ANAYSIS OF OPTIMAL CROP COMBINATIONS AND FOOD SECURITY STATUS AMONG SMALL-SCALE IRRIGATION FARMING HOUSEHOLDS IN NORTH-WESTERN NIGERIA

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A THESIS SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF DOCTOR OF PHILOSOPHY IN AGRICULTURAL ECONOMICS

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JULY, 2018

DECLARATION

I declare that thework in this thesis entitled**"Analysis of Optimal Crop Combinations and Food Security Status among Small-Scale Irrigation Farming Households in North-Western Nigeria"**has been performed by me in the Department of Agricultural Economics. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another degree or diploma at this or any other institution.

_____ _____

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CERTIFICATION

This Thesis entitled **"ANALYSIS OF OPTIMAL CROP COMBINATIONS AND FOOD SECURITY STATUS S AMONG SMALL-SCALE IRRIGATION FARMING HOUSEHOLDS IN THE NORTH-WESTERN NIGERIA"** by Segun Solomon ADEOLAmeets the regulations governing the award of degree of Doctor of Philosophy in Agricultural Economics of the Ahmadu Bello University, Zaria, and its approved for its contribution and literally presentation.

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DEDICATION

To Jesus Christ, ***the power and the wisdom*** of God.

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I sincerely thank my God for His mercies that have made the successful completion of this degree a possibility against all odds. I give my praise to the almighty God!

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ABSTRACT

Food security has maintained a centre stage of discuss in the world. The main focus of this study was to determine the optimal crop combinations and food security status of small-scale irrigation farming households in North-Western Nigeria. Specifically,the study described the socio-economic characteristics of the households engaging in small-scale irrigation farming in the region; estimated their food security levels; identified the coping strategies used by the households when faced with food insecurity challenges; estimated the determinants of food insecurity in the region and to developed an optimum farm plan for the irrigation farmers in the region. Adopting a multi-stage sampling technique which included a random proportional factor, a total of 240 small-scale irrigation farming households were selected from four randomly selected states (Katsina, Kano, Sokoto and Zamfara) across the region. Using structured questionnaire, data were collected from the households and analyzed using descriptive statistics, freedom from hunger scale, coping strategy index, ordered logit and linear programming models. Results showed that the household heads were male dominated (89%), with an average age of 44.81 years, with 91% of them married and 52.1% of them various levels of western education. Most of the household heads (83.8%) were members of associations and have large household sizes (average of 12 people) composed of mainly unemployed members. Furthermore, the household heads were experienced irrigation farmers with an average of about 17 years irrigation farming and an average of 4 extension contacts per season. The study also found that the major source of credit used for irrigation farming was from personal savings and loans from friends and acquaintances (32.5%). About 49% of the households have close proximity to their farms and markets while the average irrigation farm size was about 1.2ha. The Study revealed that 53% of the households are in the moderately food insecure category. Furthermore, the study revealed that the predominant coping strategies used by households to withstand food insecurity are reducing the quantity of food consumed (74%) and eating less preferred meals (70%). The significant determinant of household food insecurity in the study area are total farm output ($p \leq 0.01$), farm size($p \leq 0.05$), years of irrigation farming experience($p \leq 0.05$), the distance of the household from their homestead ($p \leq 0.01$) and markets ($p \leq 0.05$), amount of credit accessed ($p \leq 0.10$) and frequency of extension visit ($p \leq 0.01$). Each of these had different marginal effects among different categories of food security levels. Majority (58%) of the farmers practice sole cropping and out of the 15 different crop combination enterprises included in the optimization equation used for the study, only five sole copping patterns (maize, tomato, wheat, pepper and cowpea) were included in the optimum farm solutions, implying that the sole cropping system was better than the mixed cropping systems in the region. The optimal solution showed a possible expansion in the size of land beyond 3.3ha and the sensitivity analysis shows that increasing the use of NPK and labour by 50 and 85% respectively will lead to about 23% increase in output. However, when the inputs were doubled, the increase in output was not significant. Most of the farmers (51%) indicated inadequate access to credit facilities and high interest rate (where accessed) as the major impediments in small-scale irrigation faming. The study therefore recommended the formation of a formidable farmers' association for easy access to loan facilities for use in small-scale irrigation farming in the region. Also, irrigation farmers were encouraged to concentrate on sole cropping pattern rather than mixed cropping.

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CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Food security issues have continually attracted the attention of the world leaders. The discussions of the world food summit of 1996 in Rome (Food and Agricultural Organization, FAO,2014) and that of the trade ministers from around the world in Doha 2001 (Trueblood and Shapouri, 2002) were centered on world food security matters especially in the least developed countries of the world. In 1974, the world leaders declared during the world food conference that "every man, woman and child has the inalienable right to be free from hunger and malnutrition in order to develop their physical and mental faculties" (FAO, 2014). As a follow-up to this, the world food summit of 1996 set the target of eradicating hunger in all countries, with an immediate view of reducing the number of undernourished people by half not later than 2015 (FAO, 1999).

Eighteen years after the Rome declaration however and less than a year to the set target, FAO (2014) stated that about 805 million people were estimated to be chronically undernourished in 2012-14 and that one out of every nine people in the world still has insufficient food. It was also noted that most of the undernourished people (791 million) live in developing countries, includingNigeria. Currently, Nigeria is ranked thirty-eighth out of 76 countries on the Global Hunger Index (GHI), having a GHI of 14.7 (International Food Policy Research Institute, IFPRI, 2014). Though this shows a slight improvement over the 2011 figure of GHI 15.5 (IFPRI, 2011), it is still outside an acceptable range for the global food security target (GHI of $\leq$4.9).However, the GHI report of 2016 that show the countries status for the year 2015 is of great concern as Nigeria has sunk deeper to having a GHI of 25.5 a category described by IFPRI (2016)

as serious. This is of concern because the GHI mirrors the food security situation of the nation. It is designed to comprehensively and track hunger globally and by country and region. The GHI is an indicator that is calculated based on four important components/indicators that is linked to correct feeding (food security). The first of these indicators is undernourishment (the proportion of undernourished people in as a percentage of the population). This reflects the share of the population with insufficient caloric intake. The second indicator is child wasting, which is the proportion of children under the age of five that have weights that are too low for their heights. The third indicator, child stunting is based on the proportion of children under the age of five that who suffer from stunting (low height for their ages). The second and the third indicators of GHI are reflection of acute and chronic under nutrition. The final indicator hinges on child mortality of children under the age of five which partially reflects the fatal synergy of inadequate nutrition and unhealthy environments (IFPRI, 2016).

In the report of Ibrahim and Oyewole (2010), major interventions have been initiated by the government of Nigeria aimed at increasing the domestic food production. This was as a result of the output drop in the agricultural and food sector following the shift of attention from agriculture to the oil sector in the early 1970's. One of such interventions include irrigation agriculture. Irrigation farming is the provision of the right amount of water at the right time for plant growth and development. Nigeria is characterized by fair to good soil environment but poor and unreliable rainfall, especially in the arid and semi-arid areasof the north-western Nigeria (Oriola,2009). According to Dauda, Asiribo, Akinbode, Saka and Salahu, (2009), irrigation farming has increased in Nigeria in the recent times and to improve agricultural productivity, especially in areas of low rainfall of northern Nigeria, irrigation farming has been adopted as best alternative.

They went further to state that globally; massive investments have been made in the development of irrigation schemes so as to make the supply of food possible throughout the year.

According to Anon (2008) as cited in Dauda *et al.*(2009), about 90% of the country's food is produced by small scale farmers cultivating small plots of land and depend on rainfall rather than irrigation system. Thus, how the country's economy performs depends largely on the performance of the small scale farmers because they dominate the economy. Therefore, given agricultural prominence in Nigeria's economy, performance of small scale farmers in the sector should be of great concern to policy makers (Asogwa, Umeh and Penda, 2011) especially towards being a food secured nation. One important thing to note again is that these small-scale farmers have needs or goals for going into the farming business. The basic and most important of such goals are food security and income generation to satisfy their non-food needs. Resource allocation therefore is done based on these felt needs.

Helen (2002) as cited in Okwoche and Asogwa, (2012) reported that food security maintains political stability and ensures peaceful coexistence among people. It was stated further that food insecurity results in poor health and hinders optimal performance in children and adults. According to FAO (2014), food security exists when "all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active healthy life". Therefore, this study seeks to investigate the level of food security among rural farming households that practice irrigation in the north-western Nigeria.

1.2 Statement of Problem

With majority of Nigerians residing in rural areas and about two-thirds engaged in crop and livestock production for their own use and market sales,yet the country faced with the challenge of meeting the basic food needs of its population (Adepoju and Adejare, 2013),shows that there is a food production gap. Food and nutrition security is closely tied to agricultural productivity. This is because higher production on one's own farm or from one's livestock improves the food security status of the household and vice versa. In some areas in the northern Nigeria, the long period of dry season does not help the matter in any way as people who depend on rain-fed farming had to wait till the next rainy season. Irrigation however provides an opportunity to reduce the wide gap between food production from rain fed agriculture and the food need of the population. Irrigation contributes to livelihood improvement through increased income, food security, employment and poverty reduction (Hussain and Hanjra 2004; Lipton 2003). Therefore, irrigation can be an indispensable technological intervention to increase household income (Speelman *et al*., 2008).

Nigeria is endowed with 74 million hectares of arable and another 2.5 million of irrigable land, yet the country is still hungry (Oriola, 2009). Empirical studies have shown that irrigation has a positive impact on household food security and poverty (Tekema and Oladele, 2011, and Jema and Mohammed, 2013). It was based on that, according to GoM (2011) in IFPRI (2014), many developing countries affected by drought and floods promote irrigation interventions to reduce poverty and promote food security. Despite such intervention, in Nigeria, the presence of chronic hunger is still manifest.According to West Africa Insight (2010), the northern states were more at the receiving end of the dwindling food production capacity, rising food prices, and

dependency on food importation than in the other parts of the country. As noted by Abimbola and Kayode (2013), a large proportion ofNigeria households are still food insecure despite the several efforts by successive governments to achieve food security through setting up of various agricultural development institutions, programmes and projects. This is at variance with what one will expect if the opportunities provided by irrigated land in this region were fully maximized. This however leaves a gap be covered. If farmers with vast land resources (as is available in northern Nigeria) have the opportunity of food production throughout the year and yet they are not able to produce enough for their households, there is a problem of productivity.

North-west Nigeria is known for grain production as many are known to engage in farming. But at the same time, poverty is prevalent. Report has it that the region is the poorest (and no doubt, the hungriest). This is a source of worry calling for investigation of their farming activities. Most often than not, farmers are known to combine crops on their farms. This is in an attempt to produce most of the food they need (because many are small-scale farmers). Food security has a clear nexus with food production which is in turn determined by the cropping pattern of the households. If the farming households are working and yet are reported to be poor, then factors that are linked to productivity such as crop combinations may be the challenge. It is important to note that the farmers have their reasons for crop combination- meeting up with household food needs.

Ad de veld (2004), opined that the question of what to produce is critical and can constitute a problem to a producer. Producers attempt in answering this question, he further stated, depends on two factors: the demand (needs of the people) and the resources available. Most small-scale farming household's production is majorly stimulated by the household food needs and little attention is given to the household resource combination capacity to produce the enterprise combinations. This research

therefore seeks to investigate the problem of productivity from the perspective of farm optimization. It is to see if the irrigation farming households are optimal in their choice of enterprise combinations. The enterprise combinations of households based on their needs will naturally attempt to include what will make the household to be food secured but may not necessarily be supported by the household available resources.

There are growing studies on food insecurity in the Northern part of Nigeria. Some of them only categorize the households to food secure and food insecure but few ones focus on describing the various levels of food insecurity. This is another gap that this study has covered which provided opportunity to give policy suggestions peculiar to each level of food insecurity. Policy formulation without disaggregating food security levels among households will not help. The examination of the effectiveness of food insecurity copping is sacrosanct and urgent especially among the irrigation farming households. Also, according to Niragira *et al.*(2015), there is an optimal farm crop combination mix that produces enough output to meet the need of household despite all constraints. Does this really exist among the irrigation farmers in the north-western Nigeria? This and more questions needed to be answered. In order to investigate properly, the following more research questions were asked:

i. What are the socio-economic characteristics of the small scale irrigation farmers in the study area?

ii. What is the food security status of the small scale irrigation farmers?

iii. What are the coping strategies adopted by the small scale irrigation farmers to cope with food insecurity?

iv. What are the socio-economic determinants of the food security status of the farmers;

v. What is the representative farm enterprise combinations among the small-scale irrigation farmers?

vi. What is the optimum enterprise combinations of the small-scale irrigation farming households;

vii. What is the response of the optimal farm plan to variations in the level of inputs used? and;

viii. what are the challenges militating against food securityamong the small scale irrigation farming households in the study area?.

1.3 Objectives of the Study

The broad objective of this study was to examine the optimal crop combinations and food security status among small-scale irrigation farming households in North-western Nigeria. Specifically, the study addressed the following objectives:

i. describe the socio-economic characteristics of the small-scale irrigation farming households in the study area;

ii. determine the food security status of the small-scale irrigation farming households;

iii. identify the strategies adopted by the farming households in coping with food insecurity;

iv. estimate the socio-economic determinants of household food security;

v. identify the irrigated cropping system among the farming households in the area;

vi. develop an optimum farm plan forthe small-scale irrigation farming household's food security;

vii. estimate the response of the optimum farm plan to variations in the level of farm inputs and;

viii. identify and describe the constraints faced by the small-scale irrigation farming households in meeting their food security status.

1.4 Research Hypotheses

The following hypotheses were tested in the study.

i. Small-scale irrigation farming households in the study area are not food secure

ii. There is no significant relationship between the food security status of the households and the their socio-economic factors.

iii. There is no significant relationship between the household food security status and their coping strategies,

iv. Householdrepresentative farms arenot operating at optimum level.

1.5 Justification of the Study

According to Morris (2001), there are two ways to address the nutritional problem of the rural poor. One is to strengthen the household resource base and the second is to enhance the management of their resources. This study will go a long way in providing empirical facts that will serve as a basis to give technical advice to these rural households on effective allocation of resources and selection of the best enterprise combinations.

According to Dare *et al*., (2013), though several studies on household food security have been conducted in Nigeria, more detailed analyses at the household level are still needed especially those that provide an understanding of the types of coping strategies adopted by households to tackle the problems of food shortages. Because of the need to shed more light on the implications of food insecurity on households' welfare and ways of promoting household food security, Abimbola and Kayode (2013) stated that changes

in the food security status of households over time should be closely monitored with explanation given for the change. Eradication of extreme poverty and hunger is a prime goal of the sustainable development goals of the world summit of the United Nations.Therefore, there is an urgent need to assess the impact of irrigation farming in relation to the sustainable Development Goal of eradication of hunger and poverty from Nigeria perspective. This study contributes to the growing literature on household food insecurity by addressing these knowledge gaps through the assessment of the determinants food insecurity of Nigerian farming households that practice irrigation. The households' food insecurity status is captured by a consumption coping strategy index. It also assesses the nature of consumption coping strategies used by households with a view to providing suggestions for increased sustainability of household food supply and better targeting policies.

This study would provide information for governments, developmentagencies and potential farmers who are interested in irrigation farming. Furthermore, the outcome of this study will serve as a good basis for making life impacting policies that will gear the region towards the achievement of the sustainable development goal of eradicating hunger completely by the year 2030 and equally cause an improvement of the countries position on the world's Global Hunger Index.

CHAPTER TWO

LITERATURE REVIEW

2.1 Definition andConcept of Food Security

According to Per (2009), food security its narrowest definition, means that enough food is available, whether at the global, national, community, or household level. But the term "enough" needed to be clarified. Is it enough to meet economic demand and if so, at what price, or is it enough to meet energy and nutrient requirements? Originally, the term "food security" was used to describe whether a country had access to enough food to meet dietary energy requirements. National food security was used by some to mean self-sufficiency, i.e. the country produces the food it needs or that which its population demands. However, the generally acceptable definition is the one adopted by the World food summit of 1996 held in Rome which defined food security as follows: Food security, at the individual, household, national, regional and global levels is achieved when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life"(FAO, 1996). Food security refers to the condition in which all people, at all times, have physical, social, and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (FAO, 1996).

Food security is also being defined as the situation when all people, at all times, have physical and economic access to sufficient, safe and nutritious food for a healthy and active life (Franz *et al.*2004). The term, has, however, gone through stages of definition and redefinition. According to Olaolu *et al.*, (2013), approaches to the definition of the term have ranged from an emphasis on self-sufficiency to an emphasis on coping with

vulnerability and risk in food and nutrition access. According to Franz *et al., (*2004) overtime, varying concepts of food security have evolved. In the 1970s, food security was equated to adequate food production. In the 1980s, food security was considered to refer to the security of food access and availability. In the 1990s, the importance of nutrition was recognized, and hence the concept of food security was combined with that of nutrition security, in the 2000s, the concepts of food and nutrition security were integrated with vulnerability, risk coping, and risk management.

The main goal of food security, therefore, is for individuals to be able to obtain adequate food needed at all times, and to be able to utilize the food to meet the body's needs. Accordingly, the World Bank (2001) identified three pillars underpinning food security: food availability, food accessibility and food utilization. This concept infers that food security is not just a production issue. Food availability for a farm household means ensuring sufficient food is available for them through production. However, due to lack of adequate storage facility and pressing needs, the peasant farmers, mostly end up selling excess produce during harvest period, and sometimes rely on market purchase during the off-farm season. According to Sen (1981), food accessibility means there is the economic power to obtain food. This can be increased by investing in complementary resources such as nutrition, education, health care, provision of water and better sanitation, instituting gender symmetry and removal of child abuse practices (Doppler, 2002). Food availability can be achieved when sufficient supply of appropriate quality of foods is consistently available to all individuals.

2.2 Indicators for food availability, accessibility and consumption

The Food and Agriculture Organization (2004) generated some indicators for food availability, accessibility and consumption which are:

Food availability:

- Availability of animal protein per person.
- Availability of cereals, total protein, fat, fruits, and vegetable per person
- Dietary Energy Supply (DES) in Kcal/day per person.
- Share of cereals, roots and tubers in total dietary energy supply as a percentage of the total food available (a high percentage indicate a low diversity of the food supply)

Food accessibility:

- Percentage of household spending 70% of their income (or total expenditure) on food.
- Elasticity of food consumption relative to income.
- Percentage of households' income spent on food (or percentage of household food expenditure relative to total expenditure)
- Percentage of population with income (or expenditure) below the level of absolute poverty below which minimum food of adequate nutritional quality and essential non-food goods are not economically accessible.

Food consumption:

- Number of meals per day
- Percentage of households consuming less than two meals per day

Conclusively, therefore, food security is principally a function of availability, affordability (accessibility) and utilization of food in the right quality and time.

Furthermore, according to Per(2009), the use of the term food security at the national and global level tends to focus on the supply side of the food equation. The question raised is: is there enough food available? where food is usually interpreted to mean dietary energy. But availability does not assure access, and enough calories do not assure a healthy and nutritional diet. The distribution of the available food is critical. If food security is to be a measure of household or individual welfare, it has to address access. This was widely recognized by scholars and practitioners in the mid-1970s, and food security was defined as access by all people to enough food to live a healthy and productive life. Fukuda-Parr and Orr (2013) opined that the 1996 consensus shifted the focus from supply to access, utilization and stability, and the unit of analysis from the country to the individual. Furthermore, Per (2009) explained that a household is considered food secure if it has the ability to acquire the food needed by its members to be food secure.

A household food security may not necessarily translate to individual food security of its members because of the following reasons: first, household ability to acquire food may not exactly translate to an actual acquisition of food due to other commodities with higher priorities at that particular time like payment of children school fees. Secondly, intra-household allocation of food may not be based on the individual needs of the members of the household like an obese member. Besides, for an individual's food security to translate to good nutrition, some non-food factors like sanitary conditions, water quality, and access to health care must be put in place. Thus, food security does not assure nutrition security. First, the ability to acquire enough food may not be converted into actual food acquisition. Household preferences may not prioritize food acquisition over the acquisition of other goods and services such as school fees and

housing. Second, the intra-household allocation of the food may not be based on the needs of each individual member. The existence of a large number of households with both undernourished and obese members is a case in point. Furthermore, the extent to which individual food security results in good nutrition depends on a set of non-food factors such as sanitary conditions, water quality, infectious diseases and access to primary health care. Thus, food security does not assure nutritional security. In the same vein, Maxwell (2008) and Bazezew (2012) suggested that wherever possible, it is advisable to use more than one indicator in the measure of food security. He explains that no one food security indicator is on its own is able to "wholly" explain the food security status of the households.

2.3 Food insecurity and Types in Nigeria

The term food insecurity refers to lack of access to enough food. There are two main categories of food insecurity. These are chronic food insecurity and temporary/transitory food insecurity. In chronic food insecurity, there is continuous inadequate diet and nutrition resulting from the household's inability to acquire food. This is the type of food insecurity that is said to be experienced by households that persistently lacks the ability to either buy food or produce their own. Transitory/temporary food insecurity on the other hand, results from a temporary decline in household access to food which is mainly may be due to increase in food prices, reduced household production or household income or a combination of these factors. Food insecurity remains a fundamental challenge in Africa and both cases of food insecurity abound often existing together and jointly, predisposing affected individuals to disease and reduced vigour,vitality and strength needed for physical tasks. According to Ojo and Adebayo (2012), Chronic food insecurity now affects some 28%

of the population that is nearly 200 million people who are suffering from malnutrition. Acute food insecurity in 2003 is affecting 38 million people in Africa who are facing outright risk of famine with 24,000 dying from hunger daily. Famines are the most visible and extreme manifestation of acute food insecurity. Of the 39 countries worldwide that faced food emergencies at the beginning of 2003, 25 are found in Africa. The issue of food security is of high importance to Nigeria because; with an arable land area of 71.2 million hectares but with less than 34 million hectares under cultivation (FAO, 2005). She is among the countries in sub-Saharan Africa experiencing significant food shortages and over 40 percent of the country's population is estimated to be critically food insecure (Idachaba, 2004). According to NEST (1991), the northern region of Nigeria is faced with prevailing food insecurity emanating from enormous environmental challenges. Ibrahim, Adeola and Ibrahim identified that there are levels of food insecurity ranging from moderate to complete food insecure among households in Katsina state.

2.4 Causes of Food Insecurity in Nigeria

Food insecurity exists when people are undernourished as a result of the physical unavailability of food, their lack of social or economic access to adequate food. Food insecure people are those whose food intake falls below their minimum energy requirements as well as those who exhibit physical symptoms caused by energy and nutrient deficiencies resulting from an inadequate or unbalanced diet or from the body's inability to use food effectively because of infection or disease. According to FAO (2010) food insecurity refers to the consequences of inadequate consumption of nutritious food, considering the physiological use of food by the body as being within the domain of nutrition and health. Malnourishment also leads to poor health; hence individuals fail to provide for their families. If left unaddressed, hunger sets in motion

an array of outcomes that perpetuate malnutrition, reduce ability of adults to work and to give birth to healthy children and erode children‘s ability to learn and lead productive healthy and happy lives. This truncation of human development undermines a country‘s potential for economic development for generations to come.

As noted earlier, food insecurity can be categorized as either chronic on transitory, chronic food insecurity translates into high degree of vulnerability to famine and hunger, ensuring food security presupposes the elimination of that vulnerability. Chronic insecurity is similar to undernourishment and is related to poverty existing mainly in poor countries. No problems can be solved unless its causes are known: therefore, knowing the causes of food insecurity will help us to locate the solutions. Discussing the causes of food insecurity in Nigeria is a very difficult task; this is because most Nigerians develop apathy towards locally produced food and prefer imported food which they consider as superior to domestically produced ones. The emergence of oil sector and the substantial revenue accruing from the sector shifted emphasis from agriculture to the extent that even domestic food production is not given the desired requirement. The government felt that it was better to import food than to embark on local production, especially when oil money has changed the tastes of most Nigeria in favour of foreign imported goods. The above reasons notwithstanding, the causes of food insecurity in Nigeria can be discussed under the following:

2.4.1 Natural hazards/ disasters

In areas that are located in arid or semi-arid region, the rainfall is low, unreliable and unevenly distributed and, although there have always been cycles of drought and flooding, there is evidence to suggest that the climate is becoming more unstable and the weather events more severe. Faced with this unstable environment, the people of the region have

developed specific coping strategies. Farmers, for example, can stagger their crop planting and, when the situation is exceptionally bad, they may even resort to hunting and gathering. Pastoralists, too, have various options: they can split their herds, set aside pastureland to provide grazing reserves or migrate to new pastures. Nevertheless, even the best coping mechanism can be overwhelmed by an extended drought. (FAO, 2001). Frequent climate changes leading to shortage of rainfall and persist drought and insurgency in Northern part of the country and excessive rainfall and flood in southern and middle belt regions of the country contributed immensely to low food production in Nigeria.

2.4.2 A lack of "pro-poor" policies and policy inconsistencies

Sometimes, the government has no explicitly "pro-poor" strategies that include measures to ensure food security. Sometimes, where this is available, there is no “political will” to implement the strategies. Most of the poor rural farmers do not gain from any of the opportunities presented by the policies of the government. For example, most times, they are eluded by the benefits from commercial banking and rural financing initiatives. There is need for the government to be deliberate in making the rural poor farmers to enjoy the proceeds of policies that affect them.

Frequent policy changes and poor performance of agencies assigned to implement food and agriculture policies have serious setback on food production and distribution (Otaha, 2013). Each time a new government comes to power, the previous agricultural policies and programmes are abandoned and new ones are put in place, and not that the new ones are better than the old ones. It is in a bid to create opportunities for graft. This creates no room for stability and progress in food production. Similarly, the dismal performance of some of the past programs like Operation Feed the Nation, Green Revolution, Lower River Basin Development Authorities as well as agencies like

National Agricultural and Land Development Authority (NALDA) and the Directorate of Foods, Roads and Rural Infrastructure (DIFRRI).

Ojo and Adebayo (2012), in summary, have identified anumber of problems which have been inhibiting effectiveness of agricultural policies in enhancing food security in Nigeria. Some of them are:

(a) The frequent changes of policies on agriculture as one government replaces another. On each occasion, Nigeria has always had to start afresh.

(b) The prevailing presence of peasantry in Nigerian agriculture system is a bane to the achievement of the food national security goals. Agriculture is still largely in the hands of the illiterates in the rural areas. The big farmers – politicians, retired generals and businessmen – engage largely in crops or animals cultivation that are not common staples. They have pineapple plantations, ostrich and other exotic farms that add nothing to our quest for food security.

(c) No one knows the impact of the agriculture credit scheme with the banks and that is precisely because the impact must be very little.

(d) Corruption which has been a serious problem in the country has not left agriculture untouched. The river basins, dams, silos and fertilizer contracts have, over the years, been dripping with corruption.

(e) Many women are small scale farmers; in fact, they form the bulk of the farming constituency, but hardly are they consulted on policy and or gender issues that affect agriculture, land ownership and or usage. Such gender insensitivity is pervasive.

(f) Farmers are not well remunerated for their products. Nigeria produces the largest quantities of cassava, yams and cocoyam in the world, but the impact on their income is minimal and this tends to discourage them.

(g) Fertilizer is an important ingredient for improved yield but Nigeria plays politics with it. The people who get fertilizer allocations hardly have farms, they only have party cards. This has worsened the food situation.

2.4.3 Conflict

Armed conflict, within countries, is another central factor contributing to the increase in food insecurity. Conflict and food insecurity are inextricably linked, each triggering and reinforcing the other. Some people living in food-insecure communities feel they have been marginalized by central governments. At the same time, conflict itself almost always intensifies hunger, as it drives people from their homes and disrupts marketing and distribution systems. Then there are the long-term effects: communities that have been torn apart have little confidence in the future and are reluctant to invest in agricultural improvements.In the assertion of Oke (2009), conflicts do not necessarily mean physical fighting of wars. It means a disarticulated country or society that is experiencing structural violence without official declaration of war such as pervasive poverty, oppression of the poor by the rich, police brutality, intimidation of ordinary people by those in power, oppression of women and children and monopolization of resources and power by some sections of the society. It will be wrong to say there is peace in such a country like Nigeria where Boko Haram and other sects are threatening the unity of the country. Consequently, it is quite possible not to have peace even when there is no war.

2.4.4 Population growth

According to the National Bureau of Statistics (2016), the population of Nigeria in 2006 (143.33 million) has increased by about 27% to 182.20 in 2015. The increase in

population has a way of putting intense pressure on natural resources, particularly land and forests, as well as increasing rural urban migration. There is usually an overall increase in the number of people dependent on agriculture limiting the amount of food accessible to people if there is no significant increase in food production.

2.4.5 Gender inequality

Gender inequality is a major cause and effect of hunger and poverty: it is estimated that 60 percent of chronically hungry people are women and girls (WFP Gender Policy and Strategy, United Nations, 2012). When more women work, economies grow. An increase in female labour force participation—or a reduction in the gap between women's and men's labour force participation—results in faster economic growth (OECD, 2012). On average, women make up about 43 percent of the agricultural labour force in developing countries. Evidence indicates that if these women had the same access to productive resources as men, they could increase yields on their farms by 20 to 30 percent, raising total agricultural output in these countries by 2.5 to 4 percent. This would reduce the number of hungry people in the world by around 12 to 17 percent. (United Nations,2012). Women are generally responsible for food selection and preparation and for the care and feeding of children. Women play many roles in land use, production, distribution, processing, marketing accessing, trading and food availability. They often work as unpaid and self-employed workers on and off farm employees, entrepreneurs, traders, providers of services and caretakers of children and elderly, women farmers represent more than a quarter of the world population (Otaha, 2013).

Reducing gender inequality and recognizing the contribution of women to agriculture is critical to achieving global food security, there is consistent and compelling evidence that when the status of women is improved, agricultural productivity increases, poverty is reduced and nutrition improves. According to FAO (2013), if women have the same access to productive resources as men, women would have boost yield by 20 –30 percent, raising the overall agricultural output in developing countries by 2.5-4 percent. This gain in production could lessen the number of hungry people in the world.

2.4.6 Poverty and hunger

According to Otaha (2013), poverty and hunger prevent people from working hard to increase productivity. Food and agricultural productivity is both capital and labour intensive. Unfortunately, it is the poor peasant farmers that produce the bulk of food needs in Nigeria, due to their level of poverty, they find it very difficult to learn, work and care for themselves and their family members, let alone getting the necessary inputs and energy to produce for others. Apart from the inconsistence in policies most of these policies are neo-liberal which work against the interest of the domestic economy such as the devaluation of naira which made the importation of farm inputs very difficult and out of the reach of peasant farmers.

2.4.7 Income insecurity

According to (Maxwell, 1998), the phenomenon of urban food insecurity has been attributed to the following interconnected factors: Income insecurity making an individual or household unable to purchase sufficient food or food with adequate nutrient content to assure food security; spatial factors such as living in a neighborhood without an affordable grocery store, markets or other outlets; disproportionate income

allocation to other areas, such as rent, leaving an insufficient budget for food; and isolation, loss of autonomy or a lack of a social network. These sources of food insecurity are not related to food availability. Instead, hunger is most often attributed to problems of distribution, with gaps increasing between poor and rich countries as well as between the poor and rich within countries (Eme*et.al.,* 2014)

2.4.8 Income inequality

Income inequality is one source of food insecurity common to countries in the developed and developing world. Other common perpetrators of food insecurity in developed countries areunemployment and the welfare crisis (Riches, 1999). For instance, for many Canadians, theincreasing commodification of food supplies is removing the ability to access adequate andnutritious sustenance. Continued lack of recognition in social policy discourse suggests that thesetrends are likely to persist (Koc & Dahlberg, 1999).

2.5 The way out of Food Insecurity Problems in Nigeria

2.5.1 Science and technology

In Africa, Asia, Latin America and other third world countries, Nigeria inclusive, a deterioration in technology or ecology, which lower outputs from given input has long been identified as one of the reasons for poor agricultural production performance (Collier, 1988). It is equally important to note that indigenous techniques like crop rotation and other cultural farming practices which have been used to preserve the soil structure and its fecundity do not seem to be adequate or even relevant in the present efforts to boast food production in most developing countries. It is for this reason that the use of chemical and organic fertilizer has been widely promoted in Nigeria, while its

rate is even heavily subsidized by the State, despite the awareness of the corruption that is associated with its procurement and distribution (Idachaba, 2004). Government intervention to increase food production through technical and economic assistance to the small-scale farmers for land improvement schemes is therefore, not a misallocation of resources as some people have suggested (Davies, 2009). It is, in fact, a necessity because viewed from macro-economic perspective; this kind of intervention cannot be left to market forces in the present circumstances. There is thus the need for the government to sustain the intervention. Not only that, threat to the attainment of food security in Nigeria also comes from the unresolved issue of the safety of genetically modified foods made possible through agricultural biotechnology.

Today, biotechnology represents a scientific advance in agriculture with far reaching potentials in increasing food production in an environmentally sustainable manner. Agricultural biotechnology includes using genetics to modify crops and plants to produce more nutritious food, cloning of livestock; tissue culture technique and genetic engineering. Apart from its potential to produce higher yields the one of biotechnology gives shorter gestation and maturity periods to crops, plants and livestock as well as will continue to use biotechnology to produce genetically modified foods (Ndiritu and Wambuguli, 1999). Nigerian government has embraced the idea of using biotechnology to boost food production as a pre-condition for food security. It established the National Biotechnology Development Agency at Abuja. Furthermore, Nigerian agricultural scientists have been very enthusiastic in advancing the frontier of knowledge in biotechnology. They have been making efforts to assure the people that genetically modified foods do not pose any higher risk to consumers than conventionally cultivated crops, and have been calling on the government to allocate more research funds to

enhance the application of biotechnology in agriculture to optimize yield potentials (Akinyosoye, 2007).

The positive disposition of the government and the enthusiasm of the scientists notwithstanding, there are still obstacles to be overcome before full advantage is taken of scientific information in biotechnology in agriculture. First, the amount set aside for investment in the project is grossly inadequate. While it appears to make economic sense to invite the private sector participation in biotechnology research as the government seems to be doing at the moment, it must, however, be borne in mind that majority of the companies that have the financial capability to go into such venture are foreign-owned and are most unlikely to consider in a viable investment option to venture into purely local agricultural research endeavour. Second, the quality and the effectiveness of extension services needed to increase the awareness of the peasant farmers of the potentials of biotechnology are still low and need to be upgraded. Not only that, the mass media most especially, electronic media (radio in particular) have a role to play in educating rural farmers in their local language and dialects on the associated problems vis-à-vis abuse of agrochemicals. Finally, there are still unwarranted public fears to contend with in the safety of genetically modified foods, stemming from scare-stories, reinforced by superstition and crash ignorance, of the danger in the consumption of genetically modified foods. The incontrovertible fact is that without the help of agricultural biotechnology, success in food security will continue to elude Nigeria (Davies, 2009).

Furthermore, according to Utaha (2013), eradicating hunger and poverty requires an understanding of the ways in which these two injustices interconnected. Hunger and the

malnourishment that accompanies it, prevent poor people from escaping poverty because it diminishes their ability to learn, work, and care for themselves and their family members. Food is not like other commodities, it is an indispensable and an important factor in nation‘s quest for economic growth and development. Being an inevitable commodity all efforts must be geared toward ensuring its adequate supply for sustainable economic development and human survival. In Nigeria, most of the food need is produced by peasant farmers who are scattered all over the rural areas and not multinational companies who produce on large scale for export and profit. For the dream of food security to be realized, agricultural policies must target these peasant farmers and their rural environments. The following are ways that have been identified as Nigeria’s escape route out of food insecurity

Increasing agricultural productivity: several key steps to increasing agricultural productivity which is in turn key to increasing rural income and reducing food insecurity. They include:

- Boost agricultural science and technology. Current agricultural yields are insufficient to feed the growing populations. Eventually productivity derives economic growth.
- Securing property rights and access to finance.
- Enhancing human capital through education and improved health.
- Conflict prevention and resolution mechanisms and democracy and good governance based on principles of accountability and transparency in public institutions and the rule of law are basic to reducing vulnerable members of society.

2.6 Characteristics / Typologies of Small-scale irrigation farming in Nigeria

According to Adewumi (1999), the cultivated area of small-scale irrigation is usually small ranging from 0.1 to 1.2 ha. Diverse crops are grown in irrigation across the country. Common crops grown include leafy vegetables, cowpea, ground-nut, maize (as sole crop or inter-cropped with vegetables) (Tekeshima and Edeh, 2013). In Kwara state, Adewumi (1999) reported that the most common crop combination is intercropping pepper with cabbage and lettuce, Okro, and Tomato. In Kano, dominant crops grown under irrigation according to Akinola (2008) are vegetables (54%), cowpea (42%) and Maize (4%). According to Adewumi (1999), the main production practices are land preparation, weeding, pest control, irrigation and harvesting. The land preparation methods include land clearing, cultivation, leveling and crop sowing. He added that vegetables are sown by broadcasting method.

Irrigation farmingsystems are classified into four major categories namely: Labour intensive diverted stream, tractorized irrigation system (involving the use of tractors for land preparation), coarse grain/legume irrigations and dry season vegetable irrigation Coarse grains and legumes irrigators are typically found in the Northwest region. Their production is smaller scale, and their intensity of modern input use is relatively modest, though some growers show a relative intensive use of animal traction and hired harvesting labor. These irrigation farmers rely mostly on groundwater sources, such as wells or boreholes, mostly extracted manually using hand or treadle pumps—though there are a few cases in which motor pumps are used. Noticeably, one-third of these farmers give out most of their harvests as gifts, instead of selling (Tekeshima and Edeh, 2013). In some other areas, traditional form of surface irrigation (basin type) is employed (Adewumi, 1999)

Dry season vegetable irrigation farmers are typically found in the Northeast and Northwest, but also in the Southwest. Vegetable irrigation in the Southwest appears to be increasing, particularly in urban areas such as Lagos (FAO, 2012). Similar to coarse grains and legumes irrigators, these irrigators rely mostly on groundwater sources, such as wells or boreholes, mostly extracted manually using hand or treadle pumps—though there are a few cases in which motor pumps are used. These irrigators are typically more educated and asset endowed, and they tend to cultivate slightly larger areas than other irrigators, though their input intensity is relatively modest (Tekeshima and Edeh, 2013).

Most of the irrigation systems used among small-scale irrigation farmers in Nigeria are related to surface irrigation which is also called flood irrigation which uses gravity to distribute water. Its major inefficiency however is that it relies completely on saturating the surface which means that more water will be required to get the actual amount of water to the target crop (FAO, 2015).

Modern irrigation facilities are of varying types. Majority of agricultural irrigation systems fit into one of two broad categories of irrigation systems: sprinkler irrigation and micro-irrigation. Sprinkler irrigation systems include; center pivot, linear-move, traveling gun, permanent set and solid set. Micro-irrigation system systems include drip (or trickle) irrigation and micro-sprinklers. None of these is the best for every application. However, there are factors that influence the selection of which type of irrigation system a farmer uses. These factors include among many others; the crop type that the farmer will plant, fuel availability and cost, labour requirement, size and shape of the field and the sources of water for the irrigation.

The center pivot system is the most widely used type; it is self-propelled system that rotates around a center pivot point. It covers a circular area and the travel speed of the water distribution can be set. The linear move systems are similar in construction to the center pivot system except that rather than rotating, the entire system moves laterally across the field. Its design is suitable for rectangular fields. Travelling gun has a large sprinkler (big gun) mounted on a wheel cart that is mechanically moved across the field spraying water.

The solid set irrigation systems consist of portable above ground aluminum pipe with sprinklers spaced at specific intervals along the pipe. The permanent set system consists of buried pipes with evenly spaced sprinklers. It is suitable for small acreages and crops that have a high cash value like vegetables.

Micro-irrigation systems varies but can be in one of these two categories: drip (or trickle) irrigation and micro-sprinkler irrigation. They distribute water uniformly to a crop via low-volume, low pressure devices. Micro irrigation system has the advantages of being able to conserve water, utilize energy efficiently, having fewer weed problem and reduction of labour.

2.7 Determinants of household food security

There are several studies that have been conducted on the relationship between socio-economic characteristics and household food, nutrition security and per capita caloric intake. It is essential to review this because it determines the inclusion of the type of variables to be included in a model for this study.According to Omotesho, Adewumi, Lawal and Ayinde (2010), household farm size, household gross annual farm income and household total non -farm income significantly affect the household food security

status are significantly related to food security at 5% level of significance among the rural farming households in Kwara state Nigeria. They went further to report that a unit increase in household farm size, gross annual farm income and total non- farm income increases the likelihood that the household will be food secure by a factor of 0.0181, 0.0395 and 0.0223 respectively, while a unit increase in the adjusted household size decreases the likelihood that the household will be food secure.

Similarly, in a study of the determinants of household dietary quality, Dewan, Lisa and Tauhidur (2006), gender education was found to have a relationship with the quality of food intake. For female education, both the primary and secondary education coefficients are positive and statistically significant at the 5% level in the determination of household dietary quality which is an essential component of food security. They suggest that having at least one woman with primary education in the household increases household protein demand and having at least one woman with a secondary education increased it by even more. The effect of education for men is also positive but not as strong as that of female education. The relationship between the number of household adult equivalents and protein availability is positive and significant (Dewan*et.al*, 2006). Age is a significant determinant of daily per capita calorie intake with a positive relationship (Orewa and Iyanbe, 2010). However, they found that dependency ratio significant though with a negative relationship meaning that as the number of dependants in a household increases, the amount of per capita caloric intake decreases. Based on the findings of Babatunde, Omotesho and Sholotan (2007) in their study on factors influencing food security status of rural farming households in North Central Nigeria, membership of cooperatives and access to consumption credit were not significant in food security determination.

2.8 Brief History of Irrigation Development in Nigeria

According to Ugalahi, Adeoye and Angbonlahor (2016), the history of irrigation in Nigeria dates back to the colonial era but became more pronounced after the drought of 1970-1975 which was a post-colonial era. The need to continue crop production in order to get out of the challenges of food insecurity and food shortages caused by the prolonged drought in the country resulted to an emphasis on irrigation agriculture. The reports of Yahaya (2002) and Umar (1994) shows that irrigation practices were initially traditional in nature and in the hands of the private sector where the use of gravity water flow, calabash/buckets methods which were provided and maintained by the farmers themselves having no assistance whatsoever from the government. Shadoof/bucket system of irrigation practice is one of several irrigation methods in use in dry season farming in northern Nigeria. However, each method is dependent on the economic power of the farmers involved and the level of production. Whichever way, it is an established fact that dry season farming sustained by irrigation is a coping mechanism to extend the length of farming period to boosted agricultural production and productivity (Yahaya, 2002).

A notable example was in the production of sugar cane with few crops notably rice and vegetables by the States in Nigeria's northern part. Irrigation practice was mainly based on using residual flood waters and low lands (FADAMA-flash flood plains) and supplemented with the Shadoof (bucket-left system irrigation which originated from Sudan and introduced in Nigeria over a century ago). The major FADAMA areas were located along the flood plains of Rima, Sokoto, Niger, Benue and Yobe rivers. However, according to the Nigeria National Committee on Irrigation and Drainage, NINCID (2015) as cited by Ugalahi, Adeoye and Angbonlahor (2016), the growing

need for irrigation necessitated the birth of three pilot schemes of public irrigation developed between 1972 and 1974. These schemes were Bakolori, Kano river and Chad Basin irrigation schemes.

The success of the pilot irrigation schemes led to the creation of twelve (12) River Basin Development Authorities (RBDAs) across the country which include the; Upper Benue Basin, Lake Chad Basin, Benin-Owena Basin, Sokoto-Rima Basin, Itadejia-Jema'a, Iyola Basin, Maiduguri Basin, Lower Benue Basin, Cross River Basin, Ogun-Osun Basin, Anambra-Imo and Niger Basin. The RBDAs have the core mandate of providing water for irrigation and domestic use and also to provide hydroelectric power generation, flood control, recreation facilities, fisheries projects and navigation improvement (Ugalahi, Adeoye and Angbonlahor, 2016). The RBDAs were also saddled with engendering big plantation farming and encouraging the establishment of industrial complexes that could bring about private-public business partnership, seed multiplication, livestock breeding and food processing. However, overburdening of the RBDAs with responsibilities and inconsistency in RBDAs policy framework has led to their inability to fulfill their core purpose of establishment as regards irrigated farming.

The government, donor organizations like the World Bank and the Food and Agriculture Organisation (FAO) are today seen at the core of promoting irrigation practices in Nigeria. The late 1980s witnessed the promotion of pumps and tube wells through the Agricultural Development Programmes (ADPs). By 1992 more than 80 thousand pumps each irrigating between 0.5-1ha had been distributed. From 1992 to 1999 the National FADAMA Development Project (NFDP) of the World Bank built on

the ADP achievement and was able to distribute 55 thousand pump sets with an equipped area of 1ha per pump.

Similarly, the FAO commenced a Special Food Security (SPFS) project in 1999 in three villages in Kano State through a participatory community development approach where farmers were responsible for planning and have ownership of the project. Motorized pumps and tube wells were provided for irrigation to meet the needs of farmers cultivating a total of 280 ha. After the success of this pilot scheme, the project was extended to the 36 States of the Federation and an additional 109 sites in 2002. By 2004, cultivated land area equipped for irrigation within the country was around 293117 ha (FAO, 2005).

Today, three main irrigation schemes exist in Nigeria they include: public irrigation schemes- which are systems controlled by the government and are popularly called formal irrigation, the farmer-owned and operated irrigation scheme, which receives assistance from government inform of subsidies and trainings (informal irrigation) and the residual flood plain FADAMA (purely traditional irrigation practice) which has now emerged in the World Bank assisted programme which started in the National FADAMA Development Programmes (NFDP).

2.9 Small-Scale Irrigation and Food Security Nexus

A nexus has been established by past studies on small-scale irrigation and the food security status of the farmers involved. Moro and Onoja (2006) in their work on utilization of shallow aquifers for small scale irrigation in Benue state emphasized the need for irrigation so as to make farming an all-year-round occupation thereby increasing crop production and income. According to Hillel (1997) as cited by Mwendera and Chilonda (2013), small-scale irrigated agriculture is a means of ensuring

food security as well as improved standard of living of rural people for many years. Small scale irrigation schemes have the potentials to make a significant impact on improving the livelihoods of food security and reducing poverty (Mwendera and Chilonda, 2013). According to Kay (2001), irrigation has long been seen as an option to improve and sustain rural livelihoods by increasing crop production because it reduces dependency on rain-fed agriculture in drought prone areas. Kay (2001) went further to state that irrigation increases cropping intensities in humid and tropical zones by "extending" the wet season and introducing effective mean of water control. Similarly, Awulachew, Merrey, Kamara, Koppen, Penning and Boelee(2005) found that irrigation is one of the ways to meet up with the challenges of increased demand of food demand. It does this through increased number of crops per year (crop intensity) thus providing food security assurance in an area.

According to Hussain and Hanjra (2004), irrigation water is a vital resource for many productive and livelihood activities. They went further to establish the linkage between irrigation water and poverty (of course with food security). Accordingly, they defined irrigation water as an important socio-economic "good", with a positive role in poverty alleviation. Access to reliable irrigation water can enable to adopt new technologies and intensify cultivation leading to increased productivity and greater returns from farming. The foregoing of course underscores the place of irrigation in ensuring food security among certain population. Agriculture has been described as an "engine of economic growth. Due to its potential to increase overall food productivity, irrigation-led technological change has been described as the "driver" behind productivity growth in the agricultural sector in most places (Hussain and Hanjra, 2004).

In another submission, Bekele and Maryam (2014) observed that farmers in poor areas have suffered from chronic poverty and severe food insecurity being vulnerable to climatic changes and dependant on variable rainfall. Income of course has a strong relationship with food security. It gives economic power to command a demand for food in a socially acceptable way. All things being equal, higher income should make an individual or household more food secured.

2.10 Methods of Measuring Food Security

Household food security is a dynamic rather than a static phenomenon (Jeronim, 2010). Household food insecurity has been classified into chronic and transitory. The chronic food insecurity signifies a persistent food crises caused by the continual inability of the household to acquire needed food either through market purchase or own production (Khatri-Chatri and Maharjan, 2006). The transitory food insecurity on the other hand represents a situation whereby there is a temporary decline in the household food access to the needed food due to instability in food prices, production or income. It signifies a short time inadequacy in household food access, which obligates the vulnerable to cope in order to bridge their food consumption gap. According to FAO (2014), 25% of the people who are chronically hungry are in Sub-Saharan Africa making the food security situation of the region to be worrisome. According to Edeh and Gyimah-Brempong (2015), there is a dynamics of food security situation between post-planting and post-harvesting periods.

The measurement of food security, an important dimension of wellbeing has been approached by diverse methodologies by different researchers. As a matter of fact, no single method has been agreed on by researchers.However, they all seem to have similar

objectives. According to Hoddinott and Yohannes (2002), the various methods of food security measures seek to address one or all of the following: identify the food insecure; characterize the nature of their insecurity; monitor changes in their circumstances and assess the impact of interventions. In this section, different methods of measuring food security have been reviewed with their strength and weaknesses.

2.10.1 Dietary diversity

This method of food security measure uses the number of different food or food groups consumed over a given reference period as an indicator of security under a variety of circumstances, including poor and middle-income countries, rural and urban areas and across seasons (Hoddinott and Yohannes, 2002). It is a qualitative measure of food consumption that reflects household access to variety of foods and is also a proxy for nutrient adequacy of the diets of individuals (Kennedy, Ballard and Dop, 2010). According to Hoddinott and Yohannes (2002), its strength is that respondents find the questions straight forward and non-demanding on time or recall to answer. Also, its instrumentation represents a rapid, user friendly, and easily administered, low-cost assessment tool (Kennedy, Ballard and Dop, 2010).

Dietary diversity measure of food security reflects nutrients adequacy and the economic ability of a household to access a variety of food in fact, it has been reported that there is a direct relationship between dietary diversity score and nutrient adequacy (Kennedy*et al.*, 2010). Hoddinott and Yohannes (2002) noted that it increases in Dietary Diversity is associated with socio-economic status and household food security. However, if the data thus collected is to be used to create an alternative measure, it is necessary to show a strong correlation with more traditional measures of food security.

Despite this weakness, Swindale and Bilinsky (2006) have referred to Household Diversity as being adjudged an attractive proxy indicator of food security based on the following reasons:

- A more diversified diet is an important outcome in itself,
- A more diversified diet is highly correlated with such factors as caloric and protein adequacy, percentage of protein from animals (high quality protein) sources and household income,
- Questions on dietary diversity can be asked at the household or individual level, making it possible to examine food security at the household and intra-household levels.

Rashid, Smith and Rahman (2006) added that the Dietary quality measure can be carried out using the daily household protein availability per adult equivalent (in which an adult is defined as a male between 30 and 60 years of the reference category). In constructing this measure, the cleared metric quantities of foods acquired by households were multiplied by the food's protein value, which was then multiplied by the food's edible proportion, which is finally divided by the number of days in the reference period and the number of adult equivalents.

2.10.2 Cost of calories (COC)

In this method of food security measure, the cost of buying the minimum calorie intake is used to establish a food security line which is used to classify respondents as food secure or food insecure (Amaza, Umeh, Helsen and Adejobi, 2006). According to Ojogho (2010), it satisfies the monotonicity axiom, focus axiom, symmetry axiom, transitivity axiom and decomposability by population sub group.

2.10.3 Caloric intake estimation

In this method, according to Orewa and Iyanbe (2010), questions on food consumed the previous day and the day after on information such as the types of food and the quantity consumed per meal per day are asked. The data gathered from such information are then used. The calorific content in each food item consumed are then used in estimating the proportion in the total food intake. The complexity of this method of measure makes it a little difficult to use.

2.10.4 Food Security Index (FSI)

This way of measuring food security involves the construction of a food security index. In studies like Omoteshoet. *al* (2006), the construction of the index involves two steps. The first one is identification which is the process of defining the minimum level of nutrition necessary to maintain healthy living. This is the food security line. The second step is aggregation which derives food security statistics for the household. Using the method of Food security Index also incorporates the use of daily calorie consumption. The following equation is used in estimating the food security index.

$$Food\ Security\ Index = \frac{House\,hold\ \ per\ \ capita\ \ calorie\ \ availability}{House\,hold^{'}s\ daily\ \ per\ \ capita\ \ calorie\ \ requirement}$$

2.10.5 Other methods

There are other methods that have been used to measure food security. Nanama and Souli (2007) did comparism between the Months of Adequate Household Food Provisioning (MAHFP) and FANTA/Cornell methods a joint design of the Food and Nutrition Technical Assistance (FANTA) and the Cornell University Division of Nutritional Sciences. The MAHFP was developed in the late 90's as a tool for

identifying vulnerable groups and measuring the impacts of a project on increasing or decreasing the number of people classified in the most vulnerable groups. FANTA/Cornell, a questionnaire based method was also used for the same project. Nanama and Souli (2007) observed that even though the FANTA/Cornell method provides a more structured systematic mechanism for learning about the quantitative and qualitative aspects of food security, it has a setback in that it is biased as it elicits information from the household heads (most times males) which often are not fully aware of the survival strategies adopted. One advantage of the FANTA/Cornell method again is that it has the capacity to highlight the special needs and concerns of the most severely food insecure group. The major weakness of the MAHFP is that it requires women to estimate the quantity of food intake but there is no uniformity in the units of measurements, which brought a major bias.

Head Count Method is another method of food security measures that have been used. It measures the percentage of the households that are food insecure. When calculated, it provides an index called the food insecurity index that is obtained by estimating the percentage of the food insecure households under study (Idrisa, Gwary and Shehu, 2008). When used along with the food insecurity gap (FIG), the depth of food insecurity could be measured. The FAO method for measuring food depravation and is based on a comparison of energy requirement norms with usual food consumption and is expressed in terms of dietary energy. One of the ways it is measured is the use of the Body Mass Index (BMI) which is used to determine the height to weight relationship. It is assumed that the underweighted individuals are food insecure. The BMI is the ratio of weight (Kg) to Height (square meters) those with BMI> 18.5 are considered to have adequate energy reserves.

2.11 Household Coping Strategies

Households normally have unlimited demands yet limited resources or incomes leading to the rationing of the available resources among competing basic household needs like food, clothing, education, health and housing. This makes the household to always be faced with food insecurity thus having to devise means of survival when threatened. These means of survival are called coping strategies. Devereux (2001) defines coping strategies as a response to adverse events or shocks. The definition by Snel and Staring (2001) captures the broad notion of coping strategies, namely that "all the strategically selected acts that individuals and households in a poor socio-economic position use to restrict their expense or earn some extra income to enable them to pay for the basic necessities (food, clothing, shelter) and not fall too far below their society's level of welfare" (Snel and Staring, 2001). The latter definition implies that coping strategies involves a conscious assessment of alternative plans of action. This does not necessarily mean that their choice of strategies is always successful in achieving their intended objectives. In fact, the coping strategies often have unintended negative effects. Ellis (2000) defines coping strategies as the methods used by households to survive when confronted with unanticipated livelihood failure. It is difficult to generalize about coping strategies in response to food insecurity thus they are best described based on regions.

The strategies pursued by households differ in several aspects, that is, within the household and between households (Maxwell *et al.*, 2003). Due to varying degrees of wealth among households, different coping behaviors are adopted by households at different poverty levels. However, some coping strategies are common to all households

although the extent to which such strategies enable a household to remain afloat depend on the assets at their disposal (Devereux, 2001). Above all, the general tendency is that the lower the household asset status, the more likely the household would engage in erosive responses such as selling off productive assets such as farm implements (Hoddinott, 2004).

Different studies in different areas have presented unique strategies of households in handling the threat of food insecurity. Food security of households is dynamic and influenced by a lot of factors. The poor lives in a changing world to which they must adapt to consistently (Frankenberger, 1996). Coping strategies are employed to mitigate the effects of not having enough food to meet the household's needs. Some coping strategies are positive means of overcoming food shortages (like savings, off-farm employment) while others are negative having a long term detrimental effect on the households like severe reduction in food consumption, selling productive assets, reduction of expenditure on basic services like health and education and abnormal migration (Taal, 1989).

In a study in Oyo state South-West Nigeria of rural household Edeh and Gyimah-Brempong, (2015) identified consumption of unconventional food, reduction in food quantity served to children, help from relatives, skipping of meals for a whole day and purchase of food on credit as ways by which the households survive when threatened by inadequate supply of food. Similarly, Maxwell *et al.*(2008) identified eating less preferred food, limit the size of meal times, reduce adult consumption of food, borrowing food and even going to sleep with hunger as ways by which households manage to survive when there is food insecurity.

2.12 Linear Programming:

Linear Programming (LP), in its simplest form, is a method of determining a profit-maximizing combination of farm enterprises that is feasible with respect to a set of fixed farm constraints. Linear programming method is one of the mathematical programming methods which use global objective function in finding optimal farm plan or strategy by putting together the best combination of activities or objectives (Thampapillai, 1978). It was developed by a Russian Mathematician L.V Kantorovich in 1939 and was extended by the American MathematicianDantzig in 1947 (Salvatore, 1995). Linear programming method is widely used in farm management research. According to Etuk (1979), the technique is capable of handling a large number of linear constraints and activities at the same time and efficiently too. Linear programming is a tool based on the premise that peasant farmers tend to behave in ways which optimize their objectives given the constraints within which they work. Early application of LP in farm planning assumed profit maximizing behaviour, a single period planning horizon and a certain environment (no uncertainty about prices, yield). LP is an essential planning tool. According to Yang (1995) as cited in Igwe and Onyenweaku (2013), Linear Programming as applied to farm planning is a systematic method of determining mathematically the optimum plan for the choice and combination of farm enterprises so as to maximize income or minimize cost within the limits of available farm resources. Mathematical programming models are used for determining optimal decisions and pattern of resource allocation. The need to use systematic methods for finding the optimal combination of various productive factors is driven by the fact that the productive factors available in an enterprise are usually found in limited quantities. Therefore, the aim to attain the maximum net profit presupposes the optimal

combination of productive factors to make possible the production of the most profitable goods (Eleni, Christos and Michail, 2003).

The use of linear programming method has several advantages over other analytical methods. First, it allows for several production activities at the same time. This is an advantage over the linear production functions. Secondly, it allows for use of seasonal labour and land constraints. This takes into cognizance, the limitedness of the resources available to farmers in their production activities. This is to allow effectiveness in allocation of resources in a way that will generate the maximum output possible. Also, in linear programming, more than one production technique is allowed in addition to the substitution between land, labour and behavioural constraints (Mudahar, 1974). Furthermore, another advantage of linear programming method is that from the optimum farm plan, changes in net revenue of each enterprise needed to bring about a change in the activity level can be determined. Finally, the productivity of the farm resources as well as the constraints facing the optimum plan can be evaluated for further decision by the farm manager. The method consists essentially of the objective function, the activities and the linear constraint components. The method has underlying assumptions which include additivity, linearity, divisibility and finiteness of the resources and activities. In addition, there is a single value expectation of the input-output coefficient and prices (Heady and Candler, 1973).

Linear programming method can be applied to solve problems in which all the objectives have been specified in one dimension. For this reason, where the problem has multiple objectives, Thampapillai (1978) suggested the use of either combined optimization or constrained methods. In a combined optimization, the different objectives are transformed into one dimension. In constrained optimization the

maximizing objective is in one dimension while the other objectives in the other dimension serve as constraints. Many researchers in agricultural production economics who have used the constrained optimization include Miller and Byer (1973) and Etuk (1979).

According to Olayide and Heady (1982), LP had been attractive to applied decision makers and agricultural economists offering practical advice in farming and regional agricultural development because the model is easily understood by lay decision makers and they require little data compared to sophisticated econometric models. Linear programming represents the production specification where production follows fixed input-output coefficients but is limited by resource constraints.

2.12.1 Underlying assumptions of linear programming

As a planning technique, linear programming is based on certain assumptions which include the following:

- **Linearity**

A major factor in LP is the requirement that all relationships are linear (Lucey, 2002). Linearity implies that the objective functions to be optimized as well as the constraints faced are linear. Obviously, not all factors in business decisions are linear but fortunately, many factors of production like labour hours are reasonably linear or can be linearly approximated over the operational range of the values being considered.

- **Additivity**

Enterprises are assumed to be independent of one another so that the total resources required and the total product of a number of enterprises taken together are simply the

sums of their independent inputs and outputs. In other words, the contribution to the objective function for any variable is independent of the values of the other decision variables. This also implies that the contribution of a variable to the left hand side of a constraint is independent of the values of the variables.

- **Proportionality Assumption/Continuity**

By this assumption, resources are assumed to be divisible in fractional units so that a solution may accommodate a fraction (decimal) of the units. It is required that the value of each term in linear functions is strictly proportional to the value of the variable in the term in linear functions is strictly proportional to the value of the variable in the term. Linear programming assumes that the variables are real-valued, meaning that they can take on fractional values. The contribution to the objective function from each decision variable is proportional to the value of the decision variable in other words; the contribution to the left hand side of each constraint is proportional to the value of the variable.

- **Single value expectation**

All the coefficients in the LP model are assumed to be known with certainty so that the seasonal variation in outputs that occur in practice is not accounted for in any formal manner.

- **Fitness:**

This assumption has it that there is a limit to the number of alternative activities and the resource restriction which need to be considered. According to Heady and Candler (1958), this assumption is very realistic since a farmer with unlimited number of alternatives would never have them all programmed.

- **Short-term static plan**

Solutions are short term and static in that they are bounded by a given set of fixed resources and are assumed to be repeatable from year to year.

2.12.2 Limitations and strength of linear programming:

Models constructed solely from linear relationships have certain limitations. The most obvious is that some real-world phenomena are poorly modeled by lines. Nonlinear or discontinuous relationships are not adequately approximated by linear relationships, then you must use a technique other than linear programming. A weakness common to all mathematical programming is the assumption that the input data are perfectly accurate i.e. assuming that the coefficients of the objective function, constraints and constraint right hand side (RHS) are all correct but in real world, these numbers are seldom known with accuracy.

The major limitation of Linear programming as a planning tool rests almost entirely on the assumptions underlying it. These assumptions are not always in accordance with reality. None the less, Linear programming as a planning tool has some advantages as stated by Beneke and Winterboer (1973). They include the following:

- It gives the opportunity to study very complex situations in a more comprehensive and realistic manner.
- The computational by products obtained from the output of linear programming indicates how the net revenue will change by an increase in the limiting resource.
- Linear programming produces a unique optimal solution which budgeting and programme planning can only do in terms of simpler cases

- The technique can be applied to studies involving the identification of constraints and the evaluation of the profitability of new technologies on small holder farming systems such as arable crop farming, livestock or optimizing crop-livestock combinations (Sanni, 2003).The availability of electronic computing facilities gives an added advantage for the exploitation of the benefits accruing from the use of this technique in farm planning.

Generally, the Linear programming model is given as follows:

$$Max\ Z = \sum_{j=1}^{n} C_j X_j\ (j = 1,2, \dots, n)$$

Subject to:

$\sum_{i=1}^{m} a_{ij} X_j \leq b_i (i = 1,2, \dots, m)$

And $X_j \geq 0$ for all js

Where:

Z= objective function,

X_j = activities,

C_j = marginal contributions of each variable,

b_i= total amount of ith resources available,

a_{ij} = resource requirements per unit of activity,

n= number of activities,

m= number of resources

2.13 Cropping System in Northern Nigeria

Cropping system across the zone are characterized by tremendous diversity. Area under cultivation is small (2-4ha) with a primary objective of farmers being to meet the

subsistence need of their households (Powell, 1984). Although surplus crops however are sold and some cash crops may be grown.

Labour is the main input because cropping operations are almost exclusively done manually. The amount of land cultivated annually per household is therefore a function of family and or hired labour availability during the period of peak demand, namely, during land preparation and weeding. Although this labour constraint is the critical factor in many part of the zone, Norman(1978) working in 3 villages in the northern part of Nigeria sub-humid zone found that farm size is inversely related to population density.

As in much of sub-Saharan Africa, intercropping or simultaneous cultivation of two or more crops in the same piece of land, is common throughout the zone. The main advantages of intercropping over sole cropping as mentioned by the farmers are maximizing returns from limited resources and stabilizing income overtime (Abalu, 1976).

The zone has a long growing period of between 180-270 days accommodating predominant crops of the north, including sorghum, millet, ground-nut, cowpea e.t.c. by combining crops of different growing periods, farmers develop highly diversified cropping patters, involving as many as 5 to 6 but more commonly 2 to 3 crops in a mixture. The most complex mixtures and highest yielding plots are small areas close to the household where soil fertility is maintained at high levels through concentrated additions of animal manure, night soil, household sweepings, ash and so on.

With the advent in agricultural technology and the advancement in same, better cropping systems are being developed suitable for better productivity in northern Nigeria. According to Ajeigbe *et al.*(2010) a combination of improved varieties and

improved cropping systems for higher productivity and profitability with a minimum use of insecticides and fertilizers have been developed for the dry savannas of West Africa (Ajeigbe, 2003; Ajeigbe *et al*., 2005; Singh *et al*., 2003, 2004). These cropping systems (two cereal: four cowpea row to row strip cropping system) involving improved varieties of crops, with selective use of fertilizer and pesticides, feeding of crop residues to small ruminants in permanent enclosures on the home compound and returning of the manure to the field, hold great promise for increasing the food production in West Africa without affecting the environment or degrading the soils. Small scale farmers prefer the improved intercropping system over monoculture because it provides them with sufficientcereals for home use and additional cowpea for cash income.

The traditional inter-cropping system involves little or no application of fertilizers and chemicals. Such practices lead to decreasing soil organic matter contents, increasing populations of chronic parasitic weeds (eg. *Striga* spp.), reduced soil biological diversity and enhanced erosion risk (Mortimore *et al*., 1997; Singh and Ajeigbe, 2003). Due to the increasing population in the region and resulting reduction in arable land per capita, there is a need to increase yields per unit area.

According to Foli (2012) in his study on farm characterizations in the southern and northern Guinea savannah zones of Nigeria, some areas in the zone have a 135 day growing period. The rainy season commences in May and ends in October. Land preparation is carried out between the months of March and May. Land preparation is done with oxen drawn implements or manually with a handheld hoe. The major activity is the construction of ridges. Planting commences towards the end May right after the first substantial rains have fallen through to July. By the end of November, all crops have been harvested from the fields.

Traditional cropping systems recorded for this area is the intercropping of cereals with legumes. Cereals are planted first and relayed with legumes toward the end of June. Common combinations are: sorghum-cowpea, sorghum-groundnut, sorghum-millet-cowpea, sorghum-millet-groundnut.Furthermore, he stated that in other parts of the zone; there exist a 195 day growing period. Cropping is a mosaic of both cash and subsistence crops growing side by side. Two distinct field patterns were are common (1) ginger fields which intercropped with cereals and (2) relatively larger outfields that are sub-divided and each section planted to a single crop. Sections of such fields are also left fallow for one or more cropping seasons. Home fields are common to poor farmers where most of their farming activities are carried out.

Intercropping is practiced in ginger with a cereal. In most cases this is either maize or sorghum. Grain legumes and yams are each planted as sole crops. Farmers rotate the sub-divided fields on an annual basis. Legumes are rotated with cereals and fallow plots. Some farmers owned plots close to rivers and streams and these were perceived to be more fertile. Farmers prioritized such fields for ginger and yam cultivation. Farmers cultivate all of their fields

Intercropping of cereals and legumes is done in replacementpattern. This is the type of intercropping whereby single cereal rows were substituted by a single row of either cowpea, groundnut or soybean (Snaydon, 1991). In the case where groundnut and cowpea were planted on the same field, they were mixed within the same row. This was the most prevalent trend of cropping observed in the region. Another type of intercropping recorded at this site was the replacement of 2-4 rows (strips) of cereal stands with legumes. This was especially common for sorghum-groundnut intercrops but also for sorghum-cowpea. Farmers and agricultural extension agents referred to this as an ‘improved’ system of cropping (Ajeigbe,2003; Singh *et al*. 2010)

2.14 Cropping Systems in Irrigation

Fadama areas have been known to hold great potential for variety of crops like grains, vegetables in quantities large enough to at least meet domestic demand if they are adequately exploited and managed. Several researches have been conducted in relation to irrigated cropping systems in northern Nigeria. According to Sani, Ahmed, Amans and Abubakar in Institute of Agricultural Research, IAR, (2008) in their research on performance of sweet corn as influenced by NPK fertilizer, inter-row spacing and irrigation interval at Kadawa, it was reported that there was no significant difference between intra-row spacing on plant height and biological yield when the intra-row spacing was at 20-25cm. however, a notable increase in yield was recorded when the spacing was increased to 30cm. it was also reported that fertilizer was a significant factor on yield increase only when its use was intensified. Irrigation interval was not a differing factor in the location as far as yield was concerned. This was attributed to the high water table in the area. Some other studies like Muhammad and Muktar; Kura, Abubakar, Tanimu Mahmud and Mani, Abubakar, Babaji and Sani in IAR (2008)also focused on sole cropping system in irrigation farming in the northern Nigeria.

While many studies have focused on sole cropping system in irrigation farming in northern Nigeria, a few other ones and field report have shown that mixed cropping is being practiced by irrigation farmers. In other to meet their food need, households that practice irrigation farming especially on a small-scale are found to plant mixture of crops. According to Hassan, Muhamad and Jokthan in IAR, (2012), in a study conducted on effect on planting pattern and irrigation on grain and forage of maize/lablab intercrop at Kadawa; the preliminary result indicated that sole maize had highest grain yield even under the use of 1:1, 1:2, 2:1 alternate rows. In another case of

the study conducted by Hussaini, Abubakar, Odion and Kura in IAR, (2013), it was reported that crop mixture of maize/okro performed better than the sole cropping system.

In general, both on research farms and from field observations, both the sole and mixed cropping system are found across the region. Crop mixtures as pepper/ okra mixture, onion/tomato, sole tomato, wheat/tomatoes relay cropping, cowpea/maize intercrop mixture, sole soyabean mixture, maize/okra mixture, maize/cowpea and sole rice are common across the region.

CHAPTER THREE

METHODOLOGY

3.1. Study Area

The North-Western region of Nigeria comprises of seven states namely: Kaduna, Katsina, Zamfara, Kebbi, Sokoto, Kano and Jigawa. The region is located between Latitudes $9^0 10'\text{N}\ and 13^0 50'\text{N}$ of the Equator and Longitudes$3^0 35'$and$9^0 00^0\text{E}$ of the Greewich meridian. The area covers a total land mass of about 216 065 Km^2 which translates to about 18% of the country's total land area. As projected from the NPC (2006) estimates, using a population growth rate of 2.6% there are about 35 915 467 million people living in the region with majority having agriculture as their primary source of income. The soils in the northern region of Nigeria are characterized by reddish brown or brown soils of the semi-arid and arid areas and are known as tropical ferruginous soils which are made up of about 85% sand with PH values that varied between 6.0 and 7.0 (Harris, 1999). The area is known for low annual rainfall with less than 1000 mm of rain with a prolonged dry season of up to nine months. The region is characterized by northern guinea savannah and Sudan savannah with few trees. By implication, more arable crops are grown in the area and examples of the crops grown include sorghum, maize, millet, cowpea, rice, wheat and vegetable crops.

The main source of livelihood of the people in this zone was agriculture. Although variation occurs among the States**,** off-farm activities include trading, tailoring, bricklaying and carpeting among others. Farming practices used in the States include shifting cultivation, mixed farming, mixed cropping and pastoral farming. The climate makes the farmers to cultivate a very widespread of crops such as cereal, legumes and vegetables. Livestock such as cattle, goats, sheep, and poultry farm like chicken, turkey, pigeon and ostriches etc are produced and the livestock are reared extensively. There are

irrigation dams across the region a good example is the Sokoto Rima River Basin Development Authority with locations in Dutsinma, Jibiya in Katsina state; Goronyo dam in Sokoto state and Talata Mafara in Zamfara state. Similarly,there is the Hadejia Jama'are river basin development authority in Kano and Jigawa states. These are designed to function as large-scale irrigation facilities but are not functioning to their full capacities. The region according to the National Bureau of Statistics, NBS, (2016), the north-western geo-political zone has the highest incidence of poverty with Sokoto and Kastina states topping the list of poor states in the region. According to the United Nation's report (2015) of the Global Multi-Dimensional Poverty Index, the North-west region of Nigeria has the highest record of poverty rate of 89.1%. The report also stated that about 70% of those who live below the poverty line in Nigeria are in rural communities (where the small-scale farmers reside).

3.2. Sampling Procedure

The study adopted a multi-stage sampling procedure in selecting the respondents interviewed. The population used for this study was the small-scale irrigation farming households using dams' facilities under the river basin in authorities in north-western Nigeria irrespective of the crops they grow. Based on the recommendation of Powell (1984), those irrigation farmers that have maximum of 4Ha of irrigation farm land are those referred to as small-scale irrigation farmers. In the first stage of the sampling procedure, four states in the region were randomly selected using the simple random sampling method. The states include; Sokoto, Zamfara, Katsina and Kano. For the purpose of effectiveness in scientific data collection, this study purposively adopted the farmers under the Sokoto Rima River Basin and Rural Development Authority in Sokoto, Zamfara, Katsina statesand those under the Hadejia-Jamaare River Basin

Development Authority in Kano state. This is the second state of the sampling procedure. In the third and final stage, the households used for this study were randomly selected from each state under their respective river basin authorities. The random selection was based on a proportionality factor following Ibrahim (2011). The factor eliminates bias in the selection of samples using random sampling techniques. The factor is given as:

$$n = \frac{Y}{L} \times T \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

Where:

n= Sample size per selected state,

Y= Number of households participating in irrigation farming per state selected

L= Total number of householdsparticipating in irrigation farming in the region

T= Total Sample

The selected households formed the population sample used for this study. Table 1 shows the details of the sampling based on the factor stated above.

Table 1: sampling procedure

	States where the selected Dams are located			
	Sokoto	**Katsina**	**Kano**	**Zamfara**
Y	1612	872	1124	1180
L	**4788**			
N	81	44	56	59
Total	**240**			

3.3. Data collection

Cross-sectional primary data were used for this study. The data collected include information on the socio-economic status of the household heads, the inputs used and output obtained in irrigation farming and the constraints faced by the irrigation farming households in the study area.The data were collected using a well-structured

questionnaire administered to the respondents. Apart from the personal interview with the household, focus group discussions (FGD) was conducted to have a cross-sectional opinion of the communities on the various perspectives of the households in the study area. The FGD involved selection of a group of irrigation farming household heads in the communities to ask them questions such as the perception on the severity of some coping strategies used by households. The selection cut across several categories in the community in order to get an average perception on some issues at the community level. The FGD informationwasused along with the household responses in the data analysis. Data were collected between October and December 2015 at the inception of another irrigation farming year.

3.4. Analytical Techniques

3.4.1. Descriptive statistics

Descriptive statistics such as mean, mode, median, and deviations were used to satisfy objectives (i), part of (iii), (v) and (viii).

3.4.2. Freedom from Hunger Scale (FFHS)

This was used to estimate the food security status of the households (over a long time-one year)in the study area (objective ii). There are 12 items adapted in this scale which should produce 12 binary items, so the maximum score that can be achieved by a household is 12 points. The scale was designed to picture an increasing severity on the food insecurity status. The responses of each household to the seven binary items were used to generate an aggregate that was used to classify the household food security status. The classification into the 3 food insecurity groups was done according to the following criteria:

i. Total score of 0 or 1 meant a Non Food Insecure (NFI) household or Food Secure (FS)

ii. Total score of the range 2-4 meant a Moderately Food Insecure (MFI) household

iii. Total score of 5 and above meant a Severely Food Insecure (SFI)

3.4.3 Coping strategy index (CSI)

The CSI was used to describe coping strategies utilized by respondents in the face of food insecurity (objective iii). The coping strategy index is an indicator of household food security (within a short period-one week) that is relatively simple, quick to use, straight forward to understand and correlates well with more complex measures of food security.

The *CSI* uses the responses to these questions on how households cope with in adequate food to generate scores that was used together with weights assigned on severities of food inadequacies obtained through the FGD. The index was computed thus:

$$CSI = \sum_{\tau=i}^{xiii} XY \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots .2$$

Where CSI= coping strategy index,

Ʈ= the coping strategies used by the households in the face of food inadequacy (in frequency of usage per week)

X= numerical value assigned to the strategies used

Y= level of severity of the coping strategy.

A higher CSI score denotes higher level of food insecurity in the household.

3.4.4 Ordered Logit Regression

This was used as a follow-up to the CSI to achieve objective (iv). It was used to estimate the determinants of food security among the small scale irrigation farming households in the study area based on the result of the CSI scores. As earlier noted, the CSI score denotes that the higher the value of the CSI score is, the higher level of food insecurity, and vice versa. The CSI score rank was applied for all households *i*, and it takes *j* different values, which are naturally ordered. Thus, there are 4 values (j = 0, 1, 2, 3) created. The ordered logit equation is thus given:

$$Y_i^* = X_i\beta + \varepsilon_i \text{..} 3$$

Where:

Y_i^*= unobservable latent variables from which the observed (ordered) values (Y) derive

X_i = observed individual specific factors assumed to be related to food security

βs = Vector parameters to be estimated

ε_i = Stochastic disturbance term with normal distribution

The values for the observed variables were assumed to be related to the latent variables Y_i^* in the following manner:

$$Y = 0 = food\ secure\ if\ Y_i^* < \mu_0\ where\ \mu = 0$$

$$Y = 1 = lessfood\ insecure\ if\ 0 \leq Y^* < \mu_1$$

$$Y = 2 = moderate\ food\ secure\ if\ \mu_1 \leq\ Y^* < \mu_2$$

$$Y = 3 =\ \ severe\ food\ insecure\ if\ \mu_2 \leq Y^* < \mu_3$$

μ means the unknown threshold parameters that separate the adjacent boundary values and is estimated together with the *β*s. For the estimated cut-off points, μ follows the order $\mu_1 < \mu_2 < \mu_3$. Using the maximum likelihood estimates technique, the values for the *β*s parameters can be estimated. The marginal effect (the first derivative of the log likelihood functions) are very important in the interpretation of result. The marginal

effects show the probabilities that would rank the CSI in any of the four level categories, given the group of explanatory variables assumed to affect the level of food security found in the study area.

The ordered logit equation was explicitly stated as:

$$Y_i^* = \beta_0 + X_1 + X_2 + X_3 + X_4 + X_5 + X_6 + X_7 + X_8 + X_9 + X_{10} + X_{11} + \varepsilon_i \ldots\ldots\ldots 4$$

Where;

$$Y_i^* = CSI\ Rank$$

X_1 = farm output (GWE)

X_2= Size of irrigation farm (Ha)

X_3=Household size (number of people that depend directly on the household for living)

X_4= Years of irrigation farming experience

X_5= Distance between home stead and the irrigation farm

X_6= Distance between home stead and the market

X_7=Dependency ratio

X_8= Amount of credit used in irrigation farming

X_9= Educational level

X_{10}= Age of household head

X_{11}= Extension contacts

$\beta s =$ Vector parameters to be estimated

$\varepsilon_i =$ Stochastic disturbance term with normal distribution

3.4.4.1 Definition and a priori expectations of variables used in the ordered logit model

Dependent variable (Y)

The dependent variable is the food security levels (categories) of the households. Using the Coping Strategy Index, the households have been categorized into four different food security levels in a rank order. Therefore, the value of Y can take any of the values in the order depending on the food security status of the household. The four categories are in the following order:

Y=0 when the household is food secure

Y=1 when the household is less food insecure

Y=2 when the household is moderate food insecure

Y=3 when the household is severely food insecure

Independent variables:

- **Farm output (X_1):** The farm output is the sum total of all crop outputs that the household head is able to harvest either for direct consumption of his household or for sale to generate income that is also used by the household. All crops were brought to a common unit using the crop/product conversion factors as proposed by Clark (1970) and is expected to have a positive relationship with food security. In other words, as the farm output increases, food insecurity decreases. The crops aggregated include maize, cowpea, sorghum, wheat, millet and vegetables.
- **Farm size (X_2):** The farm size in this study is the total area of irrigable land that the household head is able to cultivate as irrigation farms. It was measured in hectares and is expected to have a positive relationship with the food security

condition of the household assuming that all proceeds are used directly or indirectly for the welfare of the household members.

- **Household size (X_3)**: This refers to the number of individuals living in a household under the household head. They are also those who depend on the household for their living. Some of the members of the household under the leadership of the household head are also expected to be capable of making contributions to the success of irrigation farming and by extension the household food security level either through labour supply or through engagement in some non-farm income generation.
- **Irrigation Farming experience (X_4)**: This indicates the number of years spent so far by the household head in irrigation farming. This was carefully differentiated from years of farming experience because irrigation farming is assumed to be technically different from the general farming in some areas such as the duration and control over water supply which is not so in rain fed agriculture. Based on their exposure, it could be adjudged that the household heads possess great ability to predict possible problems and likely solutions that results to higher performance level. It is therefore expected that the processing experience should have a positive relationship with productivity and food security level of the household. It was measured in the number of years that the household head has spent in irrigation farming.
- **Distance from home (X_5):** This was measured in kilometers and is the distance covered by each irrigation farming household between the home stead and the irrigation farm site. This was considered important as some farmers are noted to be far from their irrigation plots and this is believed to have affected their productivity on the farm after trekking some distance on daily basis to their farm

sites. It was measured in kilometers and is expected to have a negative relationship with household food security level.

- **Distance from nearest input and product market (X_6)**: This was also measured in kilometers and is expected to have a negative relationship with the food security levels of households in the area. It is expected that if the input and product markets are close to the farmers' farm and homes, the cost of transporting inputs and outputs from the point of purchase and from the farm to markets respectively, will be reduced.
- **Dependency ratio (X_7):** This is the ratio of the number of unemployed members of the household to those who are employed. This gives a good picture of the weight of responsibility on the bread winners of the household. The higher the value of the ratio the higher the level of food insecurity is expected to be. It is therefore expected to have a negative relationship with food security level of the household.
- **Access to credit (X_8)**: This represents household head's access to credit facilities received either in cash or in kind from lending agencies and other individuals like banks, friends, money lenders, relatives, non –governmental organizations. This was measured as amount of credit in Naira.
- **Educational status of the house-hold head (X_9):** Formal education is a social capital which could impact positively on household's ability to take good and well informed production decisions. For this study, education was measured by years of schooling. It is assumed that as the level of household head's education rises, he/she should be have access to information (from print or other forms of media) that will equip him/her to take good decisions like taking good risk when others

are skeptical about such decision. This variable is expected to relate positively with the household food security level.

- **Age of household head (X_{10})**: The age of household head (in years) is expected to have impact on his labour supply in irrigation farming. It is expected to have impact on ability to seek and obtain off-farm jobs and income which could increase household income. Young people are stronger and are expected to cultivate larger farms than old people. Therefore, this variable is expected to have a positive relationship household food security.
- **Access to extension contact (X_{11})**: This involves the application of scientific research and new knowledge to irrigation farming practices through farmers' education. The field of extension encompasses a wide range of communication and learning activities organized for rural people by professionals of agriculture and subject matter specialists. Agricultural extension contact for this study was measured in terms of the number of times the famers were taught by extension agents in the course of the irrigation farming season and it is expected to have a positive relationship with the household food security.

3.4.5 Linear Programming

This tool was used to determine the optimum combination of household crop production activities that ensures food security and income maximization among the small-scale irrigation farming households (objective vi) and the response of optimal farm plan to changes in input levels (objective vii). It is stated as follows:

$$Max\ Z = \sum_{j=1}^{n} C_j X_j (j = 1,2, \dots, n) \quad \text{.....5}$$

Subject to:

$$\sum_{i=1}^{m} a_{ij} X_j \leq b_i (i = 1,2, \dots, m) \quad \text{.....6}$$

And $X_j \geq 0$ for all js

Where:

Z= objective function (Maximising output) in GWE,

X_j = activities,

C_j = marginal contributions of each variable,

b_i = total amount of ith resources available,

a_{ij} = resource requirements per unit of activity,

n= number of activities,

m= number of resources,

The activities used for this study were based on the various types ofcrop combination found among the small-scale irrigation farmers in the study area. Each activity will be considered and its output maximized subject to the constraints of the production input of the production activity.

3.4.5.1 Activities included in the Linear programming model

- **Crop production activities**

Several crop production activities were found in the study area however only those that were practiced by up to 30% of the respondents were included in the representative farms. Each crop production pattern constituted an enterprise. The crop enterprises included in the representative farms include seven sole crop pattern, seven two crop mixtures and a three crop mixture patterns. These include: Sole maize, sole rice, sole tomato, sole wheat, sole onions, sole pepper and sole cowpea. Others are maize/ground nut, tomato/onions, maize/cowpea, wheat/ground-nut, onions/pepper, wheat/pepper, tomato/pepper and tomato/onions/pepper. They are assumed to be the most important crop production opportunities in the study area in terms of contribution to the household

income and food. For each activity, the unit of production is one hectare (Ha). They are represented on the matrix table on column 1 to 15 on Table 2.

- **Labour hiring activities**

Both family and hired labour were used for irrigation activities in the study areas. The hired labour is an activity while the family labour is more of a constraint. The coefficient of hired labour is assumed to be negative in the family labour row implying that when a unit of labour is hired, the family labour constraint is relaxed by a unit. The unit of the hired labour is in man-hour which is the work that an adult male is able to do in a period of an hour. This is indicated on the rows 5 and 6 on Table 2

- **Fertilizer buying activities**

Fertilizer is a major input in crop production activities. Irrigation farmers spend money to purchase it for better output in the crop production. Three types of fertilizers were included in the model. The type depends on the crop requirements and crop enterprise combinations. The types of fertilizer activities are N: P: K, urea and single super-phosphate (SSP). The coefficient in the objective function shows. This activity is represented on rows 3 and 4 of Table 2.

- **Seed buying activities**

Farmers source their seed either from the previous harvest or through purchase. The model allows for both. However, in the study area, most of the irrigation farmers interviewed indicated that they buy seed for the irrigation farming activities. The value of the seed buying activity in the objective function represents the unit price and it is negative. In the row, it is also negative because it draws from the resources available on

the farm. The seed buying activity is represented on row 10 of the general crop production activities on Table 2.

3.4.5.2 Resource constraints in the linear programming model

Production resources are unlimited and farmers are usually constrained by the amount available for production purpose. The constraints in this model are specified at some levels using minimum (≤), equality (=) or maximum (≥) signs as the case may be.

- **Land restriction**

Irrigation land is unique in that it requires a source of water that can supply the minimum required water quantity for crop production during the dry season. The factor of water availability has put a restraint on the amount of land usable for irrigation activity. The lands available therefore are limited to those that the farmers hold that has a guaranteed supply of minimum water required for cropping activities. The maximum available irrigation farmland was taken as the limit of land available for cultivation.

- **Labour restriction**

Labour was supplied for irrigation farming through the work force provided by households and the one hired from outside. Family labour was determined by the composition and size of the irrigation farming household. The average household size found in the study area was about 12 people. Assuming that a woman is able to carry out 75% of a man's work and an adult child 50% of a grown up man's work; and also assuming 70% efficiency (due to fatigue or illness), the average family labour used for irrigation farming activities was calculated to be 171 man-days (1368 man-hours). For the hired labour, 237 man-days (1896 man-hours) were calculated. This labour supply was used over the few months of the year when irrigation farming activities took place

between the period of November and March/April (depending on the duration of the crops grown).

- **Fertilizer restrictions**

Fertilizer has been identified as the driving force behind crop intensification in the Northern Guinea Savannah (Ahmed, 1995). This implies that crops which can only be grown well on the basis of using inorganic fertilizers will be restricted by the availability and prices of the fertilizers.

Table 2: Crop production activities in the representative farms

Crop Production Activities													
	Objective Fxn Cj		1	2	3	4	5	6	7	8	9	10	11
Row No	Resources	Unit											
1	Land	Ha	1	1	1	1	1	1	1	1	1	1	1
2	NPK	Kg	249	201	250	175	167	349	287	175	200	438	44
3	Urea	Kg	153	180	131	175	91	190	165	125	100	46	507
4	SSP	Kg	0	0	21	25	71	1	0	8	300	106	0
5	Fam. Lab	Man-hrs	51	53	64	220	53	39	50	9	64	186	30
6	Hired. Lab	Man-hrs	66	74	25	229	21	16	131	98	64	129	73
7	Water	Liters	40000	50000	4500	50000	35000	50000	4000	50000	48000	50000	60000
8	Herb	Liters	3.81	7.13	2	0	3	11	2	2	4	25	2
9	Insect	Liters	1.5	0.3	5	0	4	0.35	5	4	6	5	8
10	Seed	Kg	26	95	32	175	4	163	46	15	0.5	4	121

Table 2 con't: Crop production activities in the representative farms Continues

Crop Production Activities								
		Objective Fxn						
		Cj	12	13	14	15	Sign	RHS
Row No	Reources	Unit						
1	Land	Ha	1	1	1	1	≤	3.3
2	NPK	Kg	1667	448	124	140	≤	700
3	Urea	Kg	267	300	48	160	≤	692
4	SSP	Kg	67	0	0	0	≤	33
5	Fam. Lab	Man-hrs	29	0	35	11	≤	171
6	Hired. Lab	Man-hrs	20	99	40	115	≤	237
7	Water	Liters	43000	43000	50000	18000	≤	36,700
8	Herb	Liters	2	20	1	0	≤	15
9	Insect	Liters	2	4	2	1	≤	9
10	Seed	Kg	0.5	38	8	0.6	≤	27

CHARPTER FOUR

RESULTS AND DISCUSSION

In this chapter, the various data collected were subjected to different analyses in accordance with the stated objectives. The results of the analyses are hereby presented;

4.1 Socio-economic characteristics of the household heads in the study area

This section describes the socioeconomic characteristics of the irrigation farming households. The various data collected were subjected to different analyses in accordance to the analytical techniques stated in chapter three. The results of the analyses are therefore presented in this section.

4.1.1 Gender of the household heads

Figure 1 shows the distribution of irrigation farmers (household heads) based on their sex. The result shows that majority (89%) of the farmers are males while 11% are females. This implies that irrigation farming is mostly managed by the males in the study area. This might be due to the fact that a lot of labour and time is needed for irrigation farming within a short period of time. This kind of doggedness is likely available among the male folks than their female counterparts. According to Ogunremi *et al.* (2016), male dominance is common with agricultural production processes that involves drudgery and requires doggedness. This result is in consonance with the findings of Ruma (2009). The report of the finding states that urban and peri-urban irrigation activities in Katsina, Northwestern Nigeria were dominated by the males. The male household heads in the study area were further described as those who dominate cultivated farm lands even though they are not the sole owners of such cultivated lands in Katsina region as some few females are equally found to own farm land. This

lopsidedness in gender participation in irrigation farming was partly attributed to culture in the area.

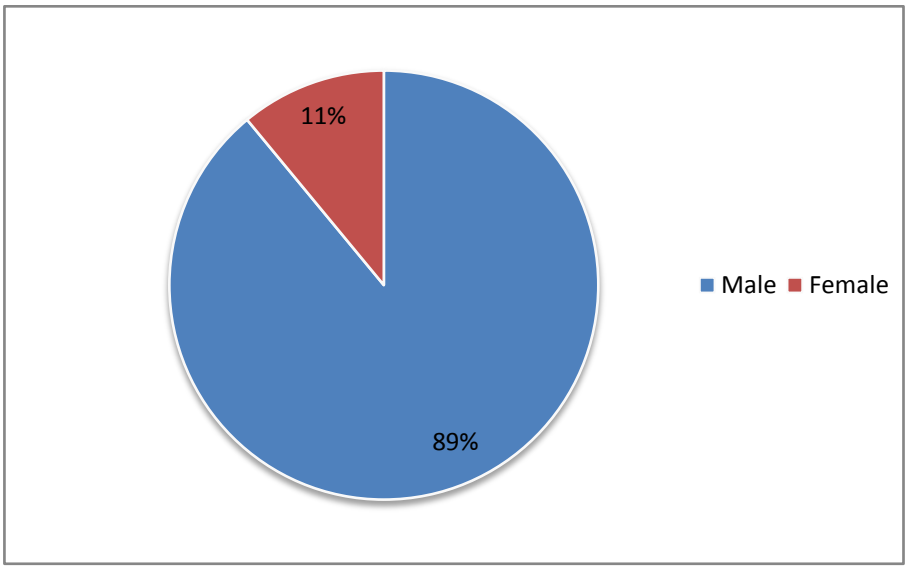


Fig.1: Gender of the Irrigation Farming Household heads

4.1.2 Age of household heads

The age distribution of household heads is presented in table 3. The age of the irrigation farmers cut across the young, the middle age and the old farmers. Majority of the irrigation farmers falls between the age groups of 41-50 years and 31-40 years which constitute 37% and 24% of the irrigation farmers respectively. In all, about 72% of the irrigation farmers are within the active age of 21-50 years (Udoh, Akpan and Effiong, 2011). The average age of the farmers as provided on table 1 is 44.81 years. This is the age group within which the energy required for a successful farming labour and management can be provided. This average age indicates that most of the household heads are within the economically active population and therefore constitute a good labour force for irrigation farming in the study area. They are also likely to be able to make rational decisions that will affect productivity positively. According to Udoh *et al*, (2011) farmers in that age group will be able to participate actively in farming.The

result of this study also agrees with Salisu (2001) who reported that irrigation was a male affair only in Northern Nigeria and conflicts with the findings of Dauda *et al.* (2009) who reported that females are actively involved in irrigation farming in Southwest Nigeria. They attributed the difference in their findings to cultural variations in the two regions.

Table 3: Age Distribution of the household heads in the study area

Age (years)	**Frequency**	**Percentage (%)**
20 and below	04	02
21-30	26	11
31-40	59	24
41-50	88	37
51-60	55	23
60 and above	08	03
Total	**240**	**100**

Minimum=19, Maximum=72, Average age = 44.81 years

4.1.3 Marital status of the Household heads

The result presented on table 4 shows that 96% of the responding household heads are married or have been married. Out of this, 91% are still with their spouses while 4% have lost their spouses. This is inline since those who are 20 years and below are only 2% of the irrigation farmers. Those who are single and are household heads are those who probably assumed the position of headship in their households after the demise of the household head (but are yet to marry). This result implies that household heads are those who have people to cater for with other family responsibility. According to Ogunremi, Ogunremi and Dubugo(2016), married people are responsible and will like to spend their profit on their family. It can also be deduced that most of the farmers might have needs that compete with the limited farming resources and will therefore need the skills for effective allocation of such limited resources. On the other hand,

Muhammad *et.al.,* (2015) stated that marriage may imply that there are members of the family that increase the quantity of food needed to be food secure especially when there are more minors in the household.

Table 4:Marital status of household heads

Marital status	Frequency	Percentage (%)
Single	10	04
Married	218	91
Widow/widower	10	04
Divorced	02	01
Total	**240**	**100**

4.1.4 Household heads' level of formal education

The distribution of the irrigation farmers based on the level of formal education attained is presented on Table 5. Looking at the distribution of the household heads by their levels of formal education, the most common type of education among the respondents is Quranic education and is an informal education and the least common is adult education. Majority (about 61%) seem to have contact with formal education that should help them to be literate. Literacy and exposure are two main factors that are important to this study. This is essential because literacy is needed for farmers to be able to decode the instructions that accompany the resources they use on the farms like chemicals and drugs they use in the farm without necessarily having to wait for technical officers all the time. However, instruction manuals that comes interpreted in Arabic will have better reception in the study area. This assertion is in line with the report of Imonikhe (2010) and Muhammad (2015), which stated that education significantly enhance a farmer's ability to take accurate management decision and a high literacy level aids adoption of best practices in production activities thereby

increasing the productivity of the farmers as. It is also believed that formal education enhances the adoption rate of rural farmers. However, is obvious that the formal educational standard of the respondents were generally low agreeing with an earlier report by Akinsanmi and Doppler (2005), that rural farmers in the south eastern Nigeria and the northern part have low level of formal education. A relatively higher educational status will encourage acceptance of innovation which may raise farm productivity and income thus improving the food security status of households (Dauda *et.al.*,2009; Muhammad, 2015).

Table 5: Household heads ' level of formal education

Highest level of formal education	**Frequency**	**Percentage (%)**
Primary school	37	15.4
Secondary school	36	15
HND/OND/NCE	39	16.3
Degree	13	5.4
Adult education	21	8.7
Quranic education	94	39.2
Total	**240**	**100**

4.1.5 Household heads' membership of associations

Table 6 shows the result of the distribution of farmers based on their membership of an association. Those who are members of an association are about 84% of the farmers while only about 16% are not members of any group or association. Furthermore, the table shows the distribution of the respondents based on the number of association they belong to. The number of associations belonged to by each irrigation farmer in the study area ranges from one to five with those belonging to only one farmer's group constituting about 58%. Membership of a farmers' group or cooperative will afford the farmers opportunity of sharing farming ideas with other farmers and learn new things

easily. Similarly, farmers can operate of a cheaper frontier whenever the association decides to pool resources together in order to make bulk purchase of farm inputs. According to Alabi *etal.* (2013), membership of cooperative reduces farmers' inefficiency in Kaduna state. This implies that productivity or output will increase as farmers join relevant cooperative societies and associations where ideas of better methods of farm practices are shared. This is also in line with Emesowum, Mbanasor and Olayiwola (2013) who stated that membership of agricultural associations/cooperatives enhances the performance of agribusinesses. Gashaw *et al* (2013) equally found that membership of cooperatives enhances members' efficiency by easing access to productive inputs and facilitating extension linkage compared to those who were not members. Increased productivity and performance will ultimately improve the food security status of the households.

Table 6: Membership of cooperative/farmers' association and number of cooperatives/association

Membership	Frequency	Percentage
Member	201	83.8
Non-Member	39	16.2
TOTAL	240	100
No of Cooperative/Associations		
One	117	58.2
Two	60	29.9
Three	21	10.44
Four	0	0
Five	03	1.50
TOTAL	**201**	**100**

4.1.6 Households sizes of Respondents

The distribution of households based on the number of persons in it is presented in Table 7. It is revealed that the number of members of the households ranged from a minimum of one to a maximum of forty-eight persons with an average of 12 persons per household in the study area. Most farming communities depend on family labor for farming activities and how much they get from the family labour depends on the size and the strength of those living in it. Where majority of those available to the households are children then there may be need for hired labour for some farming activities. This assertion is in line with Mohammad (2015). The result shows that the farming households that practice irrigation in the study area have a reasonable quantum of family labour force for irrigation farming activities. According to Akinyemi (2000), the size of the family is important in traditional agriculture as it influences the supply of labour. More studies (Tokula *et.al*, 2013; Anozie *et.al*, 2013 and Alabi *et.al*., 2013) have also linked household size with productivity and efficiency in various areas of agricultural production. Similar to the finding of this study, Imonikhe (2010) found an average family size of 11persons in some areas of North-west Nigeria.

Table 7: Households sizes

Household size	**Frequency**	**Percentage (%)**
1-8	83	34
9-16	106	44
17-24	34	14
25-32	15	06
33-40	01	01
>40	01	01
TOTAL	**240**	**100**

Average =12, Minimum=1, Maximum=48

4.1.7 Householdmembers' age distribution

The age distribution of the household members is also an important variable to be discussed. Table 8 presents the results of the distribution of household members based on their age composition. The result shows that majority of the household members are between the ages of 1 and 15 years while those who are more than 60 years are the least. However, careful analysis shows that about 57% of the entire members of the household are children (1-15years) and old people (more than 60 years) while those who are considered to be economically viable are 43% of the entire households put together.In each of the age categories, majorities are within the household categories with members ranging from 9-16 and 17-24 peoples. Furthermore, the average of the age categories 1-15, 16-60 and more than 60 years are 6, 5 and 1 year respectively. This implies that there are likely fewer of the economically viable people compared to those who dependants in the area. The economically viable is the category that has the prospect of providing family labour for the households. The quantum of labour to be sourced from this group depends on their ratio with the very young children. The implication of the age distribution is that very young children and very old people are mainly depending on the stronger members of the household for their basic needs.While the young adults and the agile groups have contribution to make to the household towards improving the level of household food security, the very young and extremely old members of the household have very little to contribute. A low ratio therefore implies that the agile category will have to be more productive in order to secure an improved level of food security for the entire households. This is similar to the findings of Anozie *et. al* (2015) where more dependants were reported among farming households.

Table 8: Household members' age groups

Household Size	Ages 1-15 years		Ages 16-60		Ages 60 and above	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
1-8	293	20	191	15	10	07
9-16	642	44	579	47	59	40
17-24	383	26	341	28	72	50
25-32	103	07	90	07	01	01
33-40	25	02	15	01	0	0
>40	20	01	23	02	03	02
TOTAL	**1466**	**100**	**1239**	**100**	**145**	**100**
Averages	6		5		1	

4.1.8 Household members' status of employment

Table 9 presents the result showing the frequency distribution of household members that are employed in any endeavor that brings income no matter how little it is. The average value presented gives a clearer picture of the employment ratio in the households. The average numbers of employed and unemployed persons in the households in the study area are 3 and 8 respectively. This shows that most of the households have more members that are not employed and so do not have much direct contribution to the resources that the household needs to be food secure. This further shows that few people have to bear the pressure of ensuring that the household are food secure. Having an income source should be a guarantee to having access to food (as defined earlier) and being employed is therefore important in ensuring food security. According to Anyiro and Emerole (2013), unemployment and underemployment increases vulnerability to food insecurity. Any meaningful production activity that brings income reduces food insecurity.

Table 9: Households members based on employment status

Household Size	No Household members Employed		No of Household members Unemployed	
	Frequency	Percentage (%)	Frequency	Percentage (%)
1-8	195	25	685	33
9-16	375	48	774	37
17-24	173	22	527	25
25-32	21	3	62	3
33-40	5	1	8	1
>=40	9	1	16	1
TOTAL	**240**	**100**	**240**	**100**
Average	3		8	

4.1.9 Experience of household heads in irrigation farming

The distribution of households based on their irrigation farming experience is presented on Table 10. The highest group in years of irrigation farming experience is those that have between 9 and 16 years. This group constitutes about 39% of the respondent. The least group are those who have over 40 years of irrigation farming experience. The average irrigation farming experience is about 16 years. From table 10, it is also clear that about 74% of the respondent have irrigation farming experience of between 9 and 32 years. This shows that the farmers are well experienced in irrigation farming. It implies that the farmers in the area are those who should have mastered the 'art and acts' of irrigation farming for higher productivity. The years of farming experience in agricultural production generally plays significant roles in improving productivity. Several studies *across* different fields of agriculture (Mazza *et.*al., 2016; Anozie *et.al.*, 2016; and Onyemauwa *et.al.*, 2016) have confirmed the fact that years of farming experience improves productivity. It was also reported by Anozie *et.al.*, (2016) that farmers count on their farming experience than educational attainment in order to increase their efficiency. Experience, the result of learning by doing, affords the farmer

the opportunity to improve upon their managerial skills and make viable enterprise combinations (Ajibefun, 2002). Good irrigation farming experience therefore should imply better output which in turn is expected to lead to reduction of food insecurity.

Table 10: Household heads' years of irrigation farming experience

Years	Frequency	Percentage (%)
1-8	45	18.75
9-16	93	38.75
17-24	53	22
25-32	32	13
33-40	06	2.5
>40	11	05
Total	**240**	**100**

Average= 15.7 years

4.1.10 Household heads' access to Agricultural Extension services

Table 11 presents the result of the distribution of household heads based on their access to and the frequency of agricultural extension services. The results shows 91% of the respondents have had extension contact while just 9% do not have extension contact. Among those who have had contact, about 78% have between 1 to 5 contacts with agricultural extension workers per season while those who have between 6 and 10 contacts and those that have more than 10 contacts are 14% and 7% respectively. The average extension contact per household head per season is 4. This implies that the farmers are current in, and should be able to track the latest trend in farming methodologies available. The role of extension in agricultural productivity and even commercialization is enormous. According to Onyenobi *et.al.* (2015), access to extension services is significant in of agricultural production.

Table 11: Access to and frequency of extension contact

Access	Frequency	Percentage (%)
Those who had contact	218	91
Those who had no contact	22	09
Frequency of contact per season		
1-5	171	78.44
6-10	31	14.22
>10	16	7.33
TOTAL	**218**	**100**

Average contact per farmer in a season = 4

4.1.11 Household heads' access to farm credit

Table 12 shows the distribution of the household heads that practice irrigation based on their access to, type and sources of credit for the purpose of irrigation farming. The result shows that only about 33% of the respondents have access to credit for use in irrigation farming. 50% of those who have access to credit access the credit in cash while about 8% and 42% of them get credit in kind and both cash and kind respectively. About 32% of the credits used in irrigation farming are from friends and the farmers' personal savings. Those who access credit from Bank of Agriculture and Micro-finance banks are about 18% and 20% respectively while cooperatives, commercial banks and the village money lenders provides 16%, 4% and 10% of the credit used in irrigation farming respectively. The result implies that only about 42% of the credit accessed by the 33% who got access to credit for irrigation farming was provided by the banks. This is very low as credit is expected to be a catalyst that triggers productivity of farmers. The low accessibility to credit from the banks (commercial, micro-finance and bank of agriculture) is a setback that might affect the performance of the farmers negatively. The interest rate among the farmers was as low as 0% for those who saved money and used or those who got credit without interest for friends and relatives to as high as 40%

for a few who patronized village money lenders. The average of the interest rate charged as shown on table 12 was about 2.3%. Previous studies have shown a direct relationship between credit accessibility and productivity. Studies have also confirmed the low availability of credit to farmers from formal financial institutions. CBN (2005) reported that the existing micro-finance banks in Nigeria serve less than 1 million out of the existing 40 million people that need the service. Furthermore, in 2015, Arene, Okpukpara and Ukwuaba decries the low volume of credit made available to farm households. One of the challenges they identified is the inability of the farmers to provide collaterals for the credits. Also, Osondu and Ijioma (2015) reported that farmers have very low access to credit from money lenders, commercial banks, micro-finance banks and even agricultural banks.

Table 12: Access to, type and sources of credit for irrigation farming

Access to credit	**Frequency**	**Percentage (%)**
Yes	80	33
No	160	67
Total	**240**	**100**
Types of credit		
Cash	40	50
Kind	06	7.5
Cash and Kind	34	42.5
Total	**80**	**100**
Source of credit		
Commercial Banks	03	4
Micro-Finance Bank	16	20
Bank of Agriculture	14	17.5
Personal Savings/Friends	26	32.5
Cooperatives	13	16
Village money lender	08	10
Total	**80**	**100**

Interest rate average=2.3%, max=40%, min=0%

4.1.12 Household heads' non-farm income sources

The result on Table 13 shows the distribution of respondents according to off-farm income sources. The result reveals that majority (78%) of the respondents have other sources from which they generate income apart from irrigation farming. The various sources of off-farm activities they engage in include civil services, trading, animal husbandry, transportation and tailoring. The implication of having about 78% of the respondents engaging in off-farm activities that generate income is that they might be able to raise savings for irrigation farming activities. According to Anyaegbunam (2013), having streams of income sources has been found to expand the profit horizon of small-scale businesses. Similarly, off-farm income sources help farmers to raise some money which they invest into farming business like irrigation farming (Ezike and Okonkwo, 2016). Similar report has been credited to Akinbode, Salami and Ojo (2014). On the other hand, it means most of the irrigation farmers do not have all the time to concentrate on farming activities and should they be absent during critical periods when major decisions are to be taken, it might affect the productivity or the performance of the farm. However, experience will help the farmers to manage their time in such a way that the farming activities are not affected negatively. The income generated has a role to play in boosting the farm productivity if invested into the irrigation farming since most of the farmers do not have access to formal credit.

Table 13: Non-farm income sources

	Frequency	Percentages (%)
Those with Non-Farm Income	188	78
Those without Non-Farm Income	52	22
Sources of non-farm income		
Civil Service	23	12
Trading	50	26
Animal Husbandry	80	42
Artisans	13	7
Transporters	09	5
Menial Labour	03	2
Processing	02	1
Pottery	01	1
Tailoring	07	4
Total	**188**	**100**

4.1.13 Households' proximity to irrigation farms and markets

Table 14 presents the results of the proximity of the household heads from their homestead to the irrigation farms and to markets. Proximity to farm is an important factor in irrigation farming especially for vegetable crop production in which case small-scale farmers water their crops early in the morning and late in the evenings. Table 14 shows that most of the farmers (49%) resides with in the distance of 3km from the farms and not less than 71% within a distance of 6 Km away from their farms. It means that majority of the farmers stay within a trek-able distance from their farms and this will help them to give the attention needed to crops being the small-scale farmers that they are. Similarly, majority of the farmers (37%) reside within an average distance of 3 Km away from markets where they can sell their products. This is advantageous to small-scale farmers who produce perishable crops and do not intend to process. Selling their produce in a market may give them a higher bargaining power than when buyers

come to the farm gates. Also those who stays in areas that is more than 15 Km away from markets constitute about 33%. The average distance of the farmers from their farms and markets are about 2.89 Km and 2.71Km respectively. Far distances from markets may not constitute problems as far distance from the farms. This is because the frequency of visits to the farm is more than that of the markets. Equally so, transportation in rural communities tends to be easier on market days than any other days. So it is better for the farmers to be closer to their farms than the markets.

One of the aims of some irrigation farmers is to sell some of their output to buy food items necessary for the household food security that they do not produce. According to Olowa and Olowa (2016), the distance from farm to markets is a significant variable that determines market supply and is negatively related to it. This implies that as the distance of farms widens from the markets, the supplies to the market reduces, market prices rises and on the other hand, the products that could not be taken to the market perishes and food insecurity level rises. Other studies like (Nwigwe *et.al.*, 2016; Nwaogu; Okoye and Okoye, 2016 and Onwusiribe, Okpokiri and Nzeako, 2016) have all identified that distances from the farmers homesteads to their farms and markets have significant relationships with adoption of technology, productivity, participation in farming activities and farm efficiencies. All these have an indirect link with the level of food insecurity of the households.

Table 14: Household heads' distribution based on proximity to irrigation farms and local markets

Distance in Kilometers	Distance from Homes		Distance from Markets	
	Frequency	Percentages	Frequency	Percentages
1-3	117	49	88	37
4-6	54	22	32	13
7-9	21	9	13	5
10-12	48	20	19	8
13-15	0	0	10	4
>15	0	0	78	33
TOTAL	**240**	**100**	**240**	**100**
Average	2.89Km		2.71 Km	

4.1.14 Households'Irrigation farm sizes

The distribution of the household heads based on the sizes of irrigation farm land they control is presented in Table 15. The result shows that more than 50% of the respondents have less or equal to 1.5 hectare of irrigation farm plots. The modal farm size class is 1.6-2.0ha which constitutes about 30% of the respondents. The average farm size obtainable among the irrigation farmers was found to be 1.64 hectares. This, based on the assertion of Osuagwu, Ihenacho and Chikaire (2015), implies that irrigation farmers in the area are typical small-scale farmers operating on a subsistence level (an average farm size of 1.64 ha). This may be tied to the fact that the farmers have low capital available for investment into the farm business. Capital investment is a catalyst that transforms farm business from a subsistence level to a commercial level.Previous studies have established a relationship between the sizes of farm and the output that proceeds from it. For example, Anozie *etal.*, 2015; Onuegbu-Johnson, Nwajiuba and Okoye, 2015) have found that farm size is significant and positive in the determination of cassava output. Similarly, the farm size cultivated by household heads in Abia state has been found to affect the amount of credit they accessed for farming (Udensi, Anyim and Udensi, 2016). If farm sizes have been found to increase output of

crop and the amount of credit a farmer has access to, then it is expected that it will have a positive relationship with food security levels. This implies that promulgating policies that can help households to expand the amount of irrigation farm sizes will help in reducing food insecurity level in the area.

Table 15: Farm Size

Farm size (ha)	Frequency	Percentages (%)
0.1-0.5	39	16
0.6-1.0	66	28
1.1-1.5	26	11
1.6-2.0	73	30
2.1-2.5	15	6
2.6-3.0	14	6
3.1-3.5	7	3
Total	**240**	**100**

Average farm size =1.64 ha

4.2 Long-term Food security status of irrigation farming households

Table 16shows the distribution of the households based on food security levels using the Freedom from Hunger Scale (FFHS). This is to give a panoramic (wide) view of the food security situation of the household in a year in order to analyze the dynamics of the food security of the irrigation farming households. The score was computed based on the responses that a period of time that spans through the year. The lowest score was zero (0) while the highest was twelve (12). The mean food security score of the distribution was 5.45 which tend towards food insecurity. This implies that on the average, the rural households in the study area are food insecure. This agrees with the early postulates of Swaminathan and Sinha (1986) and Ibrahim *et.al*(2009) that there is more of food insecurity in rural communities than the urban area. There is therefore need for this to be addressed because these rural dwellers are seen as those who produce

food for the entire nation. The FFHS has an advantage in that it does not consider only a short period of time in the estimation of food security food security status of households. It therefore implies that if the small-scale irrigation farming households are empowered to get better output, more people will be free for hunger throughout the year.

Table 16: Distribution of householdsby food security levels

Food Security Score	Food security level	Frequency	Percentage (%)	Group Percentage (%)
0	Food	29	12	
1	secure	27	11	23
2	Moderately	17	7	
3	Food	14	6	23
4	Insecure	24	10	
5		7	3	
6		17	7	
7	Severely	29	12	
8	Food	14	6	
9	insecure	24	10	54
10		16	7	
11		11	4.5	
12		11	4.5	
Total		**240**	**100**	**100**
Mean Score		5.458333		

A graphical depiction of the result ispresented on Fig 2 shows that about 54% of the households are severely food insecure while 23% and 23% of the households are food secure and moderately food insecure respectively. A similar study conducted by Ibrahim *et.al.,* (2009) among urban households reported that about 43% of the households are food secure while 28% and 30% are moderately food insecure and non-food secure respectively. This further justifies the need for policy implementations that will boost food production and food security in the rural communities where a lot of

farming is been done all year round through the rain fed and irrigation agriculture as in the case of the study area.

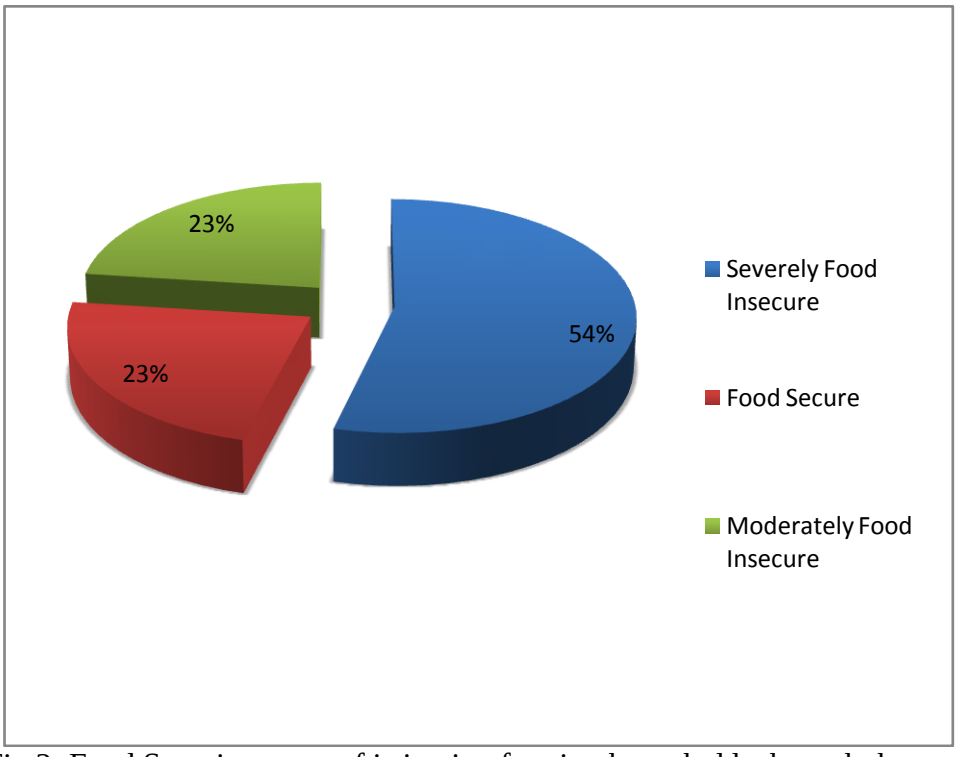


Fig.2: Food Security status of irrigation farming households through the year

4.3. Coping strategies adopted by irrigation farming households

Several studies have shown that there are set of behavioral responses to food insecurity that are employed by anyhousehold, anywhere and this reflects accurately the food insecurity status of the households (Edeh and Gyimah-Brempong, 2015). In the face of food inadequacy, there are several strategies that households adopt in order to cope with hunger situations. In the study area, the most important strategies are presented on Table 17;gathering wild food (fruits), sending members of the households to eat elsewhere and reducing the quantity of food consumed (77%, 77% and 74% respectively) are at the top of the strategies adopted by the households in the study area to cope with food inadequacies. Next to this category are eating less preferred meals, consuming the seed stocks meant for planting and food rationing among family members; these are being

adopted by 70%, 67% and 61% of the households in the study area. Begging for food, restricting adult consumption, and skipping of meals are also coping strategies practiced by 20%, 23% and 37% of the households in the study area. Owing to the fact that the quantity, quality and preference are components of food security (FAO, 2014), it is obvious that there is the presence of food insecurity among the sampled irrigation farming households. The severity of hunger may also be determined by the type of coping strategy used by the households. For example, it is considered an extremely bad practice in some rural communities for farmers to eat the seed meant for the next season. Looking at the severity of each of these strategies, the communities rated sending children to eat elsewhere, consuming seed stock, skipping of meals, begging for food and restricting adult from eating to give room for children as severe coping strategies which are being practiced only when there are no further options available. Other strategies were rated moderately severe and none was rated very severe at the community levels. However, at individual levels, some of the strategies were rated as very severe (such include: eating of seed meant to be planted, begging for food).

Table 17: Coping strategies adopted by irrigation farming households

Strategies	**Users**		**Non-Uses**	
	***Frequency**	**Percentages**	**Frequency**	**Percentages**
Skipping of meals	90	37	150	62.5
Eating less preferred meals	169	70	71	30
Begging for food	49	20	191	80
Food rationing or reducing number of meals	147	61	93	39
Borrowing of food	99	41	141	59
Purchase food on credit	133	55	107	45
Reducing the quantity of food consumed	178	74	62	26
Restrict consumption by adults to enable children eat	56	23	184	77
Consume seed stock held for next season	162	67	78	32.5
Send household members to eat elsewhere	84	35	156	65
Gather wild food (Fruits)	84	35	156	65

*Each strategy was considered independent of others so addition across the rows is give 240 and 100 for frequencies and percentages respectively.

A further investigation into how frequently each household responds to food insecurity using the coping strategies was carried out. This was done following the categories of Edeh and Gyimah-Brempong, (2015) which grouped the frequencies to zero, one to two time per week, three to six times per week and seven times per. This study has gone ahead to defined these categories as follows: zero frequency as Never, one to two times per week as rarely, three to six times per week as often and seven times per week as always. The result on table 18 reveals that very few households use the strategies of borrowing food and buying food on credit always in the study area (1 and 2 percent respectively). For the other strategies, no household use them always. The strategies that are often used include food rationing (36%), eating less preferred meals (20%), reducing the quantity of meals consumed (17%) and gathering of wild foods especially fruits (25%). From the categories defined earlier, those who respond to food inadequacy using the strategies listed above use them 3-6 times a week. The result presented on Table 18 also shows that about 51% of the respondents rarely consumed stock for the next season while 37% and 37% rarely skipped their meals and reduced the quantity of meals consumed respectively. Furthermore, 42% of the respondents rarely eat less preferred meals in their households as a means of coping strategy against food shortage.

Table 18: Frequency of use of coping strategies (with percentages in parenthesis)

Strategies	Never		Rarely		Often		Always	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Skipping of meals	97	52	70	37	20	11	0	0
Eating less preferred meals	71	38	78	42	38	20	0	0
Begging for food	138	74	23	12	26	14	0	0
Food rationing or reducing number of meals	57	31	62	33	68	36	0	0
Borrowing of food	105	56	58	31	23	12.5	1	0.5
Purchase food on credit	71	38	65	35	49	26	2	1
Reducing the quantity of food consumed	86	46	69	37	32	17	0	0
Restrict consumption by adults to enable children eat	131	70	54	29	2	1	0	0
Consume seed stock held for next season	61	33	96	51	30	16	0	0
Send household members to eat elsewhere	103	55	47	25	37	20	0	0
Gather wild food (Fruits)	103	55	38	20	46	25	0	0

Key: **Never** =0; **Rarely** =1-2 times; **Often**=3-6 times; **Always** =7 times per week. Note that n=187 (53 are food secure using the CSI)

4.3.1 Short-term food security status domain of irrigation farming households

The food security status of the irrigation farmers within the week (current status domain) of data collection (which was at the inception of irrigation farming season of 2015) was estimated using the coping strategy index. This has an advantage over the freedom from hunger scale in that it gives the present picture of the food security status of the irrigation farmers. Table 19 shows that the percentages of the irrigation farming households that are food secure are lower than those that are food insecure. The result of the analysis further revealed three different categories of the food insecure most of which are moderately food insecure (53%). Previous studies have reported various percentages of food insecurity. For example, the study of Ibrahim, Bello and Ibrahim (2009), reported that over 58% of farming households in north central of Nigeria are food insecure; on the other hand, Lemma and Wondimagegn (2014) reported 63% food secure in a farming community and Ibrahim, Uba-Eze, Oyewole and Onuk (2009) established that 30% of urban households were food secure in Gwagwalada, North central Nigeria. Their reports are not too far from the findings of this research except that one expected that more of the farming households who are engaged in irrigation should be food secure. However, looking at factors that determined levels of food security among the irrigation farming households may give further explanations to the reasons.

Table 19: Food Security Status of the farming households in the last seven days

Food Security Status	**Frequency**	**Percentage**
Food Secure	53	22
Less Food Insecure	41	17
Moderately Food Insecure	126	53
Severely food Insecure	20	8
Total	240	100

Key: **FS** [CSI=0], **LFI** [CSI=1-15], **MFI** [CSI=16-30] and **SFI** [CSI >30]

4.4 Determinants of food security among small-scale irrigation farming households

The results of the ordered logit regression model are presented in Table 20. The overall model is highly significant ($p<0.01$) with a lower log likelihood of about -272.95561. This implies that the model is statistically reliable for the estimation of the coefficients of food security determinants investigated.The estimated cut-off points (μ) satisfy the conditions that $\mu1 < \mu2 < \mu3$. This implies that these categories (food secure, less food insecure, moderately food insecure and food insecure) are ranked in an ordered way (Knight *et al.*, 2005). The first cut-off point (Y=0 for "food secure group") was used as a reference for the purpose of comparison.

From the result, significant explanatory variables are: total farm output, the size of the farm cultivated by the household head, the years of farming experience, the distanceof the household's farm from the homestead and market, amount of credit accessed and the frequency of extension visit that the farmer has during the production season. However, the age of the household head and dependency ratio were not significant.

Table 20: Determinants of food insecurity among farming households

		FOOD SECURE		LESS FOOD INSECURE			MODERATELY FOOD INSECURE			SEVERELY FOOD INSECURE		
Variables	Coefficient	SE	P-Value	M E	S E	P-Value	ME	SE	P-Value	ME	SE	P-Value
Farm output	-0.000025	0.00010	0.018	2.13E-06	0.00000	0.020	-9.10E-08	0.00000	0.856	-5.95E-06	0.0000	0.013
Farm size	0.2185078	0.10835	0.044	-0.018142	0.00944	0.055	0.0007736	0.00417	0.853	0.50547	0.02471	0.041
House-hold size	-0.0663336	0.03835	0.084	-0.005507	0.00341	0.106	0.0002349	0.00124	0.850	0.0153448	0.00891	0.085
Experience	-0.0363358	0.01670	0.030	0.0030168	0.00154	0.049	-0.0001286	0.00068	0.849	-0.0084055	0.00389	0.031
Distance from home	-0.057926	0.01375	0.000	0.0048094	0.00152	0.002	-0.0002051	0.00108	0.850	-0.0133999	0.0032	0.000
Distance from market	0.0666967	0.03137	0.034	-0.005537	0.00286	0.053	0.0002361	0.00125	0.850	0.0154288	0.00729	0.034
Dependency Ratio	-0.2039543	0.59840	0.733	0.0169337	0.04978	0.734	-0.0007221	0.00447	0.872	-0.0471803	0.13832	0.733
Amount of credit	-6.70E-06	2.5E-06	0.009	5.56E-07	0.00000	0.022	-2.37E-08	0.00000	0.850	-1.55E-06	0.0000	0.010
Level of education	0.1252904	0.05591	0.025	-0.010402	0.00511	0.042	0.0004436	0.00234	0.850	0.0289832	0.01301	0.026
Age	-0.0134472	0.01571	0.392	0.0011165	0.00132	0.399	-0.0000476	0.00026	0.852	-0.0031107	0.00364	0.393
Extension contact	0.0985749	0.03421	0.004	-0.008184	0.00330	0.013	0.00034900	0.00184	0.850	0.0228031	0.00797	0.004
	Cut 1	-1.928501										
	Cut 2	-0.959233										
	Cut 3	0.103946										

SE: standard error; ME: Marginal effect

The marginal effects for the probabilities of farm households' food insecurity situation as "less food-insecure," "moderate food-insecure," and "severe food-insecure" as opposed to "food secure" are also presented in Table 20. Most of the variables have significant effect that ranged between ($p<0.01$) and ($p<0.10$) on food insecurity. Among the less food insecure rank, most of the variables have effects on food insecurity level with a level of significance ranging between ($p<0.02$ and ($p<0.10$). the marginal effects for some of the variables are negative while others are positive. The negative sign of the variables indicates that an increase in it will cause the level of food insecurity to decrease and vice-versa. The variables of farm output ($p<0.05$), experience ($p<0.10$), distance from home and amount of credit ($p<0.05$) and ($p<0.05$) respectively are all significant and positive. The implication of this is that the increase in the amount of total food produced will cause an increase in food insecurity among the less food insecure households. This is against the *apriori* expectation which stated the reverse (Babatunde, Omotesho and Solotan, (2007) and Ibrahim,Adeola and Ibrahim (2016)). One possible cause of this is that the food insecurity is low among members of this category (the "less food insecure") which are about 41% of the respondents and increase in food production is not causing a significant rise in their food security status but a rise in other household factors other than food. In the case of experience, the positive relationship it has with food insecurity might be due to the fact that in real life situation, their relationship is not an absolute linear one throughout the life time of the household head. A time is reached when additional years of farming experience does not translate to increase in farm output.

The variable of distance from home has an inverse relationship with food security implying that increasing it will affect the current food security status of the group by raising their food insecurity from the current rank to the next (moderately food insecure)

or beyond. Effective transportation system therefore has a way to improve on the food security status of the irrigation farmers. This is because when there is effective transportsystem, wastage is reduced; cost of transportation is reduced thereby increasing the amount of financial resources available to the household to spend on improving their food security status. As it is, most of the farmers dwell within treck-able distances from their farms. The amount of credit that the household got and used for the purpose of irrigation farming is also positive implying that it has the capability of reducing the level of food-insecurity among the households. The result for access to credit is also in line with that of Olagunju, Oke, Babatunde, and Ajiboye, (2012) and Ayantoye, Yusuf , Omonona, and Amao (2011) . If farming households have a more secure access to credit, they will be able to purchase improved inputs which will improve the productivity of the irrigation farming households in the study area.

Farm size ($p<0.10$), distance from market ($p<0.10$), level of education ($p<0.05$) and frequency of extension contacts ($p=0.050$) are all negative. An increase in the size of farm, all things being equal, is expected to reduce the food insecurity of the households in this category. This is expected because farm holdings and the output have a direct relationship. The distance from market is also a significant variable that determines the level of food-insecurity of households. Most of the irrigation farmers buy inputs and sell their produce in the market. Some of these produce are perishables and so the efficacy of the road transport systems have bearing on the amount of income that is available to the households after selling in the market. It shows that good roads and suitable means of transportation are necessary so as to reduce their expenses on transportation and the quantity of post-harvest losses due to transportation. Also, education and extension contact are expected to reduce food insecurity among the “less food insecure” category because they both are able to increase the output of farmers all things being equal.

For the "moderately food insecure" category, none of the variables is significant at ($p<0.10$). On the category of those who are "severely food insecure", the following variables are shown to reduce the level of food-insecurity among the households: farm output ($p<0.05$); household size ($p<0.10$); Experience ($p<0.05$); distance to market ($p<0.05$) and frequency of Extension contacts ($p<0.01$). The explanation for the farm output being able to reduce food-insecurity is supported by the findings of Babatunde, Omotesho and Solotan, (2007) and Ibrahim, Adeola and Ibrahim (2016) as it is in line with what the study expected. By virtue of the facts that the coefficients of the socio-economic variables considered here as independent variables are statistically different from zero when related to the different levels of food security, we reject the null hypothesis that there is no relationship between food security and socio-economic factors of the households in the area.

4.5 Representative Enterprise Combinations and Cropping System of the Irrigation Farming Households

Table 21 presents the distribution of irrigation farming household heads based on the crops they grow. The crops grown range from cereal and legumes to vegetables and spices. Rice and maize are grown by majority of the irrigation farmers in the area. Also, the cropping pattern of the farmers shows that the irrigation farmers practice sole cropping (58%) more than the mixed cropping system (42%). For the farmers practicing sole cropping system, managing the farm should be easier and that may inform the reason, why majority of the farmers in the area choose the sole cropping system. On the other hand, those who may have the objective of producing more crops that they eat will consider the mixed cropping system as a better choice. Chukwuji (2010) postulates that most times, mixed crop farmers are those who have limited access to finance to invest in farming and consequently grow a smaller area of hectrage and try to grow as many crops as possible in an attempt to maximize the satisfaction of their households. He

further stated that those who practice mono cropping are those who produce mainly for cash purposes. This however seem not to be the case among the irrigation farmers in the North-west Nigeria. Though they are small-scale farmers, they practice more of sole cropping than mixed cropping. This might be because many of them grow to sell and therefore grow their crops under more intensive system that requires close spacing. Recent studies like Ukeje *et al.*(2016) conducted in the southern part of the country have recommended mixed cropping system for raising food security and income generation levels of households.

Table 21: cropping activities of the household heads

Crop enterprises/Cropping system	Frequency	Percentage (%)
Sole maize	22	9.2
Sole rice	36	15
Sole tomato	12	5
Sole wheat	17	7
Sole onions	19	8
Sole pepper	17	7
Sole cowpea	17	7
Maize/Ground nut	14	5.8
Tomato/onions	10	4
Tomato/onions/pepper	14	5.8
Maize/cowpea	10	4
Wheat/Ground-nut	12	5
Onions/pepper	7	2.9
Wheat/pepper	9	4
Tomato/Pepper	11	5
Maize/Tomato	2	0.9
Maize/Rice	2	0.8
Maize/Tomato/Cowpea	1	0.4
Maize/Tomato/Onions	1	0.4
Maize/Tomato/Onions/Pepper	1	0.4
Maize/Tomato/Pepper/Cowpea	1	0.4
Maize/Tomato/Wheat	1	0.4
Rice/Tomato/Wheat/Onions	1	0.4
Tomato/Okro	1	0.4
Watermelon/Tomato	1	0.4
Wheat/Okro	1	0.4
Total	**240**	**100**

4.6 Farm Production Activities with Optimal Farm Plan Solution

The farmers who practice irrigation in the study area plant different combinations of crops in order to meet up with their food and possibly financial needs. An optimal farm plan is such that combination of enterprises that brings the best output and in the cheapest way possible. When this is achieved, the households have access to more food and income which reduces the food insecurity levels of the households. There are many crop combination activities (Table 21) but fifteen (15) prominent ones were selected (Table 22). These are those that were carried out by at least 5% of the respondents (Table 21). From the entire irrigation farms cultivated, an output of about 208, 311 GWE was realized per hectare. However, only five (5) of the crop activities entered into the optimal farm plan solution. The result presented on Table 23shows the list of the various crop combination activities carried out in the area and the recommended proportion of the optimal farm plan solution suggested to be devoted to each. Sole pepper has the largest proportion of 59% of the irrigable land area. Sole maize, sole tomato, sole wheat and sole cowpea have 5.8%, 15%, 1.7 and 18.5% to be devoted to it in the optimal farm solution respectively. It is noted that the sole crops mainly are the one that entered the optimal farm solution in the area. This implies that the sole cropping systems are better in the area than the mixed cropping in efficient and productive utilization of resources. This supports the findings of Ohikere and Ejeh (2012) In their study on impact of small-scale irrigation technology on crop production by fadama users in Kogi state. They found that out of four cropping pattern studied only one (sole rice) entered the optimal farm solution. However, according to Niragira *etal*., (2015),mixed cropping is a characteristic of peasant farming and they suggested that concentrating on those crops in which small holder farming households have

comparative advantages and trading produce and input with other farms can improve productivity.

Table 22: Optimal farm plan solution for crop enterprises.

Crop Activities (1)	**Value** (2)	**Percentage** (3)	**Existing activity level** (4)	**Optimum farm level** (5)
Objective function gross output= 514471.24 GWE				
Sole maize	0.34	5.8	88053.95	30305.26
Sole rice	0.00	0.00		
Sole tomato	0.90	15	85062.42	76191.54
Sole wheat	0.10	1.7	86696.00	9066.37
Sole onions	0.00	0.00		
Maize/G.nut	0.00	0.00		
Tomato/onions	0.00	0.00		
Tomato/onions/pepper	0.00	0.00		
Sole pepper	3.44	59	87093.60	299622.61
Maize cowpea	0.00	0.00		
Wheat/G.nut	0.00	0.00		
Onions/pepper	0.00	0.00		
Wheat/pepper	0.00	0.00		
Tomato/pepper	0.00	0.00		
Sole cowpea	1.09	18.5	91156.37	99285.45

The result shows that only sole maize, sole tomato, sole wheat, sole pepper and sole cowpea entered the optimal farm plan solution. This suggests that sole cropping is more excellent under the irrigation farming in the study area. That a majority of the crop production activities are mixed shows that the farmers aimed at satisfying their household food need and possibly to reduce the risk of crop losses as a result of crop failure but are not efficient.

To get the optimal farm solution, the farmers are expected to expand their farm size from the existing 3.30ha to about 5.87ha. There is possibility of expansion because there still exists, the irrigable farm lands that could be made available for cultivation in the

North-western Nigeria if the available facilities perform to full capacity. However, the implication of this is that there must be proportionate increase of other production resources used. For food crop production (cereals and legumes) only 26% of the total land area is to be cultivated while for vegetable crops (pepper and tomatoes) about 74% of the land should be devoted in order to maximize the output.

The overall value of the objective function in the optimal farm is 514471.24 GWE against 208,311 GWE of the existing farm. The resources required were 3.3 hectares of land, 700 Kg, 692 Kg and 33 Kg of NPK, urea and SSP respectively. Others include 408 mandays of labour (about 42% of which came from family labour and 58% from hired labour), about 5000 liters of water, 15 liters of herbicides, 9 liters of insecticides and 27 Kg of seed per hectare. This finding therefore leads to the acceptance of the null hypothesis that the representative farms are operating below the optimal farm. The output of the objective function of the planned farm is more than 50% above the output of the unplanned farm.

Comparing the existing farm activities with the proposed optimal farm levels, the result (Table 22) shows that for sole maize, sole tomato and sole wheat production, there is an increase of 57748.69 GWE, 8870 GWE and 77626 GWE respectively in the optimal farm plan. There is however a drop in the changes in sole pepper and sole cowpea production by 212528.4 GWE and 8129.08 GWE respectively. This drop might be due to the efficient resource allocation by the plan which has an overall output which outweighs that of the existing unplanned farm in the area.

According to the result of the available resources, slack and surplus variable presented on Table 23, Land was completely used up, land and therefore the most limiting factor when compared to other resource available and so the model suggested that more land

(2.74ha) should be added (with the restrictions on the other resources) for optimal performance. There was an unused NPK fertilizer of about 232.86Kg in the model out of the average of 700Kg available for irrigation farming in the area. Herbicides, insecticides, seed as well as hired labour were also limiting resources as they were completely used up. Increase in the use of any of these is likely going to increase the total farm output of irrigation farming in the study area. On the other hand, Urea is not a limiting resource and for the optimal farm plan, about 179 Kg more of it need to be injected into the system. There is a surplus of family labour of about 93 man-days. The shadow prices of herbicides, insecticides and seeds are all positive. This implies that an increase in the use of the production resources will increase the objective function.

Table 23: Slack/Surplus variables in the optimal farm plan

Resource	Average used	Unit	Slack/Surplus
Land	3.3	Ha	-2.74
NPK	700	Kg	232.86
Urea	692	Kg	-178.56
SSP	33	Kg	0.00
Family labor	171	Man-days	92.69
Hired labor	237	Man-days	0.00
Water	5050	Liters	494.13
Herbicide	15	Liters	0.00
Insecticide	9	Liters	0.00
Seed	27	Kg	0.00

4.7 Response of the Optimal Farm Plan to Variations in Farm Input Levels

The initial farm plan was subjected to two parametric models as shown in Table 24. The selection of NPK fertilizer and family labour was based on the fact that those resources were not completely used up in the initial optimal plan. The first model subjected the initial model into using up the entire surplus in both resources and the output was found to increase by 23% when NPK and family labour were increased by 50% and 85% respectively. This indicated that the percentage increase in the resource level is higher than that of the output level. Furthermore, in the second model, the initial quantity of

both NPK fertilizer and family labour were both doubled to have 100% increase in both the NPK fertilizer and family labour usage levels respectively and this time, there was only about 17% increase in the output level.

Table 24: Sensitivity models and levels of input usage of NPK fertilizer and Family Labour

Models	Changes in quantity of N:P:K Fertilizer (Kg) and Labour in Man-Hrs				Changes in output level (GWE)	
	Quantity of N:P:K	Percentage increase	Quantity of Labour	Percentage increase	Quantity of output	Percentage increase
Initial plan	467.14		78.31		514471.24	
1st Change	700	50%	171	85%	632799.33	23%
2nd change	1400	100%	342	170%	740375.216	17%

4.8 Major Constraints Faced by Irrigation Farmers in North Western Nigeria

The irrigation farmers in the Northwestern Nigeria are faced with a number of constraints that militate against productivity and enhance food insecurity. Based on the responses of the irrigation famers sampled, the following constraints were identified. The result is a s presented on figure 3.

Majority of the farmers (51%) said they face productivity constraint due to inaccessibility to credit facilities for irrigation farming. There are few of the farmers who were able to access informal loans but they complain of high interest rate on such loan facilities which could be as high as 30% interest rate. At such a high interest rate, profit making will be difficult for the farmers and that may eventually lead to loan defaulting. Another constraint faced by the farmers is input related. About 41% of the

farmers see this as a major problem. While some farmers said they cannot access inputs such as good seed varieties and fertilizers, others complain of delay in arrival of such inputs. There is a general complain of high cost of labour and fertilizer where they are available. Some of the farmers claim they do not have genuine inputs such as chemicals for production of crops during irrigation.

Poor market conditions and poor produce prices are problems to more than 35% of the irrigation farmers. Most of the markets are difficult to access due to (poor roads), no standard or guaranteed price for the farm produce, farmers have inadequate facilities and techniques for storage of perishable goods to get good market prices, no processing facilities for value addition, some of the major markets are far from the farmers making the farmers to be at the mercies of the middle men who come into the villages to buy directly from the farmers at the farm gates, glut, and lack of motivation in the prices of produce and the margin of profits that gets to the farmers. About 15% of the farmers experienced constant problem of water supply in irrigation farming. Those who are close to dam facilities complain about the dilapidated state of some of the irrigation structures such as broken canals, frequent breakdown of pumping machines of those who used motorized machines to lift water from the dams to their farm sites (because such services are not rendered by the dam managers because of breakdown of facilities). A secondary problem of conflicts is being created in areas where water supply is by gravity. Some farmers try to divert such water to their own farms thereby limiting the amount of water that gets to the other farmers down their own plots. This has been reported to lead to conflicts among the irrigation farmers where such is obtained. Poor irrigation facilities are reported to be a major problem by not less than 13% of the irrigation farmers in the study area. Absence of modern canals, high cost of maintaining

and fueling pumping machines, high cost of tractor hiring are problems that some farmers faced. Some farmers who want to open up more hecterage of farmland are reported not being able to do so because of lack of tractor hiring services in their area.

There is the problem of pest and diseases attacks (14%). Prominent complain in this category is the attack of grains by quella birds. This leads to great loss of the potential crop to be harvested. Other problems include straying grazing animals going to destroy crops on the irrigation farms (9%) (this is because during the dry season, there are green pastures close to the irrigation sites); inadequate extension services to the farmers (1%), soil fertility problems arising from salt accumulation, and bad road networks in communities that practice irrigation farmers. According to Dauda *et.al* (2009), factors militating against irrigation farming as reported by the farmers were lack of enough capital in form of soft loans (85%), lack of access to fertilizer as at when due (65%), unavailability of seeds (37%) and in adequate extension services (9%). It should be noted that some farmers reported more than one problem.

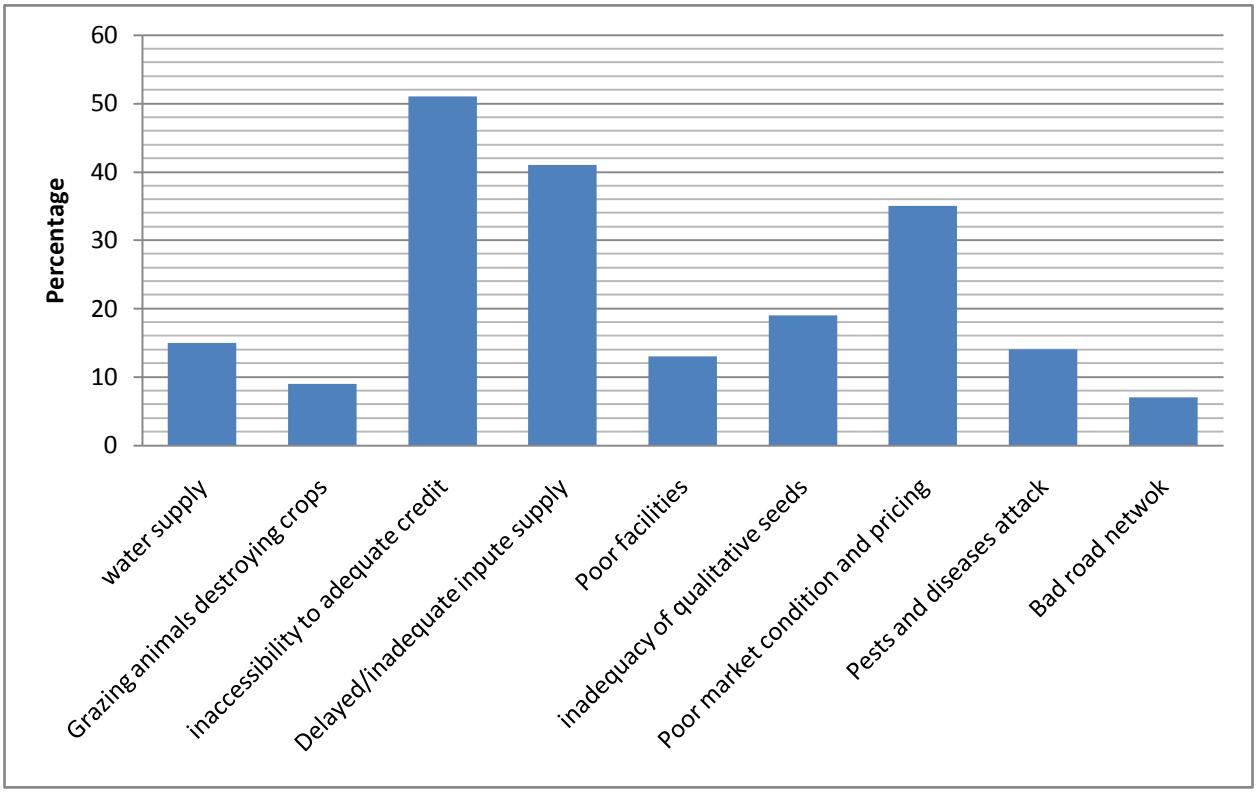


Fig.3: Major constraints faced by irrigation farming households in the study area

4.8.1 Suggested measures to mitigate the problems encountered in irrigation farming in the study areas

The following measures have been proposed by the researcheras ways by which the constraints encountered in irrigation farming can be reduced.

i. Farmers should be encouraged to from cooperative groups or strengthen the existing ones so that they can have stronger voice in making cases that will solve their challenges. Such will help them to easily access formal loans from the agricultural and commercial banks for irrigation farming. This will also facilitate bulk purchase of inputs for onward distribution to members of the cooperative when they pool their resources together.

ii. Relevant agencies like Bank of Agriculture (BOI) and Micro Finance Banks (MFBs) assigned with the responsibilities should do more work in monitoring

loan disbursement that is being announced to have been given to farmers to be sure that they are actually going to real farmers and not "arbitrary ones".

iii. As the government at all levels are focusing on the agricultural sector, research agencies and seed companies should be engaged and mandated to supply quality seed materials timely in different regions of the country. Specifically, the state governments in the north western Nigeria should collaborate and take up this challenge and engage researchers and seed companies for seed multiplication and supply to the farmers in the region

iv. Most of the irrigable farmlands in this region are yet to be opened up. Efforts should be made by the new government to invite investors in the agricultural sector to invest in and manage irrigation facilities. This will strengthen the sector and there will be a gradual transition from subsistence to commercial farming in the region and by extension in the country. This will handle the problem of water supply as investors will put in place necessary facilities for effective water distribution.

v. More extension agents should be trained so that they can assist the farmers through training so that they can handle such problems as diseases and pest attacks based on the recommendations of the researchers.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

The broad objective of this study was to examine the optimal crop combination and the food security status of households that practice irrigation farming in North Western Nigeria where the poorest of the poor in the country resides. In trying to achieve this objective, a multistage sampling procedure was engaged in selecting two hundred and forty households that practice irrigation farming in the study area and their heads were interviewed. In the first stage, four states in the region were randomly selected from the region. These states include Sokoto, Zamfara, Katsina and Kano. From the states, communities surrounding the dams where irrigation activities were notably carried out were noted and 240 farmers were selected (81 from Sokoto states, 59 from Zamfara, 44 from Katsina and 56 from Kano). Relevant information were gathered from the household heads using a well-structured questionnaire which was analyzed using descriptive and inferential statistics, freedom from hunger scale, food insecurity coping strategy index, ordered logit regression and linear programming.

The results show that most of the irrigation farmers are males, married (96%) and majority (37%) are within the age group of 41-50 years. About 60% of the farmers had formal education with many of them ending their formal education either in primary or secondary schools. Informal education (Quranic) is popular in the region. Majority of the farmers (83.8%) belong to a farmers' association or cooperatives. More than 58% of those who belong to association or cooperative however belong to only one group. Average household size is 12persons with 44% having household sizes ranging from 9 to 16. Majority of the household members are young within the ages of 1 and 15years. Most of the households members are not employed (showing that they are real

dependants). The average years of irrigation farming experience is 16.7 years showing that the farmers in the region are not new in the practice of irrigation farming. The presence of extension agents were acknowledged in the area but with very low frequency. Majority of the farmers do not have access to credit facilities while those who got sourced their facilities from informal sources like friends and money lenders with exorbitant interest rates. Most of the farmers have secondary sources of income (but farming is their main work). Houses and markets are averagely far from the irrigation farms. The average distance from homes and markets are 5.51Km and 11.54Km respectively. Majority of the farmers (54%) holds between 0.1 and 1.0 ha of irrigation farms showing that they are mainly small-scale farmers and most of them (58%) practice the sole cropping system.

Investigation of the food security status of the respondents outside the period of irrigation shows that majority of them are food insecure (54%) while those who are moderately food insecure and those who are food secure are 23% and 23% respectively. However, at the time when the process of irrigation is beginning using a shorter memory recall, the food security status of the respondents is a little different. About 22% are food secure and 8% of the respondents is severely food insecure; those who are moderately food insecure and those who are less food insecure are 53% and 17% respectively.

The determinants of food security among those who are food secure are: total farm output, size of the farm, experience and frequency of extension contact. For those who are less food insecure, the factors that are responsible for their food security status include total farm output, experience distance from market and the amount of credit accessed for irrigation farming activities. The size of farm, household size, distance of farm from the market and the frequency of extension visit are the main determinants

responsible for the food security status of the severely food insecure category of the irrigation farmers. The main coping strategies used by the irrigation farmers are: gathering of wild fruits, sending members to eat elsewhere, eating less preferred meals and reducing the quantity of meals taken per time.

The linear programing results show that only five (5) crop enterprise activities out of the fifteen (15) entered into optimal farm plan solution in the area. These enterprise activities include: sole maize, sole tomato, sole wheat sole pepper and sole cowpea. All these were found to be sole cropping system and having about 59% of the resources to be devoted to sole pepper production. The response of the optimal farm to changes in the levels of NPK and family labour shows a lower increase in output than in the levels of the inputs considered.

5.2 Conclusions

From the findings of this study, the following conclusions can be drawn:

i. The socio-economic variable of the households engaging in irrigation farming in the study North-Western Nigeria have significant influence on their food security status.

ii. Most households engaged in irrigation farming are food insecure (at different degrees). Their food security status is better when considered over the year than when considered at some short periods within the year.

iii. Existing crop production activities among the irrigation farmers in the study area operates far below the optimal level.

iv. The response of the optimal farm to changes in levels of inputs is positive, low and decreasing.

5.3 Recommendations

Predicating on the findings of this research, the following recommendations are hereby made:

i. Closer distance to homes and markets were variables found to favour food security. While building houses close to their farms may not be immediately feasible, providing effective transport systems will be an advantage. It is therefore recommended that loans be provided through cooperatives to help farmers afford mobility like motor cycles to ease their movement from home to the farm. This will also save time better than when they use public transport.

ii. Based on the findings of the linear programming analysis, farmers should be encouraged to concentrate on sole cropping instead of attempting to grow all crops needed in their households. This will allow for better performance and more efficient utilization of limited resources thus a greater output from which sales can be made in order to buy other things that the households need to be more food secure.

iii. There should be more effort to supply inputs to farmers timely and cheaper. This is not basically because farmers have no access to them but to encourage them to increase the farm sizes that they cultivate.

iv. Private investors should be encouraged through viable policies to invest in building irrigation facilities in the North-western region of Nigeria in order to take advantage of the vast untapped potential resources of irrigation for better food security level in the region.

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APPENDIX I (QUESTIONNIARE)

AHMADU BELLO UNIVERSITY, ZARIA

SOCIO-ECONOMIC ANALYSIS OF SMALL-SCALE IRRIGATION FARMING HOUSEHOLDS: FOOD SECURITY IN NORTH-WESTERN NIGERIA.

Dear respondents, the information to be collected from this interview is purely for research purpose only. All information provided will be accorded a high level of confidentiality. I therefore seek your sincerity in answering the questions accurately.

Thanks,

Researcher.

Information on Location:

State_____Village_____ Latitude_____
Longitude_____Altitude_____ Date_____

Time _____

SECTION A. Socio-Economic Characteristics Data

1. Gender: Male [ ] Female [ ] 2) Age……

3) Marital Status a) Single [ ] b) Married [ ] c) Widowed [ ] d) Divorced [ ]
4) What is your highest level of Education?
   a. Primary [ ]
   b. Secondary [ ]
   c. Degree [ ]
   d. ND/NCE /HND [ ]
   e. Masters/PhD [ ]
   f. Adult Education [ ]
   g. Quoranic Education [ ]

5. Are you a member of any cooperative/ Farmers' association? Yes [ ] No [ ]
6. If your answer to question five is yes can you state how many associations you belong to?_____
7. Household size (number of persons living in your household)_____
   (a) 1-15yr _____ (b) 16-60 yr _____ (c) > 60yr_____
8. Number of household members employed (have a source of income)……..
9. Number of household members unemployed (have no source of income…….

10. How long have you been practicing irrigation farming?
    _____Years

11. Have you ever had any contact with agricultural extension Agent? Yes [ ] No [ ]

12. If yes, how many contacts do you have in the last irrigation farming season_____

13. Do you have access to credit in the last irrigation farming season? Yes [ ] No [ ]

14. What way did you get the credit (a) Cash [ ] (b) Kind [ ] (c) cash and kind [ ]

15. What was the value of the credit?

    Cash ₦_____

    Kind (estimate) ₦ _____

16. What was the source(s) of the credit you received?

    (i) Commercial bank [ ] (ii) micro-finance bank [ ] (iii) friends and relatives [ ] (iv)Cooperative [ ] (v) village money lender [ ] (vi) Bank of Agriculture[ ]

    What was the interest rate of the money you borrowed (if any)____%

17. Do you have any other activities you do that bring in money for you? Yes[ ] No[ ]

18. What do you do? _____

19. How much do you make annually from the activity per month? ₦_____

20. How far is your farm from your home?_____Km

21. How far is your farm from the nearest market where you can sell your produce_____Km

SECTION B

22. In the last 12 months, which of the following best describes the situation in your household?

S/No	Items	Criteria (Binary Item)
1	We could not afford to eat balanced meals	Yes [ ] No [ ]
2	Did you or any other members of your household ever reduce the size of meals or skip meals because there was not enough food or money to buy food?	Yes [ ] No [ ]
3	Were you and your household members ever worried that your food will run out before you have food or money to buy more?	Yes [ ] No [ ]
4	Were you and your household members ever hungry but did not eat because you could not afford enough?	Yes [ ] No [ ]
5	Have you have had to eat same food daily over a period because you did not have varieties of food?	Yes [ ] No [ ]
6	Did you ever eat less than you felt because there was no food?	Yes [ ] No [ ]
7	Did you or any other household member stop eating for a whole day because there was no food?	Yes [ ] No [ ]
8	Did you rely on few kinds of low cost food because you did not have money?	Yes [ ] No [ ]
9	Did you ever comment that the food you bought did not last and that you did not have money to buy more	Yes [ ] No [ ]
10	Did you or any member of your household lose weight because food was not enough?	Yes [ ] No [ ]
11	I could not feed my children with balanced and enough meal because there was no enough food	Yes [ ] No [ ]
12	Which of the following describes your household food consumption during the past 12 months? Always have enough of what is required [ ] Have enough but not always of what is required [ ] Sometimes have enough food [ ] Often have not enough food [ ]	1= No 2-4=Yes

SECTION C

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

Coping strategies	**Frequency of usage (Days) during the dry season** **Never/ week =0,** **A day in a week= 1** **Two days in a week =2** **Three days in a week=3** **4 days in a week= 4** **5 days a week= 5** **6 days a week =6** **7 days a week =7**
Skipping of meals	
Eating less preferred meals	
Begging for food	
Food rationing or reducing number of meals	
Borrowing of food	
Purchase food on credit	
Reducing the quantity of food consumed	
Restrict consumption by adults to enable children eat	

Coping strategies	**Severity Code:** **Not severe=1, moderately severe=2** **Severe=3, Very severe=4**
Skipping of meals	
Eating less preferred meals	
Begging for food	
Food rationing or reducing number of meals	
Borrowing of food	
Purchase food on credit	
Reducing the quantity of food consumed	
E35th3qRestrict consumption by adults to enable children eat	
Consume seed stock held for next season	
Send household members to eat elsewhere	
Gather wild food (Fruits)	

PLOT NO:……CROP GROWN (Sole Crop/Mixed)_____												
FARM SIZE (Ha)												
FERTILIZER TYPE1……..QUANTITY USED…….(Bags) FERTILIZER TYPE 2……..QUANTITY USED…….(Bags) FERTILIZER TYPE 3……..QUANTITY USED…….(Bags)												
LABOUR USED	Family Labour						Hired Labour					
	Male		Female		Children		Male		Female		Children	
Activities	No of men	No of days	No of women	No of days	No of children	No of days	No of men	No of days	No of women	No of days	No of children	No of days
Land clearing												
Ridging												
planting												
Replanting												
1st Fertilizer application												
2nd Fertilizer application												
1st weeding												
2nd weeding												
Pesticide application												
Harvesting												
Threshing												

ANIMAL TRACTION				
Operation	No of yokes of animals	No of hours used/day	No of days used	Cost per day/Yoke (₦)

WATER USAGE			
VOLUME/DAY (LITRES)	No of Days per week	Total No of weeks that water was used	Cost of water/day (₦)

CHEMICAL USAGE					
HERBICIDES			INSECTICIDES		
Types	Volume (Litters)	Cost(N)/ Litre	Types	Volume Litters)	Cost (₦)/Litre
1.`			1.		
2.			2.		
3.			3.		

SEEDS USAGE			
Crops	Sources of seed (tick on No)	Quantity (Kg)	Cost (₦)/Kg
1	[1] [2] [3] [4] [5] [6]		
2	[1] [2] [3] [4] [5] [6]		
3	[1] [2] [3] [4] [5] [6]		
4	[1] [2] [3] [4] [5] [6]		
Code: Seed company=1, ADPs=2, Stocks from last harvest=3, from fellow farmers=4, Research Institutes=5, Local markets=6			

OUTPUT (Kg)				
Crop	Quantity Harvested	Quantity consumed	Quantity Sold	Quantity as gift	Cost (N)/Kg

24. What are your constraints in integrated irrigation farming?

(i)_____

(ii)_____

(iii)_____

(iv)_____

(v)_____

(Vi) _____

24. Make some suggestions on how the constraints can be handled

(i) _____

(ii)_____

(iii)_____(

iv) _____

(v) _____

(vi) _____

Thank you for your time

LINEAR PROGRAMMING OUTPUT SUMMARY

Title: Generated Tableau
Final Iteration No.: 7
Objective Value = 514471.24

Variable	Value	Obj Coeff	Obj Val Contrib
x1: X1	0.34	88053.95	30305.26
x2: X2	0.00	84752.70	0.00
x3: X3	0.90	85062.42	76191.54
x4: X4	0.10	86693.00	9066.37
x5: X5	0.00	84881.60	0.00
x6: X6	0.00	86656.79	0.00
x7: X7	0.00	91045.98	0.00
x8: X8	0.00	82183.60	0.00
x9: X9	3.44	87093.60	299622.61
x10: X10	0.00	89715.40	0.00
x11: X11	0.00	89518.09	0.00
x12: X12	0.00	44226.04	0.00
x13: X13	0.00	89479.60	0.00
x14: X14	0.00	84858.23	0.00
x15: X15	1.09	91156.37	99285.45

Constraint	RHS	Slack-/Surplus+
1 (<)	3.30	2.74-
2 (<)	700.00	232.86-
3 (<)	692.00	178.56-
4 (<)	550.00	0.00
5 (<)	171.00	92.69-
6 (<)	237.00	0.00
7 (<)	500.00	494.13-
8 (<)	7.20	0.00
9 (<)	9.00	0.00
10 (<)	27.00	0.00
UB-x1X1	6.00	5.66-
UB-x2X2	7.00	7.00-
UB-x3X3	8.00	7.10-
UB-x4X4	5.00	4.90-
UB-x5X5	6.00	6.00-
UB-x6X6	7.00	7.00-
UB-x7X7	8.00	8.00-
UB-x8X8	7.00	7.00-
UB-x9X9	6.00	2.56-
UB-x10X10	5.00	5.00-
UB-x11X11	4.00	4.00-
UB-x12X12	7.00	7.00-
UB-x13X13	8.00	8.00-
UB-x14X14	8.00	8.00-
UB-x15X15	9.00	7.91-

Sensitivity Analysis

Variable	Current Obj Coeff	Min Obj Coeff	Max Obj Coeff	Reduced Cost
x1: X1	88053.95	84881.60	124399.64	0.00
x2: X2	84752.70	-infinity	243497.68	158744.98
x3: X3	85062.42	73915.16	328899.78	0.00
x4: X4	86693.00	80337.18	358990.45	0.00
x5: X5	84881.60	-infinity	88053.95	3172.35
x6: X6	86656.79	-infinity	480846.88	394190.09
x7: X7	91045.98	-infinity	151537.09	60491.11

x8: X8	82183.60	-infinity	135661.69	53478.09
x9: X9	87093.60	34369.31	108300.45	0.00
x10: X10	89715.40	-infinity	705624.45	615909.05
x11: X11	89518.09	-infinity	493403.83	403885.74
x12: X12	44226.04	-infinity	165360.01	121133.97
x13: X13	89479.60	-infinity	392768.44	303288.84
x14: X14	84858.23	-infinity	441771.66	356913.43
x15: X15	91156.37	-1858.26	97790.17	0.00

Constraint	Current RHS	Min RHS	Max RHS	Dual Price
1 (<)	3.30	0.56	infinity	0.00
2 (<)	700.00	467.14	infinity	0.00
3 (<)	692.00	513.44	infinity	0.00
4 (<)	550.00	418.38	757.33	362.82
5 (<)	171.00	78.31	infinity	0.00
6 (<)	237.00	8.51	362.87	495.52
7 (<)	500.00	5.87	infinity	0.00
8 (<)	7.20	5.78	10.11	17895.29
9 (<)	9.00	4.26	12.78	7526.19
10 (<)	27.00	7.06	106.44	33.34
UB-x1	6.00	0.34	infinity	0.00
UB-x2	7.00	0.00	infinity	0.00
UB-x3	8.00	0.90	infinity	0.00
UB-x4	5.00	0.10	infinity	0.00
UB-x5	6.00	0.00	infinity	0.00
UB-x6	7.00	0.00	infinity	0.00
UB-x7	8.00	0.00	infinity	0.00
UB-x8	7.00	0.00	infinity	0.00
UB-x9	6.00	3.44	infinity	0.00
UB-x10	5.00	0.00	infinity	0.00
UB-x11	4.00	0.00	infinity	0.00
UB-x12	7.00	0.00	infinity	0.00
UB-x13	8.00	0.00	infinity	0.00
UB-x14	8.00	0.00	infinity	0.00
UB-x15	9.00	1.09	infinity	0.00

Key to enterprise activities

X1=sole maize
X2= sole rice
X3=sole tomato
X4=sole wheat
X5=sole onions
X6=maize/G.nut
X7=tomato/onions
X8=tomato/onions/pepper
X9=sole pepper
X10=maize/cowpea
X11=wheat/G.nut
X12=onions/pepper
X13=wheat/pepper
X14=tomato/pepper
X15=sole cowpea

APPENDIX III: Maize 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 Social and Economic Research (NISER), Ibadan, 1996.