed that apart from the income earned from their farming activities, a bigger portion of the farmers' earnings is from non-farm activities. This would help to boost their purchasing power and thereby increase their disposable income.

Across the three CSAP groups, the average farm size cultivated by the household heads included 3.22 hectares for the low-user category, 4.61 hectares for medium-user and 3.81 hectares for high-user. On the whole, the average farm size among the farm household was 4.16 hectares. Large farm size implies large scale farming enterprise and consequently large farm output (Akinola and Adeyemo, 2013).

Land acquisition was basically through inheritance, as majority of the arable farm households got their farm lands by means of inheritance (77.5%), while 14.2%, 8.0% and 0.4% got their farm lands through purchase, rent and as gifts, respectively. The results showed a similar trend across the three CSAP groups as shown in Table 4.3. Similar result was also reported by Bamiro (2010) as cited in Tsue *et al*. (2014), who found out that land acquisition in the Northern part of Nigeria was predominantly by inheritance.

Table 4.3: Enterprise characteristics of the arable farming households by their level of use of CSAP

Variable	Low-user of CSAP (n=106)	Medium-user of CSAP (n-332)	High-user of CSAP (n=139)	Pooled (N = 577)	Difference test
Years of Farming experience (average)	22.03	26.20	26.82	25.58	14.15***
Access to agricultural credit					
Yes (%)	30.2	24.4	36.7	28.4	7.40*
No (%)	69.8	75.6	63.3	71.6	
Livestock ownership					
Yes (%)	87.7	80.4	93.5	84.9	13.94***
No (%)	12.3	19.6	6.5	15.1	
Farm income (₦) (average per year)	195,033.84	205,074.84	209,109.24	204,202.08	7.35*
Non-farm income (₦) (average per year)	293,140.80	392,268.60	386,243.16	372,606.48	8.03*
Farm size (Ha) (average)	3.22	4.61	3.81	4.16	11.04**
Land ownership					
Inherited (%)	85.9	74.1	79.1	77.5	16.79**
Rented (%)	6.6	10.8	2.2	8.0	
Purchased (%)	7.6	14.8	18.0	14.2	
Gift (%)	0.00	0.30	0.7	0.4	

Source: Field Survey, 2016

Kruskal-wallis difference test: ***** =10% level of significance, ****** =5% level of significance, ******* =1% level of significance

4.1.4. Farmers' perception on the impact of climate variability

Table 4.4 showed the percentage distribution of CSAP users according to their perception on the effect of climate variability on their farming activities in the last five years (2011 - 2015). It would also give first hand information about the existence of climate variability in the study area. The need to access the perception of the farmers is vital as this will inform the reason(s) why farmers used a particular type of Climate-Smart Agricultural Practice (CSAP). The aptitude of farmers to notice climate change impact is imperative in their choice of a particular type of CSAP. From the results in Table 4.4, most (74.5%) of the farmers perceived temperature increase within the reported period, 23.6% perceived a decreased temperature, while 1.9% did not perceive any change in temperature. Across all the three CSAP groups; 83.0%, 67.2% and 85.6% of the low-user, medium-user and high-user categories respectively, ascertained that they perceived increased temperature for the same period. The result aligns with *a priori* expectations and supported by the discovery of Gbetibouo (2011), who found that temperature has been increasing and rainfall/precipitation has been decreasing because of climate change impact, which has brought about the unexpected temperature rise, which has negative consequence on crop production. Those who perceived decrease in temperature across the three CSAP groups over the past five years were 12.3%, 31.0% and 14.4% respectively, while 4.7%, 1.8% and 0.0%, respectively did not perceive any change in the temperature around their respective environment within the same period.

One other vital climate variable which affects crop production that was considered was rainfall. If there is shortage in rainfall, crop production will be affected negatively, since moisture is a vital requirement for plant growth. The results from Table 4.4 also indicated that most (74.2%) respondents perceived a decreasing rainfall pattern within the period, while 23.7% perceived increasing rainfall pattern and 2.1% perceived no change. Across the three CSAP groups, 58.5%, 82.2% and 66.9% of the low-user, medium-user and high-user categories, respectively, perceived decreasing rainfall pattern for the period under consideration due to climate variability impact. This result concurs with Gbetibouo (2011), who opined that over the years, temperature is on the increase, while rainfall/precipitation has been decreasing due to climate change impact. Also, 34.9%, 16.6% and 32.4% of the low-user, medium-user and high-user categories, respectively, perceived increased rainfall pattern, while 6.6%, 1.2% and 0.7%, respectively perceived no change in rainfall pattern within the same time.

The results in Table 4.4 also showed that 72.3% of the farm households recognized that climate change negatively affect their crop yield, 22.5% perceived positive effect, while 5.2% perceived no change in their crop yield within the period under study. Due to its effect on temperature and rainfall pattern, climate change had negatively affected crop yield by reducing its output and this have been affirmed by the works of Ajetomobi *et al*. (2010) and Campbell *et al*. (2011). Across all the three CSAP groups; 71.7%, 75.9% and 64.0% of the low-user, medium-user and high-user categories, respectively, ascertained that their crop yield had been affected negatively since 2011. Also, 17.0%, 20.2% and 32.4% of the low-user, medium-user and high-user categories respectively, perceived that climate change had positively affected their crop yield for the past five years, while 11.3%, 3.9% and 3.6%, respectively perceived no effect. The higher percentage of farmers who perceived that climate change negatively affected their crop yield affirms the need to mitigate this menace using CSAP.

Climate change impact on water supply is also a signal of its impact on farming activities. When sources of water used for irrigation are dried up due to high temperature, it will affect cropping activities. The results from Table 4.4 showed that 68.1% of the respondents perceived that climate change had worsened water supply for the past five years, 23.7% perceived improvement in water supply within the same period, while 8.2% perceived no effect as a result of climate change. The result is supported by the outcome of Cline's (2008) research work, who opined that global warming has caused a reduction in the water bodies around the world and this has had adverse effect on agriculture. The results across the three CSAP groups followed similar trend as 54.7%, 71.4% and 70.5% of the low-user, medium-user and high-user of CSAP, respectively perceived worsened effect on their sources of water supply. It is also congruent with the work of Ngoran *et al*. (2015), who opined that climate change results in drought which brings about water shortage causing diverse impact on crop vegetation.

Most of the arable farmers (64.3%) perceived the magnitude of drought to be moderate in the last five years, 23.4% perceived it to be mild, while 12.3% perceived it to be severe. This revealed that drought, which is one of the menaces of climate change, is not yet a severe problem to the farmers. Results across the three CSAP groups revealed similar trend as 44.8%, 67.7% and 70.2% of the low-user, medium-user and high-user of CSAP, respectively perceived that the magnitude of drought was moderate in the last five years; 40.6%, 22.4%, and 13.4%, respectively perceived it to be mild, while 14.6%, 9.9% and 16.4%, respectively perceived it to be severe. This result is in congruent with the findings of Atedhor (2015), who examined the liability of agriculture to climate change in Sokoto State and reported that the magnitude of drought was moderate in their study area.

Results also indicated that the duration of rainfall in the area under study was short. Majority (61.9%) of the respondents affirmed that rain fell for an average of 3 to 4 months annually in the last five years, while 37.8% affirmed 5 to 6 months in their own environment and only 0.4% of the respondents stated that rainfall exceeded 6 months at their location. This result confirms the perception of the 74.2% of the farmers who perceived decreased rainfall pattern as stated above. The duration of rainfall is very vital to farming activities. It determines the crop type to be grown and amount of cropping seasons the farmers will have the opportunities to engage in a farming year. In places like Southern Nigeria (rain forest zones) where the duration of rainfall is up to 8 months, farmers usually undertake double cropping. This is not the case in North-western Nigeria where this study was carried out, except for few farmers who engaged in irrigation farming where water is easily accessible (Yamusa *et al*., 2015). Results were similar across the three CSAP groups as 57.6%, 67.5% and 51.8% of the low-user, medium-user and high-user affirmed that rain fell for an average of 3 to 4 months annually in the last five years. This result tallies with the discoveries of Ekpoh (2010), Atedhor (2015) and Yamusa *et al*. (2015), who reported reduction of rainy season duration caused by late onset/start of rains and likewise quick cessation of rains in Northern Nigeria.

Table 4.4: Percentage distribution of CSAP user groups by perception of the impact of climate variability

Variables	Low-user (n=106)	Medium-user (n=332)	High-user (n=139)	Pooled (n=577)	Difference test
Change in temperature					
Increasing (%)	83.0	67.2	85.6	74.5	31.36***
Decreasing (%)	12.3	31.0	14.4	23.6	
No change (%)	4.7	1.8	0.0	1.9	
Change in rainfall pattern					
Increasing (%)	34.9	16.6	32.4	23.7	37.43***
Decreasing (%)	58.5	82.2	66.9	74.2	
No change (%)	6.6	1.2	0.7	2.1	
Effect of climate variability on crop yield					
Positive (%)	17.0	20.2	32.4	22.5	19.54***
Negative (%)	71.7	75.9	64.0	72.3	
No effect (%)	11.3	3.9	3.6	5.2	
Effect of climate variability on water supply					
Improved (%)	34.9	20.8	22.3	23.7	11.18**
Worsened (%)	54.7	71.4	70.5	68.1	
No effect (%)	10.4	7.8	7.2	8.2	
Impact of drought					
Mild (%)	40.6	22.4	13.4	23.4	28.69***
Moderate (%)	44.8	67.7	70.2	64.3	
Severe (%)	14.6	9.9	16.4	12.3	
Duration of rainfall (in months)					
3 – 4 (%)	57.6	67.5	51.8	61.9	13.38**
5 – 6 (%)	42.5	31.9	48.2	37.8	
> **6** (%)	0.0	0.6	0.0	0.4	

Source: Computations from Field Survey, 2016

Kruskal-wallis difference test: *****=10% level of significance, ******=5% level of significance, ******* =1% level of significance

4.1.5. Frequency of use of CSAP by the farm households

The frequency of use of CSAP is as revealed in Table 4.5. Results here indicated which of the CSAP is most used in a ranking order. For the pooled data, use of organic manure was the most frequently used CSAP by the farmers, followed by conservation agriculture, crop diversification, planting of cover crops and crop rotation, while agro-forestry and mulching were the least used CSAP by the farmers. Across the CSAP user groups, the results indicated that for farmers in the low-user of CSAP group, conservation agriculture was the most frequently used CSAP, followed by use of organic manure, crop diversification, soil conservation techniques and crop rotation; among the medium group however, the use of organic manure was more frequently used, then planting of cover crops, crop rotation, conservation agriculture and crop diversification, while for the high-user of CSAP group, crop diversification was highest in terms of use, followed by organic manure usage, planting of cover crops, conservation agriculture and use of wetlands.

The use of organic manure was the major and most used CSAP as it ranked first (1^{st}) in the area under study, but ranked 2^{nd} amongst the low-user and high-user. This is a common practice in North-western Nigeria where farmers use animal dung and farm yard manure as organic fertiliser instead of inorganic fertiliser for their cropping activities (Omotesho *et al*., 2010; Usman and Kundiri, 2016). The use of inorganic manure is been discouraged by advocates of adaptation strategy (Bryan *et al*., 2010; Elizabeth and Sophie, 2014). As expressed by Bryan *et al*. (2010), treatment with domestic animals' manure lead to sequestration of soil carbon, enhance water retention as well as recharge soil nutrients. Elizabeth and Sophie (2014) also opined that the quantity of inorganic fertilisers required could be lessened, since organic manure contributes vital nourishment to the soil, and lead to decline of GHG release from the soil.

Conservation agriculture was also one of the main CSAP in the area under study across the various CSAP groups. It involves minimum soil disturbance which reduces run-off and soil water loss. Conservation agriculture supplies direct profits to ecological issues of global importance and it is one of the adaptation strategies that reduces crop vulnerability. Pye-Smith (2011) also opined that conservation agriculture which involves reduced soil disturbance will also lessen soil erosion.

Crop diversification, which involves the intercropping of cereal and legume crops on the same plot of land, was also one of the commonly used CSAP in the study area across the three CSAP groups. This practice provides the food security benefit (one of the 'triple win' benefits of Climate-Smart Agriculture as stated by Elizabeth and Sophie, 2014), that is, the farmers will be well protected or mitigated from total crop failure and thereby food availability. This is supported by the findings of Lin (2011), who opined that crop diversification has the ability to improve resilience in a number of ways by suppressing pest outbreaks and dampening pathogen transmission, which are worst under climate scenarios, thereby buffering crop production. This supports the fact that crop diversification as a CSAP is of importance, as it helps to curb the menace caused by climate change.

Planting of cover crops was also found to be one of the vital CSAP used among the various CSAP groups, as it ranked as the forth most used CSAP in the study area. This is because cover crops are effective control of weeds by smothering, provides soil cover, curb soil erosion, enhance soil biomass, improve soil structure, reduce pest and disease infestation, increase the organic matter component in soil and further improve the soil fertility, which will consequently bring about yield increase and improved crop quality (Miguel *et al*., 2010).

Crop rotation as shown on Table 4.5 was ranked as the fifth (5^{th}) most used CSAP in the study area. Crop rotation also has the benefits of reducing pests and diseases in the crop production, control weeds, improve soil quality as well as increase crop yield. Crop rotation also helps to achieve sustainable agricultural production (Miguel *et al*., 2010). It is very important that farmers be encouraged to engage in crop rotation as this would help to improve soil structure, facilitate crop development, destroy the biological lifecycles of pests, subsequently improving soil organic matter (Miguel *et al*., 2010).

Table 4.5: Frequency of Use of CSAP by Farming households in the study area

CSAP	Low-User ASUI	Low-User Ranking	Medium-User ASUI	Medium-User Ranking	High-User ASUI	High-User Ranking	Pooled ASUI	Pooled Ranking
Use of organic manure	1.548	2nd	2.445	1st	2.589	2nd	2.316	1st
Conservation agriculture	1.755	1st	1.731	4th	2.418	4th	1.902	2nd
Crop diversification	1.329	3rd	1.722	5th	2.670	1st	1.878	3rd
Planting of cover crop	0.537	6th	2.031	2nd	2.475	3rd	1.863	4th
Crop rotation	0.624	5th	1.959	3rd	2.028	7th	1.731	5th
Planting of heat and drought tolerant crops	0.312	8th	1.695	6th	2.136	6th	1.548	6th
Use of wetland (Fadama)	0.225	9th	1.011	7th	2.325	5th	1.185	7th
Soil conservation Techniques	0.810	4th	0.732	9th	1.929	8th	1.035	8th
Agro-forestry	0.330	7th	0.855	8th	0.921	10th	0.774	9th
Mulching	0.207	10th	0.516	10th	1.323	9th	0.654	10th

Source: Author's computation from field survey, 2016

4.2. Factors influencing level of use of CSAP by the arable farm household

4.2.1 Determinants of the level of use of CSAP by the farmers

The ordered probit model results which showed the factors determining the level of use of CSAP are shown in Table 4.6. The three levels of use of CSAP, which are low-user, medium-user and high-user, were ordered as 0, 1, and 2, respectively. And this formed the dependent variable for the ordered probit model. The Log likelihood of -529.8531 with Prob > chi-square value of 0.0000 (62.20), significant at $p<0.01$, is a sign that the model in totality was statistically significant and well fitted. The Pseudo R^2 was 0.0554, while the estimated cut-off points (μ) showed that the categories were ranked in an ordered way of $\mu_2>\mu_1>\mu_0$. The dependent variables are low-user (Y=0), medium-user (Y=1) and high-user (Y=2).

The results in Table 4.6 revealed that the household heads' age, sex, farming experience, membership of farmers' association and livestock ownership were the significant variables that influenced the usage of CSAP amidst the low-user category in the study area. Age, farming experience and membership of farmers' association were significant at $p<0.01$; sex of household head at $p<0.05$; while livestock ownership at $p<0.10$. Among the medium-user group**,** results showed that age, farming experience and membership of farmers' association significantly influenced the usage of CSAP by farmers in the medium-user category at $p<0.10$. High-user group were significantly influenced by age, sex, farming experience and membership of farmers' association at $p<0.01$, and livestock ownership at $p<0.05$.

Table 4.6: Estimates of factor influencing level of use of CSAP among the farm households

Variable	Coefficient	Low-user		Medium-user		High-user	
		SE	Z statistics	SE	Z statistics	SE	Z statistics
Age of household head	0.0972	0.0093	-2.63***	0.0029	-1.70*	0.0111	2.64***
Age squared	-0.0011	0.0001	2.97***	0.0000	1.78*	0.0001	-2.98***
Sex of household head (Base=Female)	0.4859	0.0619	-2.32**	0.0266	0.79	0.0378	3.25***
Education in years	0.0101	0.0026	-0.96	0.0006	-0.88	0.0032	0.96
Household size	-0.0039	0.0025	0.39	0.0005	0.38	0.0030	-0.39
Farm income	-4.58e-06	0.0000	1.30	0.0000	1.12	0.0000	-1.30
Non-farm income	1.70e-06	0.0000	-0.91	0.0000	-0.84	0.0000	0.91
Farming experience	0.0182	0.0016	-2.80***	0.0005	-1.73*	0.0020	2.81***
Farm size	-0.0048	0.0042	0.29	0.0008	0.29	0.0050	-0.29
Membership of farmers' association (Base=No)	0.4099	0.0270	-3.83***	0.0099	-1.81*	0.0308	3.94***
Access to credit (Base=No)	0.0030	0.0282	-0.03	0.0057	-0.03	0.0339	0.03
Number of extension visit	0.0105	0.0026	-1.03	0.0006	-0.93	0.0031	1.03
Livestock ownership (Base=No)	0.2757	0.0406	-1.85*	0.0083	-0.15	0.0350	2.18***
Cut 1	2.4114						
Cut 2	4.1344						
Number of observation		577					
Log-Likelihood		-529.85					
LR chi^2		62.20***					
Pseudo R^2		0.055					
Prob > chi2		0.000***					

Source: Computations from Field Survey, 2016

Legend: * =10% level of significance, ** =5% level of significance, *** =1% level of significance

4.2.2. Estimates of the Marginal Effect of the determinants of level of use of CSAP among the arable farm households

The marginal effect of the determinants of the correlates of the level of use of CSAP is as shown in Table 4.7. The results presented the increase in the probability of being in any of the three levels of use of CSAP identified per unit increase in the value of the continuous independent variables and a change from one level to the base level for categorical and dummy variables.

Results revealed that a 1.0% addition to the age of household's head will significantly ($p<0.01$) decreased the probability of the household being in the low-user and medium-user group by 0.024 and 0.005, respectively. However, it significantly ($p<0.01$) increased the probability of being in the high-user group by 0.029. This implies that older and experienced farmers are risk takers and therefore, more likely to use CSAP. This is in congruent with the works of Taruvinga *et al*. (2016), who opined that the age of rural farmers positively influenced the probability of farmers adopting adaptation strategies, with respect to earned experience, broad social networks and accumulation of wealth.

Also, a male headed household had lower probability (0.144) of being a low-user of CSAP at $p<0.05$, but higher probability (0.123) of being a high-user of CSAP at $p<0.01$. The result corresponds to the outcome of the research carried out by Ali and Erenstein (2017), who opined that households headed by male adopt more climate change adaptation methods than their female counterpart. It is a fact that households headed by males are more exposed to agricultural innovations and were more involved in agricultural activities in comparison with the female headed households (Gladwin *et al*., 2001; Temesgen *et al*., 2014).

The results also illustrated that a 1.0% addition to the years put into farming by the household head decreased significantly, the probability of the households being a low-user ($p<0.01$) and medium-user ($p<0.10$) of CSAP by 0.005 and 0.0009, respectively. However, it significantly increased the probability of being a high-user ($p<0.01$) of CSAP by 0.006. This aligns with the outcome of the study of Adefila and Madaki (2014), who opined that farmers with more experience would accept new technology that would develop agricultural production. It also tallies with the results of Fadina and

Barjolle (2018), who stated that experience in farming positively affected the selection of climate change adaptation strategy by rural farmers due to more competence in weather forecasting.

Similarly, household heads who were members of farmers' association had lower probability (0.104) of being a low-user of CSAP and a medium-user (0.018) at $p<0.01$ and $p<0.10$, respectively, but had a significantly higher probability (0.122) of being a high-user of CSAP at $p<0.01$. Membership of social group, such as farmers' cooperative society, plays a very significant function in the enlightenment of their members on beneficial farming practices. Farmers who belong to such groups are expected to be enlightened and exposed to new farming technologies or practices that will help boost agricultural output. This agrees with the report of Saguye (2016) and Ali and Erenstein (2017), who opined that farmers' involvement in cooperative groups positively influenced their adoption of adaptation strategies; meaning that farmers who participate in cooperative groups share knowledge and innovative ideas and engage in collaborative decision-making, which positively influence their use of climate change adaptation strategy. They opined that it also played an important role in helping farmers to access relevant information that empower them.

Also, households who owned livestock had lower probability (0.075) of being a low-user of CSAP at $p<0.10$. However, the household had significantly higher probability (0.076) of being a high-user of CSAP at $p<0.01$. Livestock ownership serves as an asset to a farmer and farming households that have such asset are likely to adopt CSAP. This is because these assets can serve as income source for investment in CSAP. This agrees with the findings of Ali and Erenstein (2017), who opined that livestock ownership as a proxy for farmer's wealth had positive relationship with climate change adaptation methods.

Table 4.7: Marginal effect for the determinants of the level of use of CSAP

Variable	Low-User Category	Medium-User Category	High-User Category
Age of household head	-0.0243***	-0.0049*	0.0291***
Age squared	0.0003***	0.0001*	-0.0003***
Sex of household head	-0.1438**	0.0210	0.1227***
Education in years	-0.0025	-0.0005	0.0030
Household size	0.0010	0.0002	-0.0012
Farm income	1.14e-06	2.28e-07	-1.37e-06
Non-farm income	-4.24e-07	-8.46e-08	5.09e-07
Farming experience	-0.0046***	-0.0009*	0.0055***
Farm size	0.0012	0.0002	-0.0015
Member of farmers' association	-0.1036***	-0.0179*	0.1215***
Access to credit	-0.0007	-0.0002	0.0009
Number of extension visit	-0.0026	-0.0005	0.0032
Livestock ownership	-0.0752*	-0.0012	0.0764**

Source: Computations from Field Survey, 2016

Legend: * =10% level of significance, ** =5% level of significance, *** =1% level of significance

4.3. Effect of using CSAP on crop productivity among the arable farmers

4.3.1 Crop productivity measurement among the farming households

Result of the Total Factor Productivity (TFP) estimated is as shown in Figures 4.1 and 4.2. The TFP index was estimated using the Fisher index in which the inputs and output quantities and their prices were normalized to per hectare. The benchmark TFP was 1.00, therefore, TFP less than one (TFP < 1) indicates deterioration, while TFP greater than or equal to one (TFP ≥ 1) implies progress with the difference from one (1) indicating percentage deterioration and percentage progress respectively (Ball *et al*., 2001; Latruffe, 2010).

4.3.2 Distribution of the farm household by their TFP and level of use of CSAP

Results in Figure 4.1 showed that 37.0% of the arable farming households had a TFP that is progressing, while 63.0% had a TFP that is deteriorating. The inference from this is that many of the farmers are operating under a deteriorating TFP, that is, their level of productivity was low. On the other hand, the disaggregated results across the three CSAP groups (low-user, medium-user and high-user) as shown in Figure 4.2, indicated that most (75.6%) of the farmers who were medium-user of CSAP operated at deteriorated level of TFP as compared with low-user (47.2%) and high-user (44.6%) of CSAP. The percentage of the low-user of CSAP who operated at deteriorating level of TFP was higher than the percentage of high-user of CSAP on the same level, that is, 47.2% and 44.6%, respectively; while, the percentage of high-user of CSAP who operated at the progressive level of TFP are more than the percentage of lower-user of CSAP on the same level, that is 55.4% and 52.8%, respectively. The implication is that farmers who used CSAP more (that is, high-user of CSAP) were more likely to be progressive in terms of crop productivity than farmers who are low-users of CSAP (Gwambene *et al*., 2015).

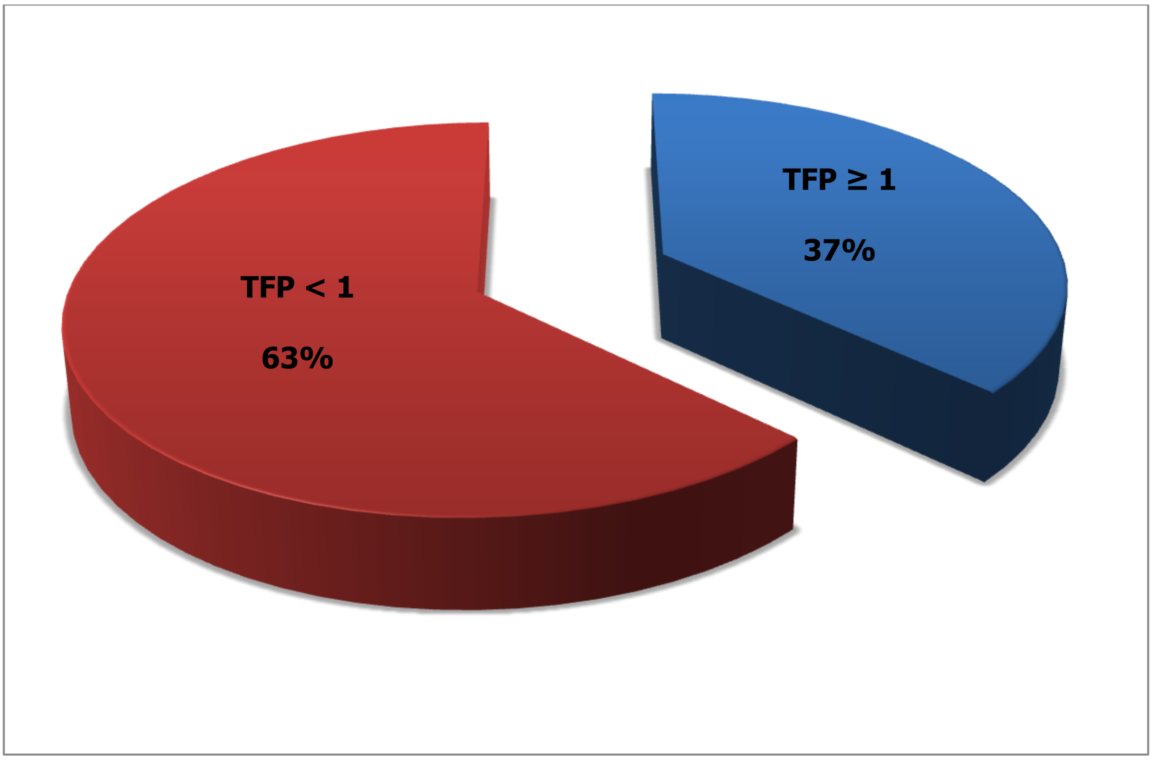

Figure 4.1: Distribution of the Total Factor Productivity of the arable farming households

Source: Computations from Field Survey, 2016

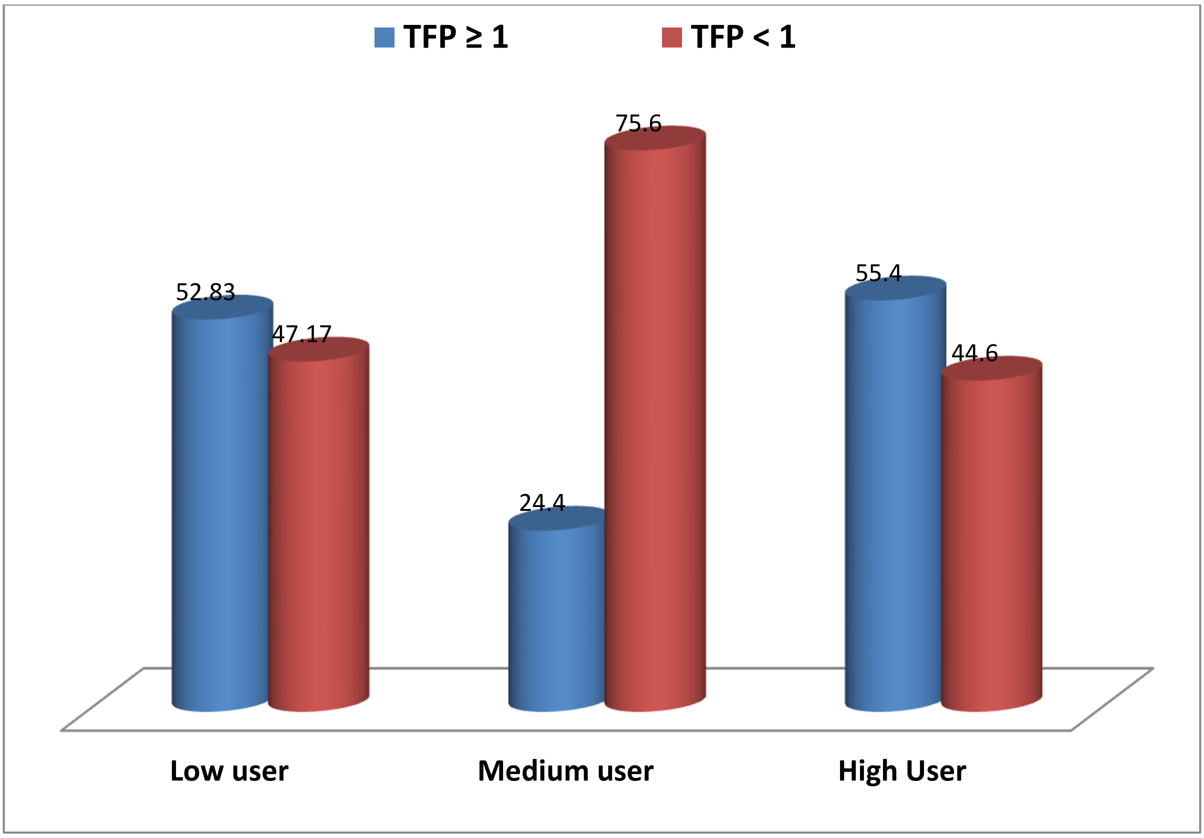

Figure 4.2: Distribution of farm households by their TFP and level of use of CSAP

Source: Computations from Field Survey, 2016

4.3.3. Estimating the effect of using CSAP on the TFP of the arable farming households

The Ordinary Least Square (OLS) regression outputs as shown in Table 4.8 is the estimates of the effect of using CSAP among other variables on the Total factor productivity among the arable farming households. Different econometric specifications of the OLS regression was applied, which included linear, reciprocal, semi-log and Cobb-Douglas functional forms. The semi-log model for the OLS regression was chosen above other functional forms, as the lead equation, since it gave the best fit of the independent variables in terms of number of significant explanatory variable, sign of the coefficient, adjusted R^2 value and the F-statistic value. The results for other functional forms can be found at the appendix section (See Appendix III, Annex I, II, III and IV). The results of the lead equation as discussed here showed a R^2 value and adjusted R^2 value of 0.33 and 0.32, respectively. This implies that 33% of deviations in total factor productivity amidst the arable farming households are described by the explanatory variables specified. F-statistic values of 23.47 was significant statistically at $p<0.01$, denoting the correctness and fitness of the model.

From the results, the quantity of seed used significantly and positively influenced productivity among the arable farming households at $p<0.01$. This implies that seed was a vital input in crop production, since the viability of seed used in production activity is a determinant of the output the farmer will get from his farm. The higher the quantity of viable seed used, the more the output from the farm. This result agrees with the research findings of Adeola *et al*. (2011), who discovered that seed had a significant positive relationship with output.

The use of inorganic fertiliser significantly and negatively influenced crop productivity in the study area at $p<0.01$. The result was in congruent with the *a priori* expectation. The use of inorganic fertiliser is a very vital input used in crop production in Northern Nigeria. Farmers in Northern Nigeria hardly carry out their farming activities without the use of either organic or inorganic manure (Omotesho *et al*., 2010; Usman and Kundiri, 2016). But the results showed a negative relationship between inorganic fertiliser and productivity; this was expected as the continuous use of inorganic fertiliser though beneficial at the onset of its usage becomes detrimental to crop productivity with continuous usage as a result of soil acidity (Apkan *et al*., 2011). The result concurs with the works of Gupta and Hussain (2014) and Usman *et al*. (2015), who submitted that regular application of inorganic fertiliser results in soil acidity and that toxic concentrations of salts will be built up in the soil, which will bring about chemical imbalances, thereby impeding productivity.

Conversely, the use of organic manure positively and significantly influenced crop productivity in the study area at $p<0.01$, which was also in line with *a priori* expectation. Organic fertilisers are far less detrimental to crops as compared with inorganic fertilisers and it adds nutrients to the soil by improving the soil biomass and soil structure (Gupta and Hussain, 2014). This study corroborates that of Uzoma *et al*. (2011) who reported that organic manure from cow dung significantly increased the productivity of maize crop. Evidences show that organic manure contains important soil nutrients that are more sustainable in crop production than inorganic fertilisers (Uzoma *et al*., 2011; Usman and Kundiri, 2016). The use of this fertiliser should therefore, be encouraged among farmers in Nigeria.

Table 4.8 also revealed that farm size of the farmers had a positively significant influence on crop productivity among the arable farming households at $p<0.1$. The implication of this is that increased farm size cropped is expected to bring about an increase in crop output/productivity thereby increasing the farm income of the rural farm households (Domanska *et al*., 2014). The result corroborate that of Akinola and Adeyemo (2013) who opined that farmers with larger farm size would have bigger yield, since they will be enjoying economies of large scale production. The result is also in congruent with the findings of Clay (2008) as cited by Akinola and Adeyemo (2013), who also reported that when larger farm size are put into farming, there would be greater area under cultivation, therefore, more output would be expected. It is noteworthy that farm size still plays a significant role as growth determinant among developing nations (Rahman and Salim, 2013).

Results as put together in Table 4.8 also revealed that the use of labour significantly and negatively influenced crop productivity in the study area at $p<0.01$. In almost all agricultural ventures, labour plays a vital role as a factor of production, especially in farming activities. But as the size of the farm starts increasing, the cost of using labour for farming activities would increase and this would culminate on the overall cost of production, which among rural farmers can negatively affect the total factor productivity. The result aligns with the outcome of the work of Obasi *et al*. (2016), who stated that high cost of labour can negatively affect productivity.

The results also showed that household size significantly and positively influenced crop productivity in the study area at $p<0.1$. The result tallies with the *a priori* expectation. A large household size that is composed of working/productive members would have positive effect on agricultural productivity as this would add to the labour force involved in the farming activity. This aligns with the work of Thapa (2007), who found out that family size (household size) had positive effect on crop output. He further stated that household size performs an important role in farm size-productivity and labour/land ratio.

From the results in Table 4.8, the use of CSAP positively and significantly influence crop productivity among the low-users and high-users of CSAP at $p<0.01$, using the medium-users as baseline. The reason for using the medium-user of CSAP as the baseline is because of the fact that most (58.0%) of the rural farm households were medium-user of CSAP (using between 4 and 6 CSAP) and likewise, to clearly show the impact CSAP would have on the productivity of new entrant (users of CSAP) and that of those who would move upwards from medium-user to high-user. The result clearly showed that if anyone who is not a user of CSAP start using CSAP even at a low-level (that is, low-user), the productivity of such a farmer will significantly improve, as seen in the results ($\beta = 0.5483$). Alternatively, if the farmers in the area under study, who are mostly medium-users of CSAP move their level of use of CSAP upwards, that is, move up to being a high-user of CSAP, their productivity will significantly increase ($\beta = 0.6014$). This follows the *a priori* expectation, as the use of CSAP serves as a form of resilience against climate variability; thereby reducing the threat that climate change poses to crop productivity and consequently improving farmers' crop production. This result is congruent with that of Gwambene *et al*. (2015), who opined that farmers adopted CSAP in order to boost their crop yield and also improve soil fertility. Furthermore, it also agrees with the findings of Meybeck and Gitz (2013), who opined that CSAP would help to boost productivity and serve as adaptation measure, which would consequently add to solving the problem of increasing global demand for food.

Table 4.8: Estimates of the effect of CSAP on TFP of the arable farming households

Variable	Coefficient	standard error	Z statistics	P>t
Seed	0.0061***	0.0009	6.65	0.000
Inorganic Fertiliser	-0.0010***	0.0001	-7.79	0.000
Organic manure	0.0002***	0.00003	8.41	0.000
Farming experience	-0.0019	0.0046	-0.42	0.673
Farm size	0.0309*	0.0167	1.84	0.066
Education	-0.0043	0.0092	-0.47	0.638
Labour	-0.0098***	0.0019	-5.13	0.000
Farm income	1.03e-06	1.78e-06	0.58	0.565
Non-farm income	-5.71e-07	1.62e-06	-0.35	0.725
Household size	0.0160*	0.0084	1.91	0.057
Low-user (Base=Medium-user)	0.5483***	0.1177	4.66	0.000
High-user (Base= Medium -user)	0.6014***	0.1075	5.59	0.000

Number of observations	577
R^2	0.33
Adjusted R^2	0.32
F-statistics	23.47
Prob > F	0.000
Root Mean Square error	1.02

Source: Author’s computation from Field survey, 2016

Legend: * =significant at p<0.1, ** =significant at p<0.05 and *** =significant at p<0.01

4.3.4. Variance Inflation Factor (VIF) Diagnostic Test

Variance Inflation Factor (VIF), which is a test for multi-collinearity, as shown in Table 4.9 was utilised to find out the absence or presence of multi-collinearity in the regression model. The multi-collinearity test results revealed that the mean/average VIF for the explanatory variables used for the OLS regression analysis was 1.42; which means there is no serious multi-collinearity challenge in the model. The rule of thumb for multi-collinearity test states that mean VIF values for a multiple regression that is from 5 to 10 implies high correlation, which may be a problem and if the mean VIF is beyond 10, one can conclude that the regression coefficient in the model were badly estimated because of multi-collinearity (Akinwande *et al*., 2015; Ekpa *et al*., 2017). But with a mean VIF value of 1.42, it would not be wrong to assume that the regression coefficients in this model were well estimated and devoid of multi-collinearity problem. This study also employed the use of the 'robust' option for the OLS regression, which ensured that the results were void of heteroskedasticity (Rosopa *et al*., 2013).

Table 4.9: Multi-collinearity Test for the variables in the OLS regression model

Variables	**Variance Inflation Factor (VIF)**	**Tolerance**
Seed	2.20	0.4552
Inorganic Fertiliser	2.37	0.4216
Organic Manure	1.17	0.8529
Farming Experience	1.38	0.7247
Farm Size	1.75	0.5723
Education	1.14	0.8763
Labour	1.26	0.7926
Farm income	1.01	0.9881
Non-farm income	1.16	0.8654
Household Size	1.26	0.7910
Low-user of CSAP	1.16	0.8630
High-user of CSAP	1.18	0.8482
Mean VIF	**1.42**	

Source: Computation from Field survey, 2016

4.4. Effect of using CSAP on food security status of the arable farming households.

4.4.1 Estimation of the food security status of the farm household

In the outcome of the research carried out by Omonona and Agoi (2007), they stated that when food is available in a country on per capita basis, it does not really mean there is sufficient food for everyone in that country. Food security at the national level is at variance from the one at the household level, the latter being a subset of the former. Food that is well utilised will have a feedback effects on household members' health and nutritional status. This will consequently impact the labour output as well as the income-earning potential of the household members (Omonona and Agoi, 2007). This research work therefore, used the cost-of-calorie measure of food security to compute the food security status of the farming household. Cost-of-calorie measurement goes beyond food availability and having access to it. It estimates the magnitude of food utilised by giving values close to the minimum calorie requirement of the farming households.

Table 4.10 showed that 45.0% of the per capita expenditure on food among the arable farming households can be explained by the households' per capita calorie consumption. The estimated coefficient of the regression tallies with the *a priori* expectations both in sign and in magnitude. This revealed that a 1.0% increment of the level of calorie consumed would cause exactly 0.02% rise in the level of expenditure on food by the arable farming households. Likewise, with LnX = 3.79 + 0.0002C and the daily per capita calorie recommended requirements of 2900Kcal, the Z value, which gives the minimum amount that is available to the household to purchase this 2900Kcal requirements of the households, was estimated as ₦79.06k per day. On the basis of this estimated Z value, households were grouped as being food secure or insecure. Households with mean cost of daily calorie consumed greater than or equivalent to Z, were classified as food secure. Conversely, households with mean cost of daily calorie consumed less than Z were classified as food insecure.

Table 4.10: Estimated coefficient of the regression for per capita food expenditure and calorie consumption equivalent

Variable	coefficient	standard error	t-ratio	p-value
Constant term	3.7902***	0.0350	108.38	0.000
Per capita calorie consumed	0.0002***	8.66e-06	21.57	0.000
$R^2 = 0.447$	R^2(adj)= 0.446	Prob > F = 0.000	Root MSE = 0.59	

Source: Computations from Field survey, 2016

Legend: * = significant at p<0.1, ** = significant at p<0.05 and *** = significant at p<0.01

4.4.2 Distribution of farming households by food security status and level of use of CSAP

The distribution of the farming households by their food security status and level of use of CSAP is as shown in Figures 4.3. The pooled result showed that 56.0% of the arable farm household were classified as food insecure, whilst 44.0% were classified as food secure. This signifies that most of the farmers under study were food insecure. It might not be farfetched that this occurrence might be caused by the effect of climate variability on their crop yield, since majority of the farming households used for this research got the major part of their daily food consumption from the outputs from their farms (own production). If this source of food is affected by climate variability, it would surely affect the food available for the farmers to feed their households. There is therefore, the need to support the use of CSAP among the farmers so as to reduce the menace of climate variability, boost their crop production and yield and consequently improve their food security status.

Across the various CSAP groups as shown in Figure 4.4, food security was higher among the high-user group (54.0%) as compared to the medium-user (42.2%) and low-user (36.8%) groups; while food insecurity was higher among the low-user group (63.2%) as compared to the medium-user (57.8%) and high-user (46.0%) groups. It is very clear from this result that high-users of CSAP are enjoying the benefits of CSAP. One can also deduce from here that being a high-user of CSAP is more likely to make a household food secure as it would increase crop productivity. This is in line with the findings of Ali and Erenstein (2017).

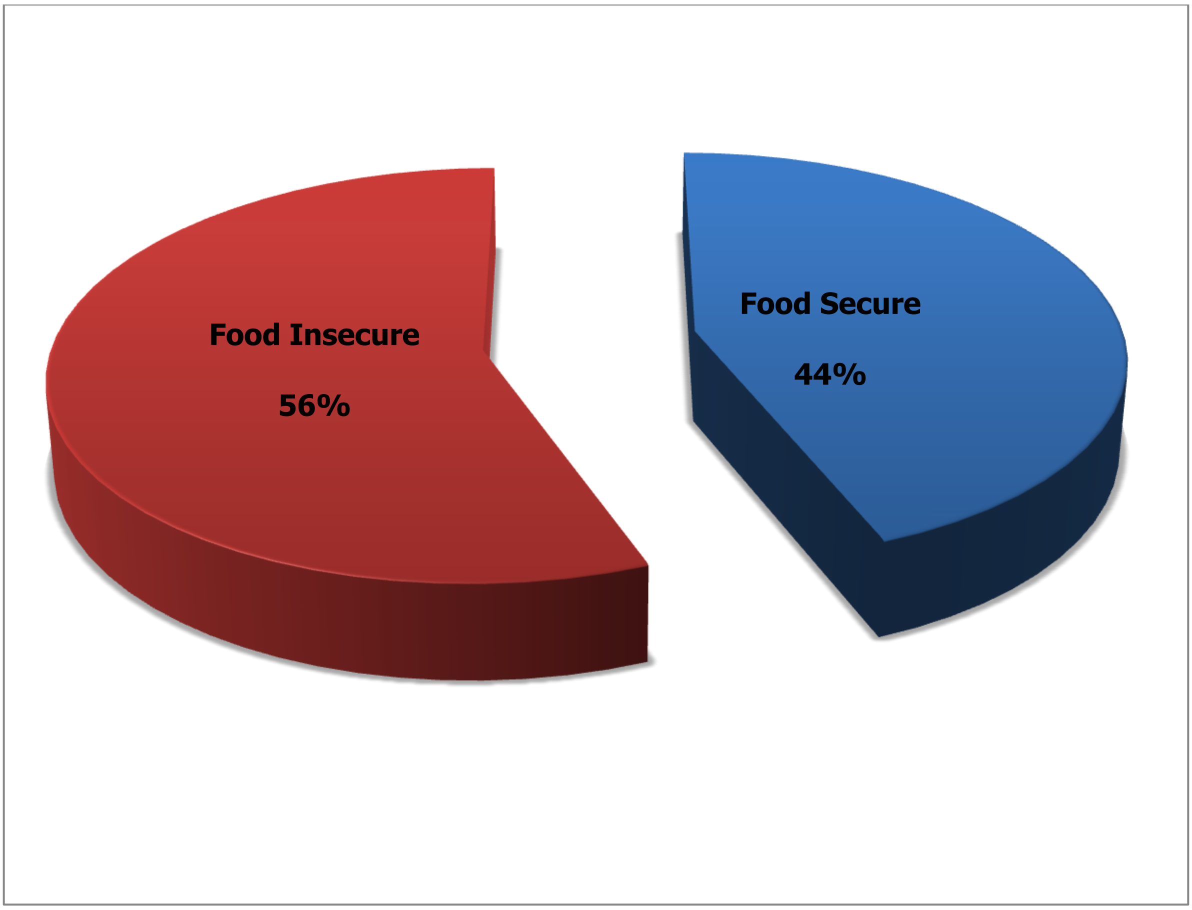

Figure 4.3: Distribution of food security status of the arable farming households

Source: Computations from Field Survey, 2016

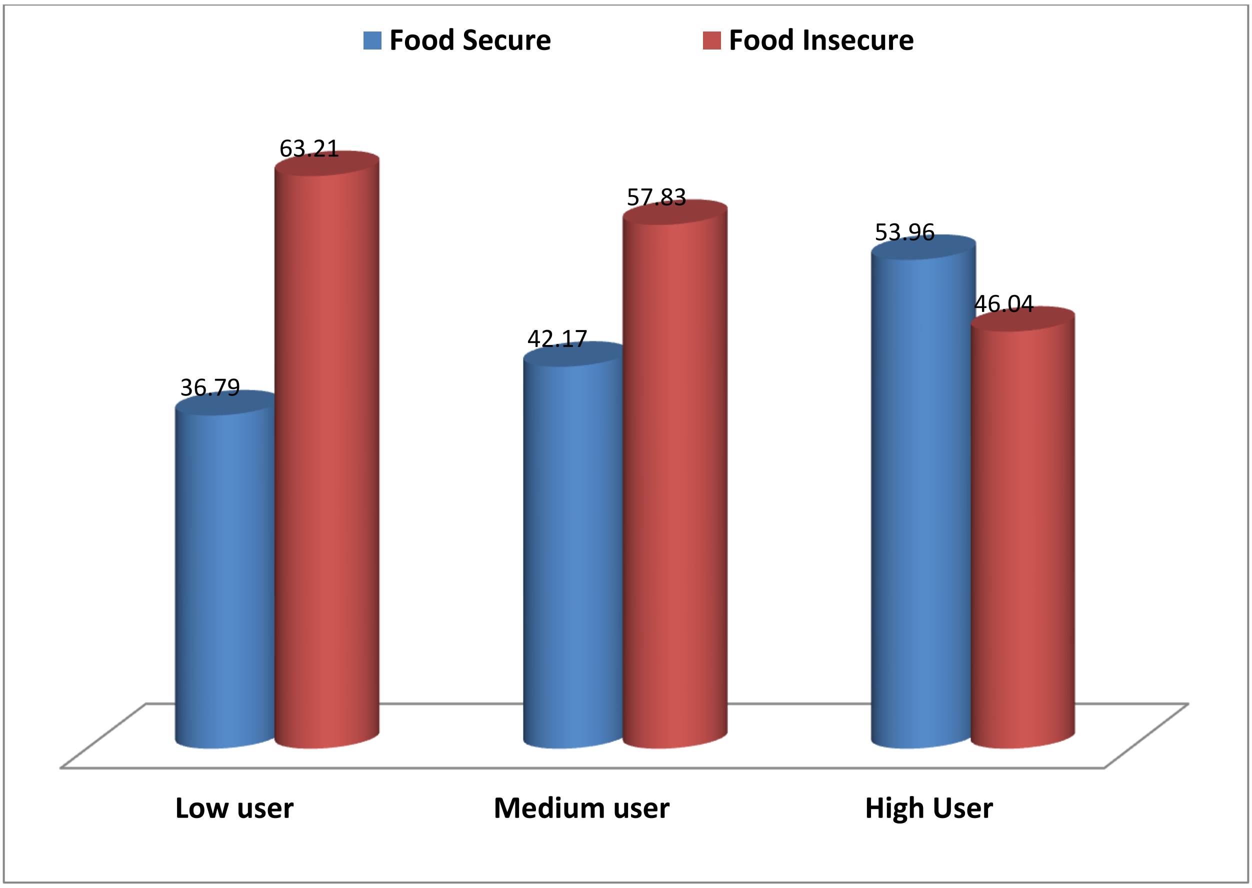

Figure 4.4: Distribution of the farm households by food security status and level of use of CSAP

Source: Author’s computation from Field Survey, 2016

4.4.3. Assessment of the degree of food insecurity

The estimates of the degree of food insecurity amongst the arable farming households as assessed based on the three CSAP groups using three food insecurity indices are as shown in Table 4.11. Here, only the households that were food insecure are considered. Results showed that food insecurity incidence was 59.0% for the medium-user of CSAP, while it was 21.0% and 20.0% for the low and high-users of CSAP respectively. In terms of depth (F_1) and severity (F_2), the medium-users of CSAP were more affected (24.0% and 14.0%) in comparison with the low-user (13.0% and 9.0%) and high-user (3.0% and 3.0%). This result also indicated that the medium users of CSAP were the worst hit by food insecurity relative to the other two categories. The implication of this is that, 59.0% of those who were food insecure were medium user of CSAP and they will require 24.0% of their Daily Calorie Intake (DCI) to get to the Recommended Minimum Daily Calorie Intake (RMDCI) of 2900Kcal. In contrast, the low-user of CSAP, who constitute 21.0% of those who were food insecure, will require 13.0% of their Daily Calorie Intake (DCI) to reach the RMDCI, while the high-user of CSAP, who constituted 20.0% of those who were food insecure, will require 3.0% of their Daily Calorie Intake (DCI) to get to the RMDCI. The results showed that the degree of food insecurity (indicated by the depth and severity) was more amongst the low-user of CSAP as compared with the high-user of CSAP.

Table 4.11: Food insecurity index of the arable farming households by their CSAP groups

CSAP groups	Incidence (F_o)	Depth (F_1)	Severity (F_2)	Head count ratio (%)
Low-User	0.21	0.13	0.09	21.0
Medium-User	0.59	0.24	0.14	59.0
High-User	0.20	0.03	0.03	20.0
Pooled (Aggregate)	0.56	0.23	0.15	100.0

Source: Computations from Field survey, 2016

4.4.4 Food security indices and sources of food consumed by the arable farming households

Results in Table 4.12 showed the food surplus index, food insecurity gap and sources of food consumed by the arable crop farming households in the study area. These indices measured the magnitude of deviation from the Recommended Minimum Daily Calorie Intake (RMDCI) of 2900Kcal (Ahungwa *et al*., 2013; Ibok *et al*., 2014). From the results, food surplus index in the study area was 0.51 for the pooled result, while across the various CSAP groups; it was 0.26, 0.73 and 0.23 for the low, medium and high-user groups respectively. This implies that on the average, households that are food secure consumed 51.0% more than the RMDCI, whereas those who are food secure among the low, medium and high-users of CSAP consumed 26.0%, 73.0% and 23.0% in excess of the RMDCI, respectively. Conversely, the food insecurity gap was 0.41 for the pooled result, while it was 0.42, 0.40 and 0.42 for the low, medium and high-users respectively. This indicated that the households which are food insecure consumed 41.0% lower than the RMDCI, on the average, while the food insecure households among low, medium and high-users of CSAP consumed 42.0%, 40.0% and 42.0% less than the RMDCI, respectively.

Furthermore, the percentage share of food consumed among the farm households from cereals, legumes and fat and oil were as shown in Table 4.12. The estimated result indicated that food consumed from cereals (76.0%) constituted the lion share of the entire food intake of the arable farm households, next, legumes (10.8%) and fat and oil (9.4%). This trend was similar for both the medium-user and high-user of CSAP, except for the low-user that had legumes as their least share (7.8%), of food consumed as compared with cereals and fat and oil.

Majority of the arable farming households sourced their food from their own production (55.6%), while 44.3% and 0.1% got theirs from the market (purchased) and received food as gift from friends and relatives, respectively. The results followed a similar trend across the three CSAP groups, except for the low-users of CSAP who sourced most of their food (66.7%) from the market, while the balance (33.3%) came from their own production.

Table 4.12: Summary of food security indices and source of food consumed by the arable farming household

Variables (in average)	Low-user	Medium-user	High-user	Pooled
Percentage food secure households (%)	36.8	42.2	54.0	44.0
Percentage food insecure households (%)	63.2	57.8	46.0	56.0
Food Surplus index	0.26	0.73	0.23	0.51
Food Insecurity Gap	0.42	0.40	0.42	0.41
Share of food consumed from Cereals (%)	75.0	74.6	79.9	76.0
Share of food consumed from Legumes (%)	7.8	12.3	9.6	10.8
Share of food consumed from Fat and oil (%)	14.8	8.8	6.4	9.4
Source of food crop:				
Own production (%)	33.3	57.6	67.8	55.6
Purchased (%)	66.7	42.2	32.2	44.3
Gift (%)	0.0	0.2	0.0	0.1

Source: Computations from Field Survey, 2016.

4.4.5 Food security statistics of the arable farm household

Results in Table 4.13 showed the food security statistics of the arable crop farming households. These results revealed the magnitude of deviation from the Recommended Minimum Daily Calorie Intake (RMDCI) of 2900Kcal and likewise the per capita expenditure on food by both the food secure as well as the food insecure households in the study area.

In terms of daily calorie consumed, the food secure household consumed 4382.88Kcal of food daily on the average, which was 1482.88Kcal in excess of the Recommended Minimum Daily Calorie Intake (RMDCI) of 2900Kcal as recognised by USDA and FAO (Ayantoye, *et al.*, 2011), while on the contrary, the households that were food insecure consumed 1720.71Kcal on the average, therefore, falling short of the RMDCI by 1179.29Kcal. Comparing the three CSAP groups, the food secure households among the low-user of CSAP consumed 3666.12Kcal of food on the average, which was 766.12Kcal in excess of the RMDCI, while the food insecure households in this category consumed 1681.29Kcal on the average, falling short of the RMDCI by 1218.71Kcal.

Also, the food secure households among the medium-user of CSAP consumed 5026.26Kcal of food on the average, which was 2126.26Kcal in excess of the RMDCI, while the food insecure households in this category consumed 1745.93Kcal on the average, falling short of the RMDCI by 1154.07Kcal. Lastly, the food secure households among the high-user of CSAP consumed 3554.62Kcal of food on the average, which was 654.62Kcal in excess of the RMDCI, while the food insecure households in this category consumed 1686.33Kcal on the average, falling short of the RMDCI by 1213.67Kcal. The short falls among the food insecure households is an indication that they would require that quantity of daily calorie intake to attain the threshold of 2900Kcal as recognised by USDA and FAO (Ahungwa *et al*., 2013; Ibok *et al*., 2014).

The food secure households on the average, had a per capita expenditure of ₦179.86k on food, whereas that of the food insecure households was ₦48.28k. Across the three CSAP groups, the food secure households among the medium-user of CSAP spent more on food (₦199.83k) for their household members as compared to the low-users (₦170.71k) and high-users (₦147.36k) of CSAP. In similar vein, the food insecure households among the medium-user of CSAP also spent more on food (₦50.05k) for their household members as compared with the low-user and high-user of CSAP, who spent ₦47.47k and ₦43.36k, respectively. The low per capita expenditure by the high-users of CSAP on food for their household members might be as a result of their high average adjusted household size of 8 persons for the food secure households in this category in comparison with the average adjusted household size of the medium-user and low-user with 7 persons and 6 persons, respectively. Likewise in the same vein, among the food insecure households, high-user of CSAP had higher average adjusted household size of 12 persons as compared with that of medium-user (11 persons) and low-user (10 persons) in the study area.

Table 4.13: Summary of food security statistics of the arable farm household

Variables (in average)	Low-user	Medium-user	High-user	Pooled
Average household daily calorie consumption (Kcal) for food secure households	3666.12	5026.26	3554.62	4382.88
Average household daily calorie consumption (Kcal) for food insecure households	1681.29	1745.93	1686.33	1720.71
Average calorie consumption (Kcal) in excess of recommended (2900Kcal) Daily Calorie Intake	766.12	2126.26	654.62	1482.88
Average calorie consumption (Kcal) in shortage of recommended (2900Kcal) Daily Calorie Intake	1218.71	1154.07	1213.67	1179.29
Average adjusted household size of food secure households	6.00	7.00	8.00	7.00
Average adjusted household size of food insecure household	10.00	11.00	12.00	11.00
Average per capita expenditure on food by food secure households (₦)	170.71	199.83	147.36	179.86
Average per capita expenditure on food by food insecure households (₦)	47.47	50.05	43.83	48.28

Source: Computations from Field Survey, 2016.

4.4.6. Estimates of effect of CSAP on food security status of the arable farming households

Binary logit was utilised to determine the effect of using CSAP on the farm household's food security status. Results obtained are as stated in Table 4.14. Log-likelihood value of -307.8533 with a prob>chi-square estimate of 0.0000 (significant at $p<0.01$), are an indication that the whole model was statistically significant and well fitted, while the Pseudo R^2 was 0.2222.

From the results, household heads' sex significantly influenced (at $p<0.10$) food security status of the arable farming households, with the odd-ratio of being food secure increasing by 2.020. Education also significantly influence food security among the arable farming households at $p<0.10$, with odd-ratio increasing in the benefit of those who are food secure by 1.042. However, the odd-ratio in support of the farm households' food security status decreased by 0.755 as household size rose up by an extra member. As the non-farm earnings of the household swelled by one Naira, the farm households' food security status also increased by 1.000 in odd-ratio, while for farm households who were high-users of CSAP, the odd-ratio favoured their food security status by an increment of 2.592.

4.4.7 Marginal effect estimates of the determinants of food security among the arable farm household

Marginal effect of the factors influencing food security amidst the farm household is as published in Table 4.14. This results as presented state that being a male headed household significantly ($p<0.10$) increased the farming household's probability of being food secure by 0.153. It tallies with the outcome of the works of Kassie *et al*. (2014), who opined that household headed by males are more food secure than those headed by females.

Similarly, when the number of years of education is increased by 1.0%, the likelihood of being food secure would be significantly ($p<0.10$) increased among the farming households by 0.01. Education has a noteworthy role in the adoption of productive farming practices that would enhance production in agriculture and subsequently food security among rural farm households. The result tallies with that of Ahmed *et al*. (2015), who revealed that education, had a positively significant effect on food security level of rural farmers. He further stated that the educational attainment of a farmer would be an additional factor that would indirectly influence the food security rating of a farm household, because it enables the farmers to be aware of the food groups required for their growth and wellbeing, which consequently influences the nutritional decisions that will enhance their quality of food intake.

However, when household size increased by 1.0%, a significant ($p<0.01$) decrease occurred in the probability of the farming households becoming food secure by 0.067. Large household sizes which are made up mainly by non-productive members would be more exposed to food insecurity due to high demand for food and consumables. The research outcome of Beyene and Muche (2010), Osei *et al*. (2013) and Ahmed *et al*. (2015) all agree with this result, as they opined that when more people feed on available food, they indirectly reduce income per head and likewise per capita food consumption, thereby leading to food insecurity. Increased household size definitely increases food expenditure; most especially when majority of them can not provide any additional income, but rely exclusively on the household head, thereby leading to a decrease in their food security status (Ahmed *et al*., 2015). This implies that a household composed largely of non-productive members puts the pressure of high per capita food burden on other active members and they are more predisposed to food insecurity (Okon *et al*., 2017).

The results likewise revealed that with a 1.0% increment in off-farm earnings, the likelihood of the farm household being food secure significantly ($p<0.01$) increased by 2.11e-06. Income generated by arable farming households from non-farm activities can be invested into their cropping activities to enhance production and consequently food availability for their households. Small households who depend solely on farm income would have insufficient income to accomplish their farm activities and meet their family food calorie requirement and thereby become food insecure. The result corroborates that of Ojeleye *et al*. (2014), who submitted that positive and significant correlation exists between non-farm income and food security among farming households. This revealed that those farmers who engage in non-farming activities are better engaged economically to buy high-value food that gives them a better access to more nutritional value. Also, the results of this study is congruent with the research outcome of Osarfo *et al*. (2016), who stated that farm household's participation in off-farm jobs received higher income as well as enjoyed better food security status in contrast with households who are not participating in such activities.

Households who were high-user of CSAP had higher probability (0.231) of being food secure at $p<0.01$, compared to those that were low-user of CSAP. This result affirmed the fact that increased level of use of CSAP in agricultural production positively enhanced crop productivity, which would consequently boost food security of farm households, who rely basically on the output from their farms as their source of food. This tally with the findings of Elizabeth and Sophie (2014), who opined that Climate Smart Agriculture has triple win benefits, which includes food security benefit. Ali and Erenstein (2017), who reported that farmers who adopted adaptation strategy had food security status that were higher as compared to those who declined to adopt, tallies with the results of this research. They also reported that rural farming households who adopted higher levels of adaptation practices, that is, using two or three adaptation strategies had higher levels of food security and low poverty levels.

Table 4.14: Determinants of food security among the arable farm household

Variable	Coefficient	Z statistics	Odd ratio	Marginal effect
Age of household head	0.038	0.51	1.038	0.009
Age squared	-0.0001	-0.18	0.999	-0.00003
Sex of household head (Base=Female)	0.703	1.80	2.020	0.153*
Education in years	0.041	1.92	1.042	0.010*
Household size	-0.281	-8.98	0.755	-0.067***
Farm income	3.27e-06	0.80	1.000	7.77e-07
Non-farm income	8.90e-06	2.96	1.000	2.11e-06***
Farming experience	-0.006	-0.44	0.994	-0.001
Farm size	0.025	0.74	1.025	0.006
Membership of farmers' association (Base=No)	-0.092	-0.42	0.912	-0.022
Access to credit (Base=No)	0.073	0.31	1.076	0.018
Livestock ownership (Base=No)	-0.247	-0.86	0.781	-0.060
Medium-user (Base=Low-user)	0.134	0.48	1.144	0.032
High-user (Base=Low-user)	0.952	2.98	2.592	0.231***
Pseudo R^2	0.2222			
Log-likelihood	-307.8533			
Prob > chi^2	0.0000			

Source: Computations from Field survey, 2016

Legend: * =significant at $p<0.1$, ** =significant at $p<0.05$ and *** =significant at $p<0.01$

CHAPTER FIVE

SUMMARY, CONCLUSION AND POLICY RECOMMENDATIONS

5.1. Summary of major findings

This study investigated the effect of using Climate-Smart Agricultural Practices (CSAP) on crop productivity and food security status of arable farming households in North-Western Nigeria.

The study adopted a four-stage sampling techniques in which 577 respondents out of 600 were used for the research using structured questionnaires and data collected for the study were analysed using descriptive statistics, adaptation strategy use index, ordered probit model, total factor productivity index, ordinary least square regression, cost-of-calorie measure and binary logit model.

The categorisation of the arable farm households into their level of use of CSAP using composite score showed that 18.4%, 57.5% and 24.1% of the respondents were low-user, medium-user and high-user of CSAP respectively. This implies that most of the farmers interviewed for this research belong to the medium-user of CSAP.

Average age of farmers was 48 years in the studied area, while across the CSAP groups, the average age were 46, 50 and 47 years for the low-user, medium-user and high-user groups, respectively. The implication is that the farmers here are in their energetic age and thereby strong enough to engage in farming activity. Majority (91.0%) of the respondents are of the male gender, with most (45.1%) of them having quranic education as highest level of education. Also, a large number of the farmers were married (92.2%), had 11 persons as their average household size and belonged to one or more social groups (52.9%). Likewise, 54.8% often had contact with extension officers.

The average years of farming was 26 years, while across the CSAP groups; it was 22, 26 and 27 years for the low-user, medium-user and high-user of CSAP, respectively. Equally, most of the farm households (71.6%) were not having access to agricultural credit, while livestock ownership was also a regular practice among the famers as 85.0% of the respondents kept livestock together with their farming activities as alternative source of income. On the average, the farmers earned as much as ₦204,202.08 from their farming enterprise per year (cropping season); while on the other hand, they earned an average of ₦372,606.48 per year from their non-farm income sources. Also, the average farm size owned by the farmers in the area under study was about 4.16 hectares, while across the three CSAP groups; it was 3.22, 4.61 and 3.81 hectares for the low-user, medium-user and high-user of CSAP, respectively. Land ownership amongst the arable farm households was mainly by inheritance (77.5%). It was the same trend across the three CSAP groups.

Perception of the farmers on how climate change affected their farming activities between 2011 and 2015 indicated that most of the farm household (74.5%) perceived a rise in temperature for the period under study, whereas 74.2% of the respondents perceived decreased rainfall pattern within the same period. Also, 72.3% of the farming households asserted negative effect of climate change on their cropping activity, most especially on crop yields, within this period. Likewise, 68.1% of the respondents perceived negative effect of climate variability on water supply in the study area, while their perception on the magnitude of drought showed that 64.3% of the respondents perceived it as moderate, showing that drought is not yet a severe problem to the farmers. The duration of rainfall in the area studied was about 3 to 4 months and 61.9% of the respondents confirmed this.

The Adaptation Strategy Use Index (ASUI) results also revealed that the five (5) most used CSAP in the studied area were organic manure use, conservation agriculture, crop diversification, planting of cover crops and crop rotation in descending order. The use of organic manure ranked first (1^{st}).

Results from the ordered probit estimates revealed that the household head’s age, sex, farming experience, membership of farmers’ association and livestock ownership were factors that significantly influenced the different levels of use of CSAP in the studied area.

Furthermore, the Total Factor Productivity (TFP) output using the Fisher index showed that 37.0% of the respondents had a TFP that is progressing, while 63.0% had a TFP that is deteriorating. But from the disaggregated results across the various levels of use of CSAP, it is evident that the percentage of the low-user of CSAP (47.2%) who operated at deteriorating level of TFP was higher than the percentage of high-user of CSAP (44.6%) at the same level. While on the other hand, the percentage of high-user of CSAP (55.4%) who operated at the progressive level of TFP are more than the percentage of lower-user of CSAP (52.8%) at the same level. The OLS regression model estimates obtained proved that seed, inorganic fertiliser, organic manure, farm size, labour, household size and use of CSAP significantly influenced crop productivity among the farming households across the various CSAP groups.

The results of the computed cost-of-calorie food security measure revealed that the food security line (Z) was estimated as ₦79.06k per day. On this basis, majority (56.0%) of the interviewed farmers were classified food insecure, whereas 44.0% were food secure. Across the various CSAP groups, results showed that 36.8%, 42.2% and 54.0% of the low, medium and high-users of CSAP were food secure, while 63.2%, 57.8% and 46.0% of the low, medium and high-users were food insecure. This result clearly showed that the percentage of high-users of CSAP who were food secure (54.0%) are higher than the percentage of low-users of CSAP who were food secure (36.8%), while on the contrary the percentage of high-user of CSAP who were also food insecure (46.0%) are lower than the percentage of low-users of CSAP who were food insecure (63.2%).

Results showing the magnitude of food insecurity revealed that food insecurity incidence was 59.0% for the medium-user of CSAP, while it was 21.0% and 20.0% for the low-user and high-user of CSAP respectively. In terms of depth (F_1) and severity (F_2), the medium-users of CSAP were more affected; 24.0% and 14.0% respectively, as compared with the low-user (13.0% and 9.0%) and high-user (3.0% and 3.0%). This implied that the medium-users of CSAP were the worst hit by food insecurity relative to the low and high-users of CSAP. The food insecure households among the medium-users of CSAP in the study area will require about 24.0% increase in their Daily Calorie Intake (DCI) to attain the RMDCI of 2900Kcal, while the low-user and high-user of CSAP on the other hand, will require 13.0% and 3.0% increase in their Daily Calorie Intake (DCI) to meet up with the RMDCI respectively.

The summary of the food security statistics showed that the food surplus index in the study area was 0.51, which implied that on the average, households that were food secure consumed 51.0% excess daily calorie requirements. Conversely, the food insecurity gap was 0.41, implying the households that were food insecure consumed 41.0% lower than their calorie requirements per day, on the average. Also, the percentage share of the food that the farm households consumed from cereals, legumes and fat and oil were estimated as 76.0%, 10.8% and 9.4% respectively. Most of the arable farming households sourced food from their own production (55.6%), while 44.3% and 0.1% purchased their food from the market and received it as gift respectively. In terms of daily calorie consumption, the households that were food secure consumed an average of 4382.88kcal of food daily, which was 1482.88kcal in excess of the RMDCI of 2900kcal, whereas, food insecure households consumed an average of 1720.71kcal of food daily, which fell short of the RMDCI by 1179.29kcal. Lastly, the average per capita spending on food by the food secure households was ₦179.86k, which is far higher than the estimated Z value of ₦79.06k per day, as compared with ₦48.28k for the food insecure household.

Binary logit results obtained indicated that five explanatory variables, which included sex, education, household size, off-farm income and being a high-user of CSAP, significantly influenced food security in the studied area. The use of CSAP was statistically significant at $p<0.01$ among the high-user category.

5.2 Conclusion of the study

The research was carried out to evaluate the effect of using CSAP on the productivity and food security status of farm households in North-western Nigeria. From the observed evidences that emanated from this research, the conclusions below are made:

i. Arable farming households used CSAP at various levels, namely: low-users, medium-users, and high-users of CSAP.
ii. Most of the household heads were still in their active age with large household size. They were predominantly males, married, acquired quranic education and are small scale farmers with good farming experience, owning livestock and inherited their farm land.

iii. A large proportion of the farm households perceived an increased temperature level and decreased rainfall pattern. They also asserted that climate change negatively affected their cropping activities, worsened their water supply and moderately caused drought.

iv. The farm households also used CSAP for farming and the five predominant CSAP in the area under study were organic manure, conservation agriculture, crop diversification, planting of cover crops and crop rotation in descending order.

v. The household head's age, sex, farming experience, membership of farmers' association and livestock ownership were factors that significantly influenced the different levels of use of CSAP.

vi. Productivity of the rural farm households measured in terms of Total Factor Productivity (TFP) showed that the farming households were predominantly operating at deteriorating level, while few were at the progressive level.

vii. When disaggregated along the various CSAP levels, majority of households who are high-user of CSAP were at the progressive level, while majority of the households who were low-user of CSAP were operating at a deteriorating level.

viii. Also, the use of CSAP significantly influenced crop productivity, since it helps to curb the impact that climate change exert on crop production.

ix. Furthermore, most of the farm households who were high-users of CSAP were food secure, while contrariwise, most rural farm households who were low-users of CSAP were food insecure.

x. The medium-user category was the worst hit by food insecurity in the study area, requiring about a quarter of their Daily Calorie Intake (DCI) to reach the RMDCI, as compared with the low-user and high-users.

xi. The food security summary statistics revealed an excessive consumption of calorie requirements per day by the food secure households; whereas, the households that were food insecure had a low consumption, lower than their daily requirements of calorie. In addition, the highest share of food eaten by the farm households came from cereals and this food were majorly sourced from the own production.

xii. The use of CSAP among the high-user category was a very important factor that positively influenced food security among the rural farm household. Implying that more usage of CSAP by farming communities specifically in the area under study and Nigeria in general, will boost crop productivity and food security will be experienced.

5.3 Policy implications and recommendations:

In line with the outcomes of this research and the conclusions drawn, recommendations were made towards increasing the use of CSAP in North-western Nigeria in order to boost agricultural output and consequently enhance the food security condition amidst farm household under this study and in Nigeria as a whole:

i. In line with the perception of the arable farming households that climate change affected their crop productivity negatively, due to decreased rainfall, high temperature and short duration of precipitation, government and Non-Governmental Organisation (NGOs) who are concerned about improving the agricultural sector should provide irrigation facilities for the rural farmers and also organize training on rain harvesting for the farmers. This will help to curb the challenge of poor water supply and drought caused by climate change and would also facilitate double cropping system.

ii. There is a connection between the use of CSAP and crop productivity, therefore farmers in the area studied and Nigeria as a whole should be educated and enlightened on the benefits of using CSAP in their cropping activity via farmer field days by extension agents. This will enhance the usage of CSAP among the farming households and consequently boost crop productivity.

iii. Based on the findings from this research that the total factor productivity of majority of the arable farming households were at a deteriorating level, government agency like the Bank of Agriculture (BOA) should provide farmers with agricultural credit at subsidized rate that would be used to procure productive resources such as improve seed variety and other farm inputs to increase crop productivity.

iv. The use of organic manure was the predominant CSAP used by the rural farmers; therefore, there is need for the establishment of industries that produce organic manure (bio-organic fertilisers industries) in pellet form, which is less bulky. This can be achieved through public-private partnership with NGOs and agricultural firms.

v. Membership of farmers' association was a key factor that influenced CSAP usage in the studied area; therefore, farmers should be well-informed by extension agents about the benefits of belonging to farmers' association (especially farmers' cooperative society), as this might likely assist them in getting farm inputs, accessing soft loans as well as getting vital information on the benefits of modern farming techniques, like CSAP, that would help to boost crop productions.

vi. The high level of food insecurity, low calorie intake as well as food insecurity depth and severity among the arable farming households requires that farmers themselves should do more in improving their food security status by creating and partaking in off-farm economic opportunities, which will diversify the source of their income and also help to increase their purchasing power (income) and in turn, help them to meet their minimum daily calorie intake.

vii. This study revealed a strong connection between CSAP and food security; therefore, in achieving the Sustainable Development Goal (SDG) number thirteen, which stipulate taking vital steps to fight climate change and its consequential impacts, policy makers should formulate policies which would persuade investment in climate-smart agriculture both by the private sector or public sector of government. This would assist farmers in fighting the threat of climate change on their farming practices. This in turn would motivate farmers to practice CSAP more, thereby improving their food production and subsequently food security status.

viii. Improved seed varieties that are more productive and drought resistant should be developed in our agricultural research institutes and Universities in Nigeria, and supplied to the rural farmers. The results from these researches would be beneficial to the rural farmers and likewise help to boost crop productivity in Nigeria's agricultural sector.

5.4 Major Contributions of the Study to Knowledge

i. Climate-smart agricultural practices (CSAP) were developed to deal with the challenges caused by climate change and scanty empirical evidence exists on the practice of climate-smart agriculture especially among rural farming households in North-Western Nigeria and Nigeria in general. This study therefore fills the gap in literature by investigating the practice of CSAP among the rural households in North-western Nigeria.

ii. Previous studies on climate-smart agricultural practices focused on the practice from a broad perspective, that is, at national levels. This study contributed to knowledge by examining climate-smart agricultural practices at rural household level, that is, at micro-level.

iii. Most studies focused on the usage of climate change adaptation strategies among farming households as cumulative entity. This study improved on this by using the composite score analysis to disaggregate the arable farming households into three levels of use of climate-smart agricultural practices with minimum deviations within groups.

iv. Also, previous studies mainly focused on the impact of climate change and climate variability on yields of crops. This study contributed to literature by concentrating on the effect of climate-smart agricultural practices on crop productivity as well as food security status of arable farming households at various levels of use of climate-smart agricultural practices.

v. In line with the Sustainable Development Goal (SDG) number thirteen, which is to "take urgent action to combat climate change and its impacts", this study hopes to enlighten policy makers and assist them in making policies that would combat the menace of climate change impact on crop productivity.

5.5. Suggestions for further study

i. The study was carried out to empirically investigate the consequence of using CSAP on the productivity and food security levels of farm household in North-western Nigeria. The study only looked at cross sectional data, therefore, there is need for further study using panel data for comparative studies.

ii. Furthermore, this study only looked at how CSAP affect productivity and food security of rural farm households in one period, other studies can concentrate on looking at transition between different periods, which will show some dynamics.

iii. This study only considered CSAP and the effect of their usage on productivity and food security of farm households, further research can be conducted with a focus on the financial implication or cost of using CSAP.

iv. There is also the need for further studies on the policy framework involved in the operation of CSAP in Nigeria.

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APPENDIX I

Annex I: **Analysis of Objectives**

	OBJECTIVES	DATA REQUIRED	ANALYTICAL TECHNIQUES
1	Profile the level of use of Climate-Smart Agricultural Practices by farm household in the study area	Socioeconomic characteristics, Climate-Smart Agricultural Practices, Climate change variables	Composite score Descriptive statistics Adaptation Strategy Use Index (ASUI)
2	Determine the factors influencing level of use of Climate-Smart Agricultural Practices by the farm households in the study area.	Socioeconomics characteristics, levels of use of Climate-Smart Agricultural Practices	Ordered probit model
3	Examine the effect of using Climate-Smart Agricultural Practices on crop productivity among farming households in the study area.	Input and output variables, Cost of variable inputs, CSAP	Total Factor Productivity (TFP) index OLS regression model
4	Examine the effect of using Climate-Smart Agricultural Practices on food security status of farming households in the study area.	Food consumption, expenditure on food consumed, level of use of CSAP, socioeconomics characteristics	Cost-of-Calorie index Binary Logistic model

Annex II: Sample Size of the arable farming households selected for the study

STATE	LGA	VILLAGE	Number of Questionnaire retrieved
	Batagarawa	Ajiwa	20
KATSINA		Yan Rakumma	19
		Shagumba	20
	Charanchi	Kaskanoki	21
		Giangara	20
		Lamba	18
	Bakori	Bakori	17
		Kobomo	22
		Kurami	19
	Dandume	Kadawa	20
		Gyazama	22
		Mahuta	17
	Kurfi	Tasha Bara'u	20
		Birchi	19
		Kurfi	19
	Kankia	Hayin- alasan	20
		Shaiskawa	23
		Kafin-soli	17
	Tambuwal	Saida	20
SOKOTO		Romo	20
		Salah	17
	Bodinga	Badau	20
		Jirga	17
		Kofar kwasau	19
	Goronyo	Taloka	19
		Balla	20
		Sabongari dole	20
	Gwadabawa	Mammande	17
		Abdalo	17
		Attakwanyo	18
TOTAL	**10 LGAs**	**30 Villages**	**577 Respondents**

Source: Author's computation from field survey, 2016

APPENDIX II

Annex I: Grain Equivalent Conversion Factors

COMMODITY	CONVERSION FACTOR
Maize	1.00
Millet	0.93
Sorghum	0.96
Rice	1.00
Wheat	0.92
Cassava	0.30
Sweet Potato	0.30
Irish	0.28
Yam	0.25
Cocoyam	0.24
Plantain	0.21
Groundnut	1.51
Beans	0.96
Other legumes	1.10
Melon seed	1.55
Others	1.04
Vegetable	0.06
Fruit	0.10
Palm oil	2.40
Groundnut oil	2.40
Others	2.20
Sugar	1.07
Beef	0.62
Goat meat	0.60
Mutton	0.67
Poultry meat	0.36
Pork	1.05
Offals	0.40
Eggs	0.45
Fish	0.35
Milk	0.40
Butter	2.45
Cheese	0.75
Animal oil and fat	2.20
Beverage	0.08

Source: Nigerian Institute of Social and Economic Research (NISER), Ibadan, 1996.

Annex II: Adult-equivalent conversion factors for estimated calorie requirements according to age and gender

Age (years)	Calories (kcal)	Adult-equivalent
Newborns		
0-1	750	0.29
Children		
1-3	1,300	0.51
4-6	1,800	0.71
7-10	2,000	0.78
Men		
11-14	2,500	0.98
15-18	3,000	1.18
19-24**	2,900	1.14
25-50	2,900	1.14
51 and above	2,300	0.90
Women		
11-14	2,200	0.86
15-18	2,200	0.86
19-24	2,200	0.86
25-50	2,200	0.86
51 and above	1,900	0.75

****** is used as the reference mean adult calorie requirement

Source: Claro *et al*. (2010)

Annex III: Proximate composition of foods in Nigeria

S/N	FOODS	Kcal (per 100 grams edible Portion)
1	Maize	412
2	Wheat	330
3	Sorghum	394
4	Millet	414
5	Rice	333
6	Cassava	376
7	Gari	384
8	Yam	373
9	Potato	391
10	Cowpea	342
11	G/nut	570
12	Meat	237
13	Fish	223
14	Poultry	146
15	Egg	140
16	Milk	158
17	Vegetable	428
18	Tomato	220
19	Okra	455
20	Orange	440
21	Palm oil	875
22	G/nut oil	884
23	Sugar	375
24	Bread	216
25	Beverage	273
26	Dawadawa	465

Source: Oguntona and Akinyele (1995)

APPENDIX III

Annex I: LINEAR MODEL

Table 4.8: OLS estimates of the effect of CSAP on TFP of the arable farming households

Variable	coefficient	standard error	Z statistics	P > t
Seed	0.0087***	0.0019	4.59	0.000
Inorganic Fertiliser	-0.0017***	0.0003	-6.30	0.000
Organic manure	0.0002***	0.0001	2.68	0.008
Farming experience	-0.0108	0.0093	-1.15	0.250
Farm size	0.0448	0.0344	1.30	0.193
Education	-0.0365*	0.0189	-1.93	0.054
Labour	-0.0063	0.0039	-1.61	0.108
Farm income	-7.26e-08	3.66e-06	-0.02	0.984
Non-farm income	4.10e-06	3.33e-06	1.23	0.219
Household size	0.0446***	0.0172	2.59	0.010
Low-user (Base=Medium-user)	0.7758***	0.2416	3.21	0.001
High-user (Base= Medium -user)	0.5340**	0.2207	2.42	0.016

Number of observations	577
R^2	0.16
Adjusted R^2	0.15
F-statistics	9.23
Prob > F	0.000
Root Mean Square error	2.09

Source: Author's computation from Field survey, 2016

Legend: * =significant at p<0.1, **= significant at p<0.05 and *** =significant at p<0.01

Annex II: SEMI-LOG MODEL (LIN-LOG)

Table 4.8: OLS estimates of the effect of CSAP on TFP of the arable farming households

Variable	Coefficient	Standard error	Z statistics	P > t
Seed	0.2161*	0.1315	1.64	0.102
Inorganic Fertiliser	-1.0832***	0.1351	-8.02	0.000
Organic manure	0.2329***	0.0835	2.79	0.006
Farming experience	-0.1503	0.2230	-0.67	0.501
Farm size	0.6157***	0.1731	3.56	0.000
Education	0.0754	0.1124	0.67	0.503
Labour	0.1982	0.1754	1.13	0.259
Farm income	0.1111	0.1011	1.10	0.273
Non-farm income	-0.0086	0.1059	-0.08	0.935
Household size	0.1371	0.2170	0.63	0.528
Low-user (Base=Medium-user)	0.7361**	0.3257	2.26	0.025
High-user (Base= Medium -user)	0.3048	0.2120	1.44	0.152

Number of observations	273
R^2	0.33
Adjusted R^2	0.30
F-statistics	10.75
Prob > F	0.000
Root Mean Square error	1.45

Source: Author's computation from Field survey, 2016

Legend: * =significant at p<0.1, ** =significant at p<0.05 and *** =significant at p<0.01

Annex III: RECIPROCAL MODEL

Table 4.8: OLS estimates of the effect of CSAP on TFP of the arable farming households

Variable	Coefficient	Standard error	Z statistics	P > t
Seed	-6.8752*	3.7700	-1.82	0.069
Inorganic Fertiliser	186.1709***	25.4993	7.30	0.000
Organic Fertiliser	-72.2062**	29.6031	-2.44	0.015
Farming experience	0.8875	4.0267	0.22	0.826
Farm size	-1.3666***	0.4897	-2.79	0.006
Education	-0.0484	0.5049	-0.10	0.924
Labour	-3.9571	5.3712	-0.74	0.462
Farm income	-615.8153	600.2371	-1.03	0.306
Non-farm income	-83.1676	614.8000	-0.14	0.892
Household size	-0.4145	1.6777	-0.25	0.805
CSAP	0.4066	0.5698	0.71	0.476

Number of observations	273
R^2	0.22
Adjusted R^2	0.19
F-statistics	6.80
Prob > F	0.000
Root Mean Square error	1.56

Source: Author's computation from Field survey, 2016

Legend: * =significant at p<0.1, ** =significant at p<0.05 and *** =significant at p<0.01

Annex IV: COBB-DOUGLAS MODEL (LOG-LOG)

Table 4.8: OLS estimates of the effect of CSAP on TFP of the arable farming households

Variable	Coefficient	Standard error	Z statistics	P > t
Seed	0.2057***	0.0778	2.64	0.009
Inorganic Fertiliser	-0.7253***	0.0799	-9.07	0.000
Organic manure	0.2080***	0.0494	4.21	0.000
Farming experience	0.0749	0.1319	0.57	0.571
Farm size	0.1332	0.1024	1.30	0.194
Education	0.0378	0.0665	0.57	0.570
Labour	0.1269	0.1038	1.22	0.222
Farm income	-0.0311	0.0598	-0.52	0.604
Non-farm income	-0.0321	0.0626	-0.51	0.609
Household size	0.0585	0.1284	0.46	0.649
Low-user (Base=Medium-user)	0.3053	0.1926	1.58	0.114
High-user (Base= Medium -user)	0.2909**	0.1254	2.32	0.021

Number of observations	273
R^2	0.40
Adjusted R^2	0.37
F-statistics	14.47
Prob > F	0.000
Root Mean Square error	0.86

Source: Author’s computation from Field survey, 2016

Legend: * =significant at p<0.1, ** =significant at p<0.05 and *** =significant at p<0.01

APPENDIX IV

UNIVERSITY OF IBADAN, IBADAN
DEPARTMENT OF AGRICULTURAL ECONOMICS

"Climate-Smart Agricultural Practices (CSAP), Productivity and Food Security Status of Arable Farming Households in North-Western Nigeria"

This is a survey meant to find out the effect of using CSAP on the Productivity and Food security status of arable farming households in North-Western, Nigeria. The information provided are confidential and for the purpose of research only.

Name of Enumerator:………………………………………………………………..

Questionnaire number:………………… Date of interview:…………………………… State:……………………

LGA:…………… Name of village:…………..………………

Longitude:…………………… Latitude: ………………..…….

Altitude:.......................

A. SOCIO-ECONOMIC CHARACTERISTICS

1. Age of household head:……………………………………
2. Sex of household head:…………… Male = [1]; Female = [0]
3. Marital status of household head: Single =[1]; Married =[2]; Divorced/separated =[3]; Widowed =[4]
4. Educational status of household head: No formal=[1]; Koranic=[2]; Primary=[3]; Secondary=[4]; Tertiary=[5]
5. Number of years you spent in school (in total):…………………………
6. Household size: ……………………………………………..
7. How many of your household member falls into the age group below?

Age group (years)	**Number of males**	**Number of females**
0 – 4		
5 – 14		
15 – 64		
65 and above		

8. Number of dependants:……………………………………
9. Number of household members employed……………….……..

10. Number of household members unemployed……………………
11. What is the average monthly income of your households from farming activities (₦)?.......................
12. Average monthly expenditure on food (₦):
………………………………………
13. Average monthly expenditure on non-food items (₦):…………………………………
14. What other income generating activities are your household members engaged in?

Activities	Amount generated (₦)	Frequency (use codes below)

Codes: [1]=daily; [2]=weekly; [3]=twice a month; [4]=monthly; [5]=others (specily)……………….

15. Number of relatives outside your household that were involved in farming discussion with you in the last farming season ....
16. How long have you been into farming?...
17. Average distance of your homestead to your farm(s) in kilometers……………
18. Do you have access to agricultural credit? ……….. Yes=[1]; No=[0]
19. If yes, indicate the source(s) of your credit and the amount obtained in the last farming season.

Source of credit	**Amount obtained** (₦)	**Interest paid (%) per year**	**Duration of credit**
Agricultural Bank			
Commercial banks			
Local Money lenders			
Friends and Relatives			
Cooperatives			
Others (specify) ……………………….			

20. What number of times do extension officers visit you? ……………………………

21. How can you describe your contact with extension agents? ………………………

    Very often=[1]; Often=[2]; Seasonally=[3]; Not at all=[4]
22. Do you usually have farmer-to-farmer extension visits in your community? Yes=[1]; No=[0]
23. What type of agricultural production activity are you engaged in? ……………………

    Crop production only=[1]; Livestock production only=[2]; Both crop and livestock production=[3];
24. Do you belong to any association/social group? ………… Yes = [1]; No = [0]
25. How many associations/social group do you belong to?..............................
26. How long have you been a member of the associations/social group? ………………

B. HOUSEHOLD NON FOOD EXPENDITURE

27. Please supply the following information on your expenses in the past **one (1)** month

S/N	ITEMS	AMOUNT (₦)
1	Clothing (fabric, clothes, towels, beddings)	
2	Shoes and foot wears	
3	Education (fees, books, school uniform)	
4	Health (medicine, glasses, Doctor's charges)	
5	Transportation cost	
6	Handset and GSM recharge card	
7	House rent	
8	Furniture (beds, tables, chairs)	
9	Kitchen utensils (pot, cup, plates, spoons, etc)	
10	Cigarettes or tobacco, kolanut	
11	Recreational (cinemas, video/DVD rental)	
12	Petrol and engine oil, kerosene, charcoal, firewood, gas, candle	
13	Electricity bills (including purchase of light bulbs)	
14	Purchase of motorcycle/bicycle	

15	Home repairs (painting, roofing, etc)	
16	Debt repayment (cooperatives, local contribution)	
17	Ceremony and entertainment (wedding, naming ceremony, funeral, etc)	
18	Donations to religious activities, Alms, zaquat, offering, charity	
19	Other taxes and levies (community levies, night guards)	
20	Others (specify)…………………………………………………………	

C. INFORMATION ON CLIMATE CHANGE

28. Do you perceive that the weather pattern around your environment is changing? Yes=[1]; No=[0]
29. What have you observed about the temperature in your environment for the last five (5) years? Increasing=[1]; Decreasing=[2]; No change=[3]
30. What have you observed about the rainfall pattern in your environment for the last five (5) years?
    Increasing=[1]; Decreasing=[2]; No change =[3];
31. Does the rainfall pattern affect you when you plant your crops? Yes=[1]; No=[0]
32. What impact/effect, if any, do you perceive that Climate change has on your crop yield? Positive=[1]; Negative =[2]; No change=[3]
33. Have you perceived any change in temperature in your environment for the last five (5) years? (i) Increased temperature Yes=[1]; No=[0] (ii) Low temperature Yes=[1]; No=[0]
34. Have you perceived any change in rainfall in your environment for the last five (5) years? (i) Increased rainfall Yes=[1]; No=[0] (ii) Low rainfall Yes=[1]; No=[0]
35. Have you perceived any change in the duration of dry and wet season for the last five (5) years?
    (i) Dry season Yes=[1]; No=[0] (ii) Wet season Yes=[1]; No=[0]

36. Which month of the year did rains started this season in your environment?
………

37. How long does the rainy season last in your environment?
……………………….

38. What is the state of water supply in your area, as a result of this climate change? Improved=[1]; Worsened=[2]; No change =[3]

39. Are you aware of any wetlands or water sources that had water before in your area, but had since dried up? Yes=[1]; No=[0]

40. Has your cropping activity been affected negatively by drought in the last five (5) years? Yes=[1]; No=[0]

41. If yes, what is the magnitude of the effect of drought? mild=[1]; moderate=[2]; severe=[3]

42. Are the grasses/pastures around you supplying enough forage for your livestock to feed? Yes=[1]; No=[0]

43. Which of the medium below do you get information on climate change?

MEDIUM	**YES**	**NO**
Radio		)
)Television		
Newspaper	)	)
)Internet		)
i) Others (specify) ……..……………..	ii)	)

D. INFORMATION ON CLIMATE-SMART AGRICULTURE

44. Please indicate your frequency of use in the table below by ticking the one applicable

S/N	Climate-Smart Agriculture (CSA)	Frequently used	Occasionally used	Rarely used	Not used
1	Conservation agriculture (minimum tillage, leaving crop residue on the field)				
2	Agro-forestry				
3	Use of organic manure				
4	Crop rotation				
5	Crop diversification (cereal/legume intercropping)				
6	Mulching				
7	Use of wetland (Fadama)				
8	Planting of heat and drought tolerant crops				
9	Planting of cover crop				
10	Soil conservation techniques				

E. HOUSEHOLD LIVESTOCK PRODUCTION

45. State the types and the number of livestock you have in stock presently. Indicate the amount of income you generate from each type per year. (**Include the income from eggs in the case of birds**).

LIVESTOCK	CURRENT NUMBER IN STOCK	NUMBER SOLD LAST YEAR	INCOME FROM SALES (₦)
Cattle			
Sheep			
Goat			
Camel			
Chicken			
Guinea fowl			
Duck			
Donkey			
Others ………………...			

F. CROP PRODUCTION

46. How did you acquire the plot of land you are farming on? Inherited=[1]; Rented=[2]; Purchased=[3]; Gift=[4]

47. How many plots of land do you have? Complete the table below:

Plot No.	Crops grown	Size in Hectares
Total Plot size		

48. Which of the crops in 'question 47' above is the major crop grown on your farm? ……………..…………

49. Which type of seeds did you plant on your farm in the last farming season?..................

    Improved variety=[1]; Local seeds=[2]; Mixture of both improved and local varieties=[3]

50. Which of the following cropping system(s) do you practice? Mixed cropping=[1]; Mono cropping=[2]; Relay cropping=[3]; Intercropping=[4]; Others (specify)……………………..=[4]

51. Labour use on the farm during the last cropping season:

Operations	Family labour				Hired labour			Communal/Exchange labour			
	Days used	Adult male (≥15years)	Adult female (≥15years)	Children (≤14 years)	Days used	Number of Persons hired	Cost of labour (₦) (wage rate)	Number of Persons	Hours/Day	Days used	Cost (₦) (if any)
Land preparation											
Planting											
1st Weeding											
2nd Weeding											
1st Fertilizer application											
2nd Fertilizer application											
Organic manure application											
Herbicide application											

Harvesting											
Threshing											
Transporta-tion											
Others (specify) ……………											

52. What quantity of the following farm inputs did you used in the last farming season and what was the cost incurred?

Inputs	**Quantity**	**Price/unit (₦)**	**Total Cost (₦)**
Seeds (Kg)			
Inorganic Fertilizer (Bags) • NPK • Urea			
Organic Manure (Kg)			
Labour (mandays)			
Pesticide (Litres)			
Herbicides (Litres)			
Animal traction or tractor hiring			
Equipments (hoe, cutlass, tractor, etc)			
Others (specify) ……………………………..			

53. In the table below, state the type(s) of crop and quantity produce for each type

CROPS	Quantity Harvested in Kilogram	Quantity Harvested in bag(s)	Quantity sold	Amount sold (₦) (sales)	Quantity consumed	Quantity given out as gift (if any)	Quantity stored
CEREALS							
Maize							
Millet							
Sorghum							
Rice							
Wheat							
LEGUMES							
Cowpea							
Ground-nut							
Soyabean							
OTHER CROPS							
Vegetables							
Hot Pepper							
Yam							
Cassava							
Sweet Potato							
Tomato							
Sweet pepper							
Cocoyam							
Sugar cane							

Melon							
Onion							
Cotton							
Beneseed (Ridi)							
Okra							

G. **FOOD SECURITY OF FARMING HOUSEHOLDS:** Household food demand and consumption

54. Please provide information on consumption of the following food items in the last seven **(7) days/ 1 week**

Food groups	**How often do you consume it ([A])**	**Quantity consumed (specify unit of measure)**	**Proportion that came from household own production (specify unit of measure)**	**If own production, estimate market value**	**Proportion purchased (specify unit of measure)**	**Market value of food purchased**	**Proportion received as gifts (specify unit of measure)**
Starchy staples (cereals/ Grains, Roots and Tuber							
Maize flour (semo/tuwo)							
Maize paste (koko)							
Wheat							
Sorghum							
Millet							
Rice							
Cassava (tuber)							
Cassava flour							
Fufu							

Garri							
Starch							
Tapioca							
Yam							
Yam flour							
Cocoyam							
Sweet potato							
Irish potato							
Others (specify): a.							
b.							
c.							
d.							
Legumes, pulses and Nuts							
Beans/cowpea							
Moi moi/kose							
Soybean							
Groundnut							
Melon (egusi)							
Others (specify):							
Fleshy meat, organ meat, offal							
Cow meat							
Goat meat							
Rabbit							
Pork							
Hide (pomo)							
Bush meat							
Snail							
Heart							
Liver							
Kidney							

Intestine							
Others							
Fish and Sea foods							
Fresh fish							
Dry fish							
Frozen fish							
Shrimps							
Cray fish							
Others (specify): a.							
b.							
Poultry and Eggs							
Turkey							
Guinea fowl							
Chicken							
Eggs							
Exotic poultry							
Local poultry							
Others (specify): a.							
b.							
Diary and milk products							
Milk							
Cheese							
Yogurt							
Others (specify): a.							
b.							
Green Leafy Vegetables							
Water leaf							
Bitter leaf							
Spinach							
Pumpkin							
Amaranthus (Aliefo)							

Lettuce							
Roselle (Yakwa)							
Ugwu							
Others (specify): a.							
b.							
Vitamin A rich vegetables and fruits							
Tomatoes							
Okra							
Carrots							
Cabbage							
Pepper							
Garden egg							
Pumpkin							
Others (specify): a.							
b.							
Other fruits							
Orange							
Banana							
Mango							
Pawpaw							
Guava							
Pineapple							
Apple							
Plantain							
Others (specify): a.							
b.							
Oil/Fats							
Red palm oil							
Groundnut oil							
Soybean oil							

Cotton seed oil							
Butter/Margarine							
Others (specify): a.							
b.							
Sugar/Confectioneries							
Sugar							
Honey							
Cakes							
Bread							
Sweet							
Beverages/Drinks							
Beverages							
Cocoa beverage e.g. milo							
Tea/coffee							
Milk							
Water (Sachet/bottled)							
Non-alcoholic drinks (e.g. coke, fanta, malt)							
Palm wine							
Beer/other locally brewed drinks e.g. burukutu							
Spices and Condiments							
Salt							
Seasoning cubes/powder, e.g. Maggi							
Local seasoning, e.g. dawadawa							

55. Food away from Home: Please provide information on prepared food that you consume away from home, that is, food eaten at restaurant/bukateria/street food vendors in the past **7 days**.

S/N	**Food items eaten away from home**	**Price purchased per day**	**Price purchased (total food purchased in the last 7 days)**
1	Breakfast		
2	Lunch		
3	Dinner		
4	Snacks		
5	Drinks		
6	Exotic/side dishes e.g. pepper soup, suya		
7	Others (specify) ……………………………………		

H. Household food insecurity coping strategies

56. In the last **7 days**, if you did not have enough food or money to buy food in your household, how many days did your household had to:

S/N	**Coping strategies**	**Frequency of usage (Days)** [(a)]
1	Skip meals	
2	Eat less preferred meals	
3	Beg for food	
4	Borrow food from friends and relatives	
5	Purchase food on credit	
6	Reduce the quantity of food consumed	
7	Restrict consumption by adults to enable children eat	
8	Consume seed stock held for next season	
9	Send household members to eat elsewhere	
10	Gather wild food (Fruits)	

[(a)]Frequency: Never/ week =[0], One day in a week=[1], Two days in a week=[2], Three days in a week=[3], Four days in a week=[4], Five days in a week=[5], Six days in a week =[6], Seven days in a week =[7]

57. State the constraints/challenges you face in using Climate-Smart Agricultural practices
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Thank you for the anticipated kind gesture.