THE IMPACT OF IRRIGATION SCHEMES ON FARMERS' INCOME AND LIVELIHOODS IN THE UPPER EAST REGION OF GHANA

BY

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DECLARATION

I, Ziba Daniel, do hereby declare that this thesis is my own work towards the MPhil. Agricultural Economics and that all sources or materials used in this thesis have been duly acknowledged.

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ABSTRACT

The study evaluated the impact of irrigation schemes on farmers‟ income and livelihoods in the Upper East Region of Ghana. A multi-stage sampling technique was used to obtain a sample of 120 irrigators and 60 non-irrigators. Propensity score matching (PSM) was used to analyze the impact of irrigation schemes on farmers‟ income with the help of logit to estimate propensity scores. The logit estimates indicate male farmers, large household size, cultivated land size, land acquisition, education, access to credit, access to ready market and access to extension services tend to increase farmers‟ participation in irrigation schemes significantly. Contrary, farmers with large farm size are less likely to participate in irrigation scheme. Estimates of average treatment of the treated (ATT) suggest that irrigation schemes is able to impact on farmers‟ income by GH₵ 1335.09 (US$ 4272.29) and GH₵ 1353.87 (US$ 4332.38) using the Nearest Neighbor and Kernel based matching algorithms respectively.

The Kendall‟s Coefficient of Concordance (***W***) result shows that the major constraints confronting irrigation schemes were high cost of inputs, credit, water shortage, land, marketing, labour, and pest and disease. Thus, it can be concluded that irrigation schemes enabled farmers to increase income, crop yield, minimize crop failure and enhance productivity hence poverty reduction. Finally, the study suggested for expansion of irrigated areas (small-scale, medium and large scale schemes), adoption of modern technologies and formulation of farmers‟ friendly policy**.** Also the study recommends that, farm inputs such as chemicals, seeds fertilizer, access to credit and financial assistance should be accessible to farmers as well as improve market access conditions and marketing infrastructure.

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DEDICATION

I dedicated this work to the Almighty God and to the entire Ziba family for tending me with love and for their wholehearted partnership in the success of my life.

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LIST OF ACRONYMS

ATT	Average Treatment of the Treated
ATE	Average Treatment Effects
FAO	Food and Agriculture organization
FGDs	Focus Group Discussions
GDP	Gross Domestic Product
GSS	Ghana Satistical Srvice
GIDA	Ghana Irrigation Development Authority
ICOUR	Irrigation Company of Upper Region
IFAD	International Fund for Agriculture Development
IFPRI	International Food, Policy Research Institute
IWMI	International Water Management Institute
KBM	Kernel Based Matching
MoFA	Ministry of Food and Agriculture
NGOs	Non–Governmental Organizations
NNM	Nearest Neighbor Matching
PSM	Propensity Score Matching
UER	Upper East Region

CHAPTER ONE

INTRODUCTION

1.1 Background

Agriculture is the mainstay of the majority of the population living in Sub- Saharan Africa. The greater part of this is rain-fed and susceptible to drought. The key constraint on further increase in agricultural production is the scarcity of agricultural water. Therefore, national planners are strongly attracted to irrigation as a means of supporting future food strategies. About 85% of Sub-Saharan Africa‟s poor live in the rural areas and depend largely on agriculture for their livelihoods. Yet agriculture in the region remains largely subsistence, production has not kept pace with population growth, food self-sufficiency has declined, the household income required to afford bought-in food has not been generated.

The occurrence of erratic rainfall has created uncertainty for agricultural production and emphasizes the need for irrigation. Irrigated agriculture in Africa is under renewed attention in relation to food security and poverty reduction. It is widely acknowledged to play a major role in improving productivity, reducing poverty and sustaining rural livelihoods (Hussain and Hanjra, 2004; Smith, 2004; van Koppen and Safilios-Rothschild, 2005). It enables households to generate more income, increase their resilience and, in some cases, transform their livelihoods (Tucker & Leulseged, 2010). Irrigation contributes to agricultural growth and reduce poverty directly by; (a) permitting intensification and diversification, hence increased outputs and incomes; (b) increasing agricultural wage employment; and (c) reducing local food prices.

In Ghana, agriculture accounts for approximately 22.7% of the country‟s GDP and employing 54% of its work force (GSS, 2012). Agricultural activities play vital roles through employment generation, poverty reduction, food security and enhancing the standard of living by increasing income levels of the rural population. The World Bank (2010) report that an increase in GDP derived from agricultural was average, 2.9 times more effective in increasing the incomes of the poorest in developing countries than other sectors. Irz *et al* (2001) estimate that for every 10% increase in farm output, there was a 7% reduction in poverty in Africa.

Agriculture has tremendous potential to reduce poverty and create employment for the rural poor since most are employed in it. However, this cannot be achieved without improving the agriculture water resources. Given that agriculture is largely rain-fed, irrigation water has become a very crucial resource in agricultural production, and poverty reduction. In East Asia and Middle East that have succeeded in poverty reduction have the greatest proportion of irrigated land. Poverty reducing impact of irrigation is substantial as evidenced in many Asian countries. For example, about 3540% of cropland in Asia is irrigated and poverty reduction in the 1970s was substantial (Hussain and Hanjra, 2003). Other Asian research findings consistently indicated that irrigation development reduces poverty in rural areas (Mellor and Desai, 1985; Chambers *et al*., 1989; Hossain, 1989; Hussain and Hanjra 2003). In Bangladesh and Nepal, irrigation has been an effective tool for reducing poverty, increasing cropping intensity, grain production, household incomes, waged labour employment and livelihood diversification (Angood *et al*., 2003, 2002; Hussain *et al*., 2004; Hussain and Hanjra, 2003; Madhusudan *et al*., 2002). Aside these, there are also stability effects in agricultural production because of reduced reliance on rainfall. Irrigation lowers the variance of yields, output, and employment (Diao *et al*., 2005;
Dhawan, 1988).

The economy of the Upper East region of Ghana is based largely on agriculture with about 70% of the population engaged in agricultural production. However, agriculture in the region is beset with a single and erratic rainfall pattern which leads to poor yield of crops. A progressive decline in the average level of rainfall has been observed (Assan *et al*., 2009). Dazé (2007) reports an estimated 74% decrease in rainfall by 2100. This worsens the poverty situation of the population. About 34% of the population of the region, which is rural, is food insecure; the highest in Ghana and an additional 13% is vulnerable to food insecurity (WFP, 2009). In this regard, Leahi (1988) points out that, areas with arid and semi-arid climates, the luck of uncertainty about rainfall would strongly be pointed to irrigation as a prime candidate to support future food strategies in the medium and long term. Similarly, Dessalegn (1999) suggests that, where rainfall is insufficient and unreliable, rain-fed agriculture cannot fully support food production, investment on irrigation will help stabilize agricultural production and promote food security. Thus rain-fed agriculture is no longer reliable for sustainable agricultural production in the region. Hence, the development of irrigation is crucial for sustainable agricultural production and for enhancing the rural livelihoods in the region.

1.2 Problem Statement

The Upper East Region is largely dependent on agriculture, a practice which 70% of the population engages in for their livelihoods (GSS, 2002). It contributes about 65% of household income (GSS 2005). Most of the agricultural production is by smallholders, who rely on seasonal rainfall that is unpredictable and sporadic. The onset of climate change, insufficient rainfall and occasional uncontrollable floods results in frequent crop failures which are having a serious effect on the livelihood of the population. As a result the population is extremely poor and food insecurity threatens every year. Although the region has two of the largest irrigation schemes in the country, it records a high prevailing poverty incidence. Also the two irrigation projects, Tono and Vea cover areas of 2490 and 850 ha respectively (ICOUR 1995) but is under utilised.

The yield level of major crops has either declined or remained where it was decades ago and is unable to match the population growth rate. As a result of this mismatch there is an increase in the level of poverty in the region (IFAD, 2001). According to Aryeetey and Kanbur (2008), the region is identified to have the worst cases of deprivation compared with others in the country. Indeed, it is more plausible that it has worsened (Dittoh, Bhattarai, & Akuriba, 2013). As a result rural households have adopted different coping strategies (e. g permanent and seasonal migration form part of these coping strategies). There is, however, evidence of great potential for irrigated agriculture to improve income and livelihood significantly. Irrigation is frequently cited as an innovation that can improve rural livelihoods, food security, and poverty reduction (Lipton, Litchfield, and Faures 2003; Bennin and Mugarura 2006; Polak and Yoder 2006). Also Rosegrant and Cai, (2001) emphasize that irrigation has enormous potential of irrigation farming to curb food insecurity and to release millions from chronic poverty.

In connection with this an irrigation led strategy has become paramount for regions where rainfall shortage is the most severe. As an interventional tool for increasing agricultural productivity and reducing rural poverty, the government of Ghana has used irrigation development strategies to promote irrigation farming (ICOUR 2007). The major justification for this is to improve food security, reduce rural poverty, improve rural livelihoods and stimulate the local economy in general. It is expected that, farmers involvement in irrigation schemes will ensure production of food allyear-round, improve on their income, livelihoods and reduce poverty and migration. However, the region still shows higher levels of poverty, unemployment, food insecurity. Living standards, literacy levels, health and nutritional status are all extremely low and well below the national average (Whitehead, 2006). According to ODI (2005), the region is the poorest and most food insecure in the country. Recent studies on poverty in Ghana by Diao (2005), indicates that poverty rate is very high and likely to remain high, if the past growth rates are projected into the future.

The Tono irrigation scheme with a water storage capacity of 93 million m^3 and 24000 ha of irrigable land is one of the largest irrigation scheme in West Africa. However, the region is able to produce 44% of its food requirement and the remaining 56% is imported despite the efforts to ensure the production of food all-year-round (MoFA, 2007). The various reasons assigned to explain this phenomenon lack clarity and therefore require investigation. Some studies have argued that, irrigation schemes have not produced intended results (Underhill 1984, 1990; Diemer and Vincent, 1992; Rukuni 1995, 1997; Machethe *et al*., 2004). World Commission on Dams (2000) confirms that irrigation schemes have typically fallen short of physical targets, did not recover their costs and have been less profitable in economic terms than expected.

Besides the effectiveness of irrigation investment, many empirical studies fail to find the impact of irrigation on household income, livelihoods and poverty reduction. In China, Hu *et al*., (2000) found that irrigation did not contribute to Total Factor Productivity (TFP) growth of rice between 1980 and 1995; Jin *et al*., (2002) extend their work to other crops and found no link between irrigation and Total Factor Productivity (TFP) growth of major grain crop; Zhu (2004) found that irrigation did not impact on the yield of wheat or maize between 1979 and 1997 which subsequently affected their poverty levels. Internationally, the record is mixed, studies in other countries frequently find insignificant effects or low returns of irrigation. Other studies have found positive effects (Bhattarai *et al*., 2002; Dhawan, 1988; Roy and Shah, 2003). For example, Bhattarai *et al*., (2002) found that irrigation increases cropping intensity and thus crop revenue per hectare in Vietnam, India and Sri Lanka. By extension, this has left questions into the minds of many as to whether irrigation has any impacts on household income and livelihoods. Hence, the study seeks to determine the impact of irrigation on farmers‟ income and livelihood in the region.

1.3 Research Questions

In order to address the above concerns, the study seeks to address the following questions;

1. Is there difference in profit margins between irrigating farmers and nonirrigating farmers?
2. To what extent do irrigation schemes impact on farmers income to ensure poverty reduction?
3. What is the level and nature of constraints confronting farmers in the study area?

1.4 Research Objectives

1.4.1 Main Objective

The main objective of this study is to examine the impact of irrigation schemes on farmers‟ income and the implications for poverty reduction in the Upper East Region.

1.4.2 Specific Objectives

Specifically, the research seeks to;

1. Examine the profit margins in irrigation faming to ensure poverty reduction
2. Determine the impact of irrigation schemes to farmers income to ensure poverty reduction

3. Identify and describe the level and nature of constraints confronting farmers in the study area

1.5 Hypothesis

Hull Hypothesis (H_0): There is no difference in profit margins between irrigators and non-irrigators using the gross margin analysis.

Alternative Hypothesis (H_A): There is difference in profit margins between irrigators and non-irrigators using the gross margin analysis.

Hull Hypothesis (H_0): Irrigation farming has no positive impact on farmers income to ensure poverty reduction in the region

Alternative Hypothesis (H_A): Irrigation farming has a positive impact on farmers income and plays a vital role in poverty reduction in the region

1.6 Justification for the Study

The study is significant in terms of its contribution to both theory and practice. The study addresses concerns expressed by various researchers regarding the lack of understanding about the impact of irrigation schemes on farmers‟ income and livelihoods. It is hoped that knowledge acquired through this study will contribute enormously to enhancing NGOs‟ role of building farmers‟ capacity to organize, generate and utilize resources more effectively. The results will also assist the civil societies/NGOs to carry out their roles of advocacy which will ensure that constraints faced by farmers are addressed.

1.7 Significance of the Study

The findings of the study are expected to provide inputs for policymakers, development practitioners, NGOs, farmers and researchers. The results of the study would;

- broaden farmers' understanding of irrigation farming and motivate the rural non-irrigating farmers to actively participate in irrigation farming to improve farm productivity and achieve food self-sufficiency.
- help policymakers, NGOs and development practitioners to design good irrigation strategies to improve the irrigation schemes. The findings of the study can also assist in identifying the constraints and alternatives to deal with the constraints.
- provide researchers important inputs for further investigation in the subject matter. For example, supervisors can induce their students to undertake their dissertation on irrigation related issues in order to solve food security problems at household level.
- may contribute additional knowledge to the existing literature through publishing papers, conference presentation or workshop organization.

It is also important to evaluate how irrigation schemes help in increasing agricultural production and its contribution to generate income, asset creation and improving the living standard of the rural households. In general, the significance of the study is that it attempts to provide realistic information on the overall issues of irrigation development in the study area and for formulating future strategies on irrigation investment.

1.8 Scope and Limitation of the Study

This research was undertaken to assess the impact of irrigation schemes on farmers‟ income and livelihoods in the Upper East region of Ghana. It is not possible for a study such as this to deal with all the aspects of irrigation, farmers‟ income and livelihoods. There are also limitations imposed by time and financial resources. The study has some limitations. Household survey by itself is complex and to get reliable data especially on household land holding, quantities of production, income, asssets as well as other variables which have close economic and social implications are not always free from error. Most farmers can only recall the most recent information and it was not possible to get previous data easily. From their past experiences, respondents in the study area expect other land distribution practice and have responded in a different way. As a result, they were reluctant to give information on their socio-economic status and they have often underreported what they have actually owned. However, different methods such as focus group discussion and informal interviews were used to crosscheck the data gathered through questionnaire adminstration.

Another problem faced during the data gathering was unavailability of the household heads in their home during most of the daytime since they were busy sowing. The only way of reaching the farmers was to visit them on their farms and they were not willing to spend required times on the interview. Moreover, transport facility and other necessary research inputs were major constraints in this research.

1.9 Organization of the Study

The study is organized into five chapters. Chapter one provides the introduction, problem statement, objectives, justification and scope of the study. Chapter two gives an overview of literature relevant to the study. Chapter three outlines the methodology employed to achieve the objectives of the study. In particular, it describes the study area, discusses the conceptual framework on the impact of irrigation on farmers income and livelihoods and the sampling techniques adopted for the data collection. Chapter 4 provides the descriptive statistics from the survey and discusses the empirical results. Chapter 5 provides a summary and the conclusions of the study as well as some suggestions for further research.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter presents concept of definitions, an overview of irrigation schemes in the Upper East region, and synthesizes the linkages among irrigation schemes, farmers income, livelihoods and poverty alleviation. Gross margin of irrigators and nonirrigators. Constraints that influence and affect irrigation farming are also discussed.

2.2 Definition of Concepts

According to (FAO, 1997) irrigation is "the supply of water to agricultural crops by artificial means, designed to permit farming in arid regions and to offset the effect of drought in semi-arid region". Mutsvangwa and Doranalli, (2006) defined irrigation as the cultivation of land through the artificial application of water to ensure double cropping as well as steady supply of water in areas where rainfall is unreliable. Irrigation water is applied to ensure that soil moisture is sufficient to meet crop water needs and thus reduce water deficit as a limiting factor in plant growth (Van Averbeke *et al.*, 2011). Irrigation is generally defined as the application of water to the land for the purpose of supplying moisture essential to plant growth. Irrigation is intended to augment the water supply from rainfall.

2.3 Evolution of Irrigation Farming

Irrigation is a very ancient agricultural practice which was extensively used by a number of early civilizations such as the ancient Egyptians, (Grove, 1989). Punnet (1982) argued that irrigation has been carried out for centuries around the globe and it started with traditional methods that supplied water for farming. Troeh *et al.*, (1980) reported that as early as 500BC the Egyptians cultivated land made fertile by the flood waters of the Nile River. By about 3000BC they had built Canal system that carried water from the Nile to their fields. This was after the realization that they had been recurrent droughts in Egypt and many dry parts could not reserve enough food for the whole year. Large irrigation systems also had been constructed by that time in parts of China, India and South-west Asia. According to Miller (1982), irrigation therefore facilitated the growing of crops in the flood areas to supplement food production. An increase in crop production every year as resulted it becoming the attracting feature for countries to increase irrigated lands. Recent years has seen an increase in the use of irrigation to facilitate in semi-arid regions. According to Andrew and Jackson (1996), between 1970 and 1990 the total irrigated land in the world rose from onesixth of all cultivated land to one-third.

2.4 Irrigation Development

Irrigation development is an intervention to provide and control the soil moisture regimes in crop root zone in order to achieve a high standard of continuous cropping. In areas where total seasonal rainfall is adequate on average, it may be poorly distributed or variable from year to year. Also rain-fed farming is a high risk enterprise, irrigation development helps to ensure stable agricultural production (FAO, 1997). Records date irrigation‟s beginnings to about a century ago, but serious irrigation efforts date to the past fifty years. Between its inception in the 1960s and the year 1980, approximately 19,000 ha of irrigated land had been developed. By
2007 the area in irrigation had expanded to 33,800 ha.

2.5 Success of Irrigation Development

FAO (1997) in a brief general overview of the irrigation schemes concluded that irrigation farming has brought success stories to farmers. The following observations were made:

- Farmers are now able to grow high value crops both for the local and export markets, thus effectively participating in the mainstream economy.
- In areas of very low rainfall, farmers can producing their own food instead of depending on food hand outs.
- Irrigation development has made it possible for other rural infrastructure to be developed in areas which could otherwise have remained without roads, telephones, schools and clinics.
- Smallholder irrigators have developed a commercial mentality.
- Crop yields and farmer incomes have gone up manifold.

Similar inferences were also highlighted in a study of irrigation schemes in the Gambia; Webb (1991) gave the following as some of the benefits of irrigation farming;

- Increased income that was translated into increased expenditure, investment, construction and trade.
- Backward and forward linkages: traders were reportedly coming to purchase produces and in turn sell cloth, jewellery and other consumer items.
- Increased material wealth.

2.6 Overview of Irrigation in the Developing Countries

Irrigation farming plays an important role in food production and food security in the world today. About 30% of the world"s food production comes from about 18% of the total cultivated land under irrigation (FAOSTAT, 2012). There are wide variations in the proportion of irrigated agricultural land in the developing world, with 37% in Asia, 15% in Latin America, 6% in Africa and 4% in Sub-Saharan Africa (FAOSTAT, 2012). Irrigation, therefore, currently plays a less significant role in

African agriculture compared to other regions as Africa‟s irrigated cultivated land is way lower than the world average. It is argued that Africa‟s poor performance in terms of poverty reduction can be to a large extent attributed to its less reliance on irrigation farming. It is estimated that irrigated agriculture in West Africa constitutes only 3% of the value of all crop production, with no evidence that this has improved over time (Dittoh, 1997). The differences across regions, countries and areas within countries in terms of irrigation access is an important factor in determining rates of poverty reduction. The fact that Asia has experienced significant poverty reduction, while poverty has increased in Africa (Faurès and Santini, 2008; Bacha *et al*., 2011) in recent years is no coincidence but an indication of the key role irrigation plays in poverty reduction *ceteris paribus*. Low levels of irrigation in Africa are as a result of high irrigation investment costs, perceived failures of past irrigation projects, limited government commitment, and poor rural infrastructure, and fragmented farmers, and crops with low water requirements (Inocencio *et al*., 2007; You *et al*., 2010). It is largely acknowledged in the literature that the Green Revolution in Asia could not have happened without investments in irrigation water (Lipton *et al*., 2003; Turral *et al*., 2010). Irrigation was an important element of the Green Revolution package which not only lifted large numbers of rural Asians out of poverty but also created conditions that were conducive for economic development. A similar development stragegies that Asian countries has been recommended for Africa. This is so, given that the potential of irrigation development for Africa is large (Inocencio *et al*., 2007; You *et al*., 2010). There is a need to prioritize irrigation development in Africa not only because of the existence of agricultural water resources, but also the high value of irrigated agriculture on the continent and the large number of rural poor that could benefit from high productivity as a result of irrigation investment.

Many countries in Sub-Saharan Africa, Ghana included, have realized the important role of irrigation in food production, and irrigation investments have increased in the region. You *et al.* (2010) reported that the average rate of expansion of irrigated area over the past 30 years was 2.3% in Africa. Total irrigated land in Africa is estimated to be about 12.2 million hectares and six countries, namely Egypt, Madagascar, Morocco, Nigeria, South Africa and Sudan account for nearly 75% of this total irrigated land (FAOSTAT, 2012). Despite some notable irrigation expansion, the developmental impact of irrigation in Africa has been limited and below expectations (Innocencio *et al.*, 2007; García-Bolanos *et al*., 2011).

2.7 The Impact of Irrigation Schemes on Livelihoods

According to Burrow (1987), irrigation schemes have proven to be a viable and attractive option for rural farmers in developing countries. He further asserted that returns from irrigated farming even on tiny plots could greatly exceed returns from rain-fed production. In many developing countries, irrigation schemes were counted on to increase production, reduce unpredictable rainfall and provide food security and employment to poor farmers. Gor Cornist (1999) stated that some of the irrigation schemes have been discovered primarily for income generating. It enables farmers to earn an income which enables them to meet some of their basic needs. According to Kundlande et al (1994), food production from irrigated farms is a major source of wealth creation to the extent that it is the basis for economic growth in a number of localities. A study in Zimbabwe shows irrigators investment was estimated to be between $150 and $200 while rain-fed farmers‟ investment was estimated to be lower than $100. This indicates that irrigators were in a better position to invest in capital items than non-irrigators because of higher incomes. Irrigation developments have made it possible for other rural infrastructure to be developed in areas which could otherwise have remained without roads, telephones, schools and clinics. According to Webb (1991), in Chenje et al., (1998) in the study of irrigation schemes in Chakuda Village in Gambia, irrigation schemes have resulted in increased income that was translated into increased expenditure, investment, and trade. Furthermore, irrigated agriculture is an essential component of any strategy to increase global food supply. It resulted in lower food prices, higher employment and a more rapid agricultural and economic development. Chitsiko (1999) also argues that irrigation schemes are important in augmenting government policy of reducing rural to urban migration. He noted that irrigation schemes provide a source of self-reliance, livelihoods and income to some young children who did not intend to move to town. These schemes helped in reducing rural-urban migration by offering rural population an alternative source of employment and income. Food security is likely to increase in households practicing irrigation farming. Chenje *et al.,* (1998) state that the aim of irrigation is to increase crop production and grow crops in areas where such an activity would normally be impossible due to lack of water. Irrigation schemes are viewed as a substitute for costly disaster relief by the governments. According to Kadzombe *et al.,* (1973), instead of importing food relief at a higher cost, farmers are assured of a constant source of food and income by establishing irrigation schemes.

2.8 Irrigation as an option in Agriculture Production

According to FAO (1996), yields per area, for most crops have increased between 100 to 400% as a result of irrigation. This has contributed to a reduction in food prices. For example the area under irrigation in India increased by 30% between 1970–1985, from 31.1 million hectares to 41.8 million hectares, whilst food grain prices fell by 20%

relative to the price index for all commodities. These reductions have a positive impact on incomes of the urban and rural poor. Irrigation is a key to developing high value cash crops, and by helping guarantee consistent production, and creates significant rural employment. According to FAO (1988), irrigation has put smiles in the face of many people in semi-arid and arid regions where crop production without irrigation is inevitable. In Egypt, 80% of the food requirement comes from irrigated lands (FAO, 1988). It has been possible to increase and protect harvest and grow crops that could not otherwise be cultivated under conditions of extreme drought. Irrigation increases the use of farm labour and income, eliminating the uncertainty that comes from variable yearly and seasonal rainfall (Oriola, 2009). It has made higher and more reliable yield possible, as crops can be planted more than once in a year within the tropics.

According to Shah (1993) as cited in IPTRID (1999), irrigation brings a range of benefits to individuals and households.

- Increased and more stable flow of income from farming by increased intensity of cropping, improved yields.
- Appreciation of the value of land with access to water for irrigation.
- Increased and more evenly spread farm labour opportunities and improved wage rates.
- Reduced out-migration and increased return migration.
- Improved security against impoverishment.
- Lower food prices and better nutrition throughout the year.
- Increase in non-farm employment.
- More water for non-agricultural uses, including domestic uses that improve health.

2.9 Impact of Irrigation to Household Food Security

In many drought prone countries, including Ghana, there has been an optimistic view regarding irrigation development as a strategy to sustain agricultural production and ensure food security. Therefore, national planners are strongly attracted to irrigation as a means of supporting future food strategies. In this regard, Leahi (1988) pointed out that for countries with arid and semi-arid climates, the luck of uncertainty about rainfall along with rising demographic pressure on rain-fed land would strongly be pointed to irrigation as a prime candidate to support future food strategies in the medium and long term. Similarly, Dessalegn (1999) suggests that, where rainfall is insufficient and unreliable, rain-fed agriculture cannot fully support food production, investment on water management schemes will help stabilize agricultural production and promote food security.

The need for irrigation development in drought prone regions is also promoted by many international development organizations. For instance, IFAD (1985) indicated that small scale irrigation schemes would stabilize agricultural production system and ensure food supply even in years with inadequate rainfall and increase the overall level of crop production in years with normal rainfall. Irrigation farming maximizes production with double or multiple cropping, taking full advantages of modern technologies and high yielding crop varieties. Moreover, it provides farmers an opportunity to grow high value crops like vegetables and fruits that require year round and generous supply of water to grow.

The available literature on the impact of irrigation farming in some African and Asian countries generally show that irrigators have been found in a better position in terms of income, food security, nutritional status and standard of living than rain-fed. For instance, in India Sing and Misra (1960) compared the Sarda canal irrigation and nonirrigating villages and made the following observation (FAO, 2000).

- Gross farm output per acre is on the whole 8.6% higher in the irrigated areas than rain-fed.
- The crop produce from the total farm output is 5.5% more with irrigated than rain-fed.
- The value of crop produce sold per acre is 48% higher in the irrigated area than rain-fed.
- Total inputs per acre are 3.7% higher in terms of quantity in the irrigated area than non-irrigators.
- Payment to outside labour, including casual and permanent farm labour is about 21% more in irrigated areas than rain-fed.

The above study clearly shows the benefits from irrigation in terms of improved crop productivity, income source and employment creation to the community and give better chance to ensure household food security. FAO (1997) also reported that farmers" incomes from irrigated agriculture are significantly higher than incomes from non-irrigating farmers.

2.10 Irrigation Development in Ghana

2.10.1 Brief History of Irrigation Development in Ghana

Historical accounts trace irrigated agriculture in Ghana to a little over a century ago (Smith, 1969). The first scheme that the government conceived was in 1920 as part of the then Winneba Water Supply Project (Smith, 1969). According to Agodzo and Bobobee (1994), some forms of shallow tube well irrigation could also be identified in South-Eastern Ghana in the 1930's. The 1950's and early 1960's saw the development of some water schemes in the Guinea, Sudan and Coastal Savannah belts which accounted for about 240 earth dams and dug-outs in the north and about 66 in the Ho-Keta plains of the south purposely to provide water for domestic use, livestock and for dry season farming (Agodzo and Bobobee, 1994). It was soon after independence in 1959 that the first national irrigation project, Dawhenya, was started but available records indicate that Asutsuare Irrigation Project was the first to be completed in 1967. Even though the records date irrigation in the country to about a century ago, it is clear that serious irrigation is a more recent phenomenon. The realisation of the role of irrigation in Ghana‟s agricultural development dates back to the 1960s. This was manifested in the Northern and Coastal zones of Ghana where a significant investment in irrigation infrastructure was made against the backdrop of drought conditions in these areas.

2.10.2 Brief History of Irrigation Management in Ghana

Irrigation has been managed by the Ghana Irrigation Development Authority (GIDA) which was established by SMC (Supreme Millitary Council) Decree 85 in April 1977. Since then, the development and management of irrigation has been in the hands of GIDA. The responsibilities of GIDA, according to the Decree which was later amended in 1987 (FAO, 1985; MOFA, 2006) are:

- to formulate plans for the development of irrigation;
- to execute comprehensive programmes for the effective use of irrigated lands in cooperation with the other agencies involved in providing extension services to farmers;
- to carry out land use planning in areas earmarked for development in order to conserve the soil and water resources in those areas;

- to layout the environs of each project area for housing purposes and for the provision of other social amenities;
- cooperate with other agencies for safeguarding the health and safety of all people living within and around irrigation project areas;
- undertake such other activities as are incidental or conducive to the discharge of its functions; and
- to develop the country‟s water resources for irrigated farming, livestock watering and aquaculture.

2.11 Classification of Irrigation Schemes

Classification of irrigation schemes into large, medium and small-scale is often applied with reference to area irrigated, scale of operation and type of control or management. However, the consideration of such criteria to draw the line between large and small scale irrigation varies considerably from country to country. For instance, in India an irrigation scheme of 10,000 hectares is small while in Ghana the largest irrigation scheme is 3,000 hectare (Smith 1998). In most cases, large scale schemes have formally been planned and are typically managed by government departments delegated with the necessary authority for fairly comprehensive control.

Most small-scale irrigation, however, has arisen indigenously or informally under local responsibility and operated and controlled by the local people in response to their local needs.

Irrigation projects in Ghana are generally categorised as small, medium or large based primarily on size. Sizes of up to 200 ha are regarded as small and anything greater than 1,000 ha as large with anything in between the two (200-1,000 ha) as medium. It is proposed that the level of management could be factored into the classification of schemes. For example, a small scale project must also be wholly owned and managed by the farmer or group of farmers. In the same vein, projects jointly owned and managed by the state through GIDA and farmers could be regarded as medium.

Irrigation schemes may also be classified into different types on the basis of some parameters like the level of technologies, sizes of irrigated farmland, structure, the number of users etc. For example, Koegelenburg (2006) classified irrigation based on water sources as groundwater and surface water. Mzembe (1994) identifies three types of irrigation in Malawi; surface irrigation, sprinkler irrigation and micro irrigation while Rahmani and Parvin (2009) also make a classification based on water sources in Bangladesh as surface and ground water. Irrigation schemes in Ethiopia are classified into small, medium and large scale using sizes of irrigated land, technology use and management (Hagos *et al*., 2009). Schemes are classified as small (less than 200 ha), medium (200 to 3,000 ha) and large scale (over 3,000 ha) schemes (Awulachew *et al*., 2005; Awulachew *et al*., 2007).

2.12 Irrigable Potential and Capacity Utilisation

The irrigation potential in Ghana is estimated to be in the range of 120,000–500,000 ha (Agodzo, Huibers, Chenini, van Lier, & Duran, 2003). Agodzo and Bobobee (1994) had earlier put the figure at over 500,000 ha. The total area under irrigation in 1996 was estimated at 11,000 ha (Kyei-Baffour & Ofori, 2006). This represents only 0.26% of the total land area under cultivation. The irrigated area since 1996 has largely remained the same (Memuna & Cofie, 2005). The FAO (2005) puts the current figure at over 1.9 million hectares. The scale of overall development has remained low. Capacity underutilization is a major problem in many existing irrigation facilities. The potential areas that can be developed in each of the public irrigation schemes are much higher than the developed or equipped areas. The net irrigated area of about 11,000 ha on some existing 22 GIDA irrigation schemes (Sant‟ Anna, 1997) is nowhere near the irrigable potential of existing projects.

Table 2.1: Irrigation capacity utilisation of Tono and Vea irrigation projects

Irrigation Projec	Irrigable Potential (ha)	Net Irrigated (ha)	Capacity Utilisation (%)
Tono	2632	800	30
Vea	1417	400	28
Total	4049	1200	30

Source: (ICOUR)

2.13 The History of Irrigation Development in Upper East Region

Formal irrigation was introduced to the Upper East Region in the early 1950s when small dams were built for livestock, vegetable production in the dry season and for soil conservation. The government agency, GIDA, built and operated these schemes on behalf of government. At present, there are two large scale irrigation schemes, namely Tono and Vea in the Region. The Tono and Vea dams have irrigable areas of 2,638 ha and 1,417 ha but operate far below their capacities at about 30% and 28 % utilisation capacity, respectively (ICOUR, 1995). The project is being managed by ICOUR.

The history of irrigation and reservoir construction in the Upper East region goes back to the pre-colonial times. During those times traditional irrigation systems, constructed with local technology, controlled and managed by local people in response to their felt needs, have been in practice in most parts of northern Ghana (Ayariga 1992). After independence expansion of irrigation schemes was proposed to facilitate the production of grain and cash crops to raise the standards of living of the people and to turn northern Ghana into one of the largest grain baskets of the nation (Konings 1986). In general, there are four types of irrigations systems in the area namely: (i) large scale irrigation systems (ii) small-scale irrigation systems (iii) smallscale pump systems and (iv) traditional systems. The large and small-scale irrigation systems are the dominant systems, with the small-scale (reservoir and dugout) being the most prominent.

The construction of most of the schemes were supply driven, regardless of whether interested smallholder farmers and with irrigation experience were available and willing to cultivate them. The major justification for introducing irrigation schemes to the region was to improve water productivity, to increase food production, so as to improve food security, reduce rural poverty and improve rural livelihoods in general. The plan for irrigation systems was triggered by food shortages in the region as a result of serious droughts in the region (GSS, 2000). The implicit view was that the peasantry food production in the region would be complemented by irrigation schemes to project food productions (Liebie 2002). The purpose of developing these irrigation schemes by the government of Ghana was to;

- improve food security by increasing productivity;
- increase crop yields through improved agrochemical practices; and
- reduce rural-urban migration by providing employment opportunities for the youth.

2.14 Irrigation-Productivity Linkage

Literature that examines the impact of irrigation on agricultural production, household income, rural livelihoods and poverty are mixed. Rosegrant and Everson (1992) could not establish a positive impact of irrigation on productivity in India. Similarly, a study by Jin *et al*., (2002) also did not find an impact of irrigation and the total factor productivity growth of any major grain crop in China between 1989 and 1995. Empirical study conducted by Berhanu and Pender (2002) in Tigray Region, Ethiopia showed that the impacts of irrigation schemes on input use and the productivity of farming practices were insignificant. They indicated that irrigation schemes have limited impact on the use of fertilizer and improved seed leading to less gain productivity from irrigation. However, there are a number of studies in different countries that show evidence that irrigation schemes have served as the key driver behind growth in agricultural productivity and increasing household income and poverty alleviation (Lipton *et al.*, 2003). There are four interrelated mechanisms by which irrigated agriculture can increase; increasing production and income, and reduced food price, that helps poor households meet the basic needs and improve welfare, protecting against the risks of crop loss due to erratic, unreliable or insufficient rain fall, promoting greater use of yield enhancing farm inputs which creates additional employment, which together enables people to move out of the poverty cycle. Irrigation farming has a strong multiplier effect on other sectors of the economy (Ali and Pernia, 2003). Narayamoorthy (2001) reports that besides

increasing the cropping intensity and productivity of crops, the intensive cultivation of crops, access to irrigation increased the demand for agricultural laborers and wage rates. Shah and Singh (2004) found that, in India more irrigation means fewer people below the poverty line. FAO (1996) suggests that in developing countries, irrigation can increase yields of most crops by 100 to 400%, while also allowing farmers to reap the economic benefits of growing higher value cash crops less risky, more continuous and higher levels of rural employment and income for both farm families and landless laborers. Binswanger and Quizon (1986) found that in India the effect of expanding the irrigated area by 10% of the rural poor, resulted in an aggregate output increase by 2.7% and a decrease in the aggregate price level by 5.8%. With a secure water supply, farmers can choose to invest in higher yielding seeds, grow higher value crops.

A study by Haile *et al*., (1996) using farm level data collected from 324 households in Nepale also indicated that drip irrigation has generated a significant positive effect, increasing the onion yields and overall farmers‟ incomes. An average yield of drip irrigation owners was increased by 86% when compared to rain-fed farmers. The net income of irrigator exceed that of the rain-fed farmers by $69 per hectare, which has an obvious effect on the ability of the farmers to increase the production and sustained livelihood strategies.

2.15 Irrigation Impact on Household Income: Evidence from Empirical Literature

The evidence from international literature on the role played by irrigation schemes on household income presents a mostly positive picture. Whereas few studies such as Jen *et al*. (2002) found an insignificant impact of irrigation and input use or productivity of farming practices, there are a number of studies in different countries which show that irrigation has served as the key driver in increasing household income and alleviating rural poverty (Hussain *et al*. 2006; Namara *et al*. 2008; Dillon, 2011; Kuwornu and Owusu, 2012). Gebregziabher *et al*. (2009) and Kuwornu and Owusu (2012) evaluated the impact of access to small-scale irrigation on farm household welfare using the propensity score method (PSM). According to Gebregziabher *et al*. (2009), the average income of non-irrigating households was less than that of the irrigating households by about 50% in Ethiopia. The study also found that farm income is more important to irrigating households than to nonirrigating households, and off-farm income was negatively related with access to irrigation. Kuwornu and Owusu (2012) concluded that irrigation investment in Ghana is justified due to significant irrigation contribution to consumption expenditure per capita in farm households. Dillon (2011) investigated the impact of small-scale irrigation investments on household consumption, assets and informal insurance in Mali using both PSM and the matched difference-in-difference method. Both estimation methods confirmed the positive role played by irrigation schemes on household consumption and asset accumulation. Hussain *et al*. (2006)

evaluated the impact of small-scale irrigation schemes on poverty alleviation in Pakistan using descriptive statistics. The study found that poverty levels were higher in rain-fed than in irrigated areas. For example, poverty head count ratio was found to be 37% in rainfed areas, compared to 29% in irrigated areas. Interestingly, the study found that poverty head ratio was even much lower 23% in areas that practiced both irrigated and rain-fed farming. Namara *et al*. (2008) studied the role played by access to irrigation on income, rural poverty and inequality in Ethiopia using the logistic regression model. As expected, the poverty incidence, depth and severity values were lower for farmers that had access to irrigation compared to the non-irrigators. Tesfaye *et al*. (2008) and Bacha *et al*. (2011) both assessed the impact of irrigation farming on household welfare in Ethiopia using the Heckman"s two-step estimation procedure.
Both studies observed significant welfare differences between irrigators and nonirrigators, and concluded that access to irrigation had played a part in those observed differences. Tesfaye *et al.*, (2008) found that about 70% of the irrigation users were food secure while only 20% of the nonusers were food secure in Filtino and Godino irrigation schemes in Ethiopia.

A study by Fanadzo (2012) suggusts that irrigation schemes in South Africa have failed to bring about the expected social and economic development in rural areas. However, these studies were gross margin or correlation analysis (Yokwe, 2009; Hope *et al*. 2008). Van Averbeke (2012) investigated the factors that contribute to differences in the performances of smallholder irrigation schemes in Vhembe district in South Africa. Although arguing that smallholder performance has been below expectations, gross margin analysis by Yokwe (2009) and Hope *et al*. (2008) indicated that irrigators have somewhat greater gross margins per ha compared to non-irrigators. For the Zanyokwe and Thabina irrigation schemes, Yokwe (2009) found greater gross margin per ha among irrigators for all the crops that were included. Hope *et al*. (2008), however, found that irrigation schemes provide expected incomes and food for those plot holders with irrigation access. The study conducted by Tekana and Oladele (2011) using the OLS procedure, concluded that irrigation plays a central role in the improvement of household income, rural livelihood and food security.

2.16 Impact of Irrigation on Household Income

Irrigation water is a critical production input in agriculture. Irrigation directly impacts on household incomes by increasing farm revenues. There are two ways through which irrigation increases farm revenues. Firstly, it increases annual revenue per acre of land through its direct positive effect on total crop production in a given cropping season. Irrigation enhances the use of agricultural inputs (such as fertilizer and high yielding varieties), which, in turn, improves the productivity of land (Gebregziabher *et al*., 2009). Moreover, irrigation water reduces crop yield variability, hence stabilizing household incomes (Tyler, 2007; Namara *et al*., 2008). This induces the possibility of double cropping. Irrigation benefits the landless through higher wages as it results in higher marketed surpluses and increased jobs opportunities (Jin *et al*., 2012). Moreover, irrigation benefits the poor as it may lead to lower food prices since they spend a disproportionally large share of their income on food.

2.17 Negative Impact of Irrigation Schemes

The negative effects of irrigation are the environmental impacts of irrigation schemes. The construction of some irrigation are associated with particular environmental problems such as loss of natural habitat. Generally, irrigation schemes have also further detrimental impacts on the environment beyond the construction phase. Water loss through unproductive evaporation, seepage and percolation, possibly inducing problems of waterlogging and salinization have been found to be important potentially negative consequences of irrigation. The biggest negative impact is via water-related diseases, especially malaria. For example, when the Karnataka Irrigation Project was approved in 1978, the river valley was malaria free, yet owing to massive vegetation which choked drainage canals, and seepage that caused pools of standing water malaria returned (Jones, 1995). There is often inadequate baseline data from which to make accurate assessments of project impact over time (Kerr and Kohlavalli, 1999). There appears to be information on differential exposure and susceptibility to water-related diseases but it seems likely that those living and working closest to surface water irrigation sources will face higher risks. If these people form a large proportion of the poor, and this too seems likely, then the poor may bear the brunt of the negative health impacts. However, irrigation may also have positive impacts on health. Higher yields and lower prices mean greater calorie and micronutrient availability to households; higher incomes, whether through output increases or increased demand for labour, mean more resources are available for prevention of disease, through safer and better storage and preparation of drinking water and food, and resources for prompt, appropriate health care (Lipton and de Kadt, 1991). These positive effects are likely to be felt by the poor only to the extent that their yields, outputs and incomes rise with irrigation farming. If the irrigation technology bypasses the poorer residents and workers in the area, or they are excluded because they are tail-enders in a non performing system or they do not have adequate access to the decision-making institutions that control water use and distribution, then they will only experience the negative impacts.

2.18 Irrigation and Food Security in Upper East Region

In the Upper East Region, farmers produce insufficient amounts because of erratic rainfall, and as a result the government has given great attention to irrigation as a means to ensure food security and poverty reduction. Access to irrigation schemes is a major tool for agricultural growth and poverty reduction (Norton et al., 2010). This implies that investment in irrigation can increase farmers‟ independence on rainfall, it generates employment, promotes farmers to produce two or three times in a year and use more of fertilizers. Irrigation schemes in developing countries were considered as a means of increasing production, reducing the dependence on rainfall and provides employment to the poor (Chazovachii, 2012). It increases land productivity, crop yields, fertilizers, enables diversification and market oriented products (Eshetu, 2010), which positively affect households‟ diet, incomes, health and food security (Torell and Ward, 2010). Hence irrigated agriculture is accepted as essential in increasing land productivity, enhancing food security, earning higher and more stable incomes, as well as encouraging multiple cropping and crop diversification (Smith, 2004).

2.19 Irrigation-Poverty Alleviation

Irrigation farming is one of the most important rural development investments that can have both direct and indirect impacts on poverty and food security in semi-arid tropical countries (IFPRI, 2002; Bhattarai and Narayanamoorthy, 2004). The concentration of poverty in the rural parts of the country, focusing development efforts to the rural parts has for long been recommended as a poverty alleviation strategy (Abdulai and Delgado, 1995). Irrigation was particularly an important technology that enabled achieving food self-sufficiency in large parts of Asia, therefore it is also perceived as an appropriate development strategy particularly for the semi-arid areas. Irrigation had a strong inverse relationship with rural poverty in India. (Jimenez, 1995 as quoted by (Sawada and Shinkai, 2003) after summarizing various studies across 58 countries showed that irrigation contributed much more than any other rural infrastructure investment. In general, irrigation technology played a central role in increasing calorie availability per person and ultimately avoiding widespread famine (Carruthers *et al*., 1997; IFPRI 2002). In most parts of subSaharan Africa, increased agricultural production constitutes one of the most strategic ways towards poverty reduction, and investment in irrigation development can be a springboard for economic development and poverty reduction (Faurès *et al*., 2007).

For instance, China‟s rural poverty fell from 31.6% in 1978 to 2.3% in 2006 through agriculture (NBSC, 2006). Up to 40% of China‟s cropland is irrigated (Hays, 2008). Investment in irrigation infrastructure constitutes an important poverty reduction strategy since it would boost agricultural productivity by reducing the risks associated with the rainfall unreliability in arid regions.

2.20 Definitions of Livelihoods

The word „livelihoods‟ commonly means the way someone earns or means of living (Oxford dictionary). A livelihood "comprises the assets (natural, human, financial, and social capital), the activities and the access to these (mediated by institutions and social relations) that together determine the living gained by the individual or household" (Ellis, 2000). A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base‟ (DFID, 1999; Chambers & Convey, 1992). Whereas, not all households are the same in their capacity to cope with stresses and repeated shocks, Maxwell and Smith (1992) argue that poor people balance contending needs for asset preservation, income generation, present and future food supplies in complex ways.

2.20.1 Livelihoods Outcomes

Livelihood outcomes: these are the results attained from the livelihood strategies through the effective combination of the livelihood assets.

2.20.2 Categorization of Livelihood Activities

According to the livelihoods framework, livelihood activities are usually considered to generate an income (DFID 2001). The categorization of livelihoods are income sources (Hussain *et al*,. 2002, 2007), culminating in the following five categories: (i) paddy cultivation (rice crops), (ii) non-paddy cultivation (all non-rice crops including maize, vegetables), (iii) natural resource related livelihoods (incomes from fishing and cattle rearing), (iv) agricultural wages), and (v) all other non-farm livelihood activities (non-farm income from trade, self-employment and shop keeping). As explained in Hussain *et al*. (2007), in a rural setting in Sri Lanka, as is typical to the one in this study, households engage in multiple livelihood activities, (i.e., derive income from multiple sources that are both agricultural and non-agricultural). Scoones (1998) mentioned that the ability to pursue different livelihood strategies is dependent on the livelihood assets that people have in their possession. The institutional economic and environmental changes have an impact on the livelihood strategies of rural households in Northern Ghana, with their main source incomes from agricultural production. Although agriculture still represents the main economic activity in the area, survey data show an increasing diversification into nonfarm activities and migration (Assan *et al*. 2009).

2.20.3 Rural Household Livelihoods

According to Ellis (2000) a livelihood is defined as the assets, the activities and the access that determine the living gained by the individual or household. Chambers and Conway (1992) cited by Ahmed and Lipton (1997) define livelihood as the ways in which people satisfy their needs or gain a living. According to Ahmed and Lipton a livelihood should be seen as a set of flows of income, from hired employment, selfemployment, remittances or (usually in developing rural areas) from a seasonally and annually variable combination of all these. They further stress that a livelihood should be able to assist those involved to avoid poverty, and preferably, increase well-being of the concerned person and his/her dependents. Hann and Zoomers (2005) have emphasized the importance of looking at livelihoods in a much broader way. They argue that a better understanding of livelihoods in a holistic way is critical in addressing poverty and the general livelihoods approach.

2.21 Irrigation and Household Livelihoods Linkages

Many studies have argued that ensuring farmers‟ access to irrigation is important for poverty reduction and achieving household food security in developing countries (Hussain and Hanjra, 2004; Molden *et al*. 2007; Gebregziabher *et al*. 2009; Muller *et al*. 2009). Irrigation is an essential part of the package of technologies, institutions and policies that underpins increased agricultural output. Thus, as a production input in agriculture, irrigation water is an important socio-economic good, with a positive role in poverty alleviation (Hussain and Hanjra, 2004). However, Hussain and Hanjra (2004) warned against perceiving access to irrigation alone as the solution to all rural poverty problems. Instead, irrigation farming should be understood as forming part of a broader livelihood strategy (which also includes non-farming projects) among the majority of rural people (Van Averbeke and Mohamed, 2006). Hussain and Hanjra (2004) highlighted that, even though irrigation water is only a single element in the poverty equation, it plays a disproportionately dominant role. Hussain and Hanjra (2004) discussed in detail the main pathways through which access to irrigation reduces poverty. Access to irrigation enables farmers to adopt new technologies and intensify cultivation, leading to increased productivity, and greater returns from farming.

However, it is not just participation in an irrigation scheme that results in these positive effects, but access to reliable irrigation water. As was concluded by Hope *et al*. (2008), participation in an irrigation scheme although a necessary condition is not sufficient to ensure improved household livelihoods**.**

2.22 Impact of Irrigation Schemes on Rural Household Livelihoods

The importance of irrigation to rural livelihoods is highlighted by the fact that irrigated farmland provides 43% of global cereals production and 60% of the grain production in developing countries (IWMI 2000). Of the near doubling of world grain production that took place between 1966 and 1990, irrigated land (working synergistically with high-yielding seed varieties and fertilizer) was responsible for 92% of the total production. Irrigation is also the key to developing high value cash crops, and, by helping guarantee consistent production, it stimulates agro-industry and creates significant rural employment (World Bank, 1997). Robert Chambers, a pioneer of livelihoods approaches, argued that the generation and support of livelihoods has a higher priority than production per se (Chambers 1988). He emphasized that the impact of irrigation on the rural poor depends on who produces the food and who has the ability to obtain it, on who gains and who loses more generally. Generally, the poor gain from irrigation through increased employment and income, improved food security against impoverishment, less out migration and in improved quality of life. In irrigated agriculture there are four inter-related mechanisms which have the potential to enhance and sustain rural livelihoods. These include: improvements in the levels and security of productivity; employment and incomes for irrigating farm households and farm labour; the multiplier effects of irrigation schemes for the wider economy; increased opportunities for rural livelihood diversification; multiple uses of water supplied by irrigation infrastructure.

Thus, irrigation water is an essential resource in meeting subsistence needs of the rural poor and for any livelihood activity. In particular, irrigation schemes was substantial for the rural poor in order to: diversify farming and non-farming activities and cope with seasonality of income; food security of the rural population; make savings; get benefits and salary from employment. Studies by (Bhata, 1997; Dinar and A. Subramanian, 1997; Hussain and Hanjra, 2002) suggest, that access to irrigation water is essential for domestic purposes, such as laundry, washing, bathing and cleaning.

2.23 Constraints in Irrigation

Rukuni *et al*., (2006) state that a number of problems have befallen irrigation schemes such as poor marketing arrangements, limited access to water, inability to meet operational costs due to poor fee structures, financial viability and poor governance. Gyasi *et al*., (2006) state that in many countries, institutional weaknesses and performance inefficiencies of public irrigation agencies have led to high costs of development and operation of irrigation schemes. Poor maintenance and lack of effective control over irrigation practices have resulted in the collapse of many irrigation systems.

The FAO (1997) report identified a number of constraints in irrigation schemes in Zimbabwe. These are; high cost of capital investment, poor of rural infrastructure to facilitate input procurement and produce marketing, lack of appropriate irrigation technology for the farmers, shortage of human resources at both technician and farmer levels, poor catchment management, lack of decentralized irrigation service companies to give back-up service in rural areas.

FAO (1997c) further identified the following constraints to be affecting the capacity of farmers to invest and manage irrigation projects in Zimbabwe:

- Poor resource base of farmers;
- Fragmented and small size of land holdings;
- Unsecured or lack of land titles;
- High interest rates; and
- Poor transportation and marketing facilities.

In support of the above inferences, Webb (1991) further pointed out that some of the irrigation schemes collapsed in Gambia because of the following reasons:

- Frequent pump breakdowns due to poor operation and maintenance;
- Poor design of canal structures;
- Pest infestation of crops; and
- Periodic fuel shortages.

FAO (1997c) pointed out that many Sub-Saharan countries have realized the critical role of irrigation in food production, but a number of constraints have been responsible for a relatively slow rate of irrigation development in the region. The constraints are:

- Relatively high cost of irrigation development
- Inadequate physical infrastructure and markets
- Poor investments in irrigation
- Lack of access to improved irrigation technologies
- Lack of cheap and readily available water supplies

According to (Namara *et al*., 2011) most of the constraints observed are common to all forms of irrigation schemes. The major constraints can be grouped into six major areas:

- financial and institutional issues;
- access to Inputs and Services;
- output marketing and post-harvest handling or value additions;

- technical constraints; ➢ biophysical constraints; and
- labour availability.

CHAPTER THREE

STUDY AREA AND RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents a description of the study area and the research design used in the study. It also considers the population of the study, sampling techniques and sampling size, and data collection procedures, types of data and methods of data analysis. The first section discribes the geographic location, Bio–Physical features, demographic structure and economic activities of the study area. The second section deals with the methodology, highlighting on the techniques‟ and data collection methods used.

3.2 Description of Study Area

The UER is the least urbanized in the country with 84.3% of the people living in dispersed rural settlements. It is also one of the poorest of the ten regions of Ghana. Administratively, the region is made up of nine districts with Bolgatanga municipality being the regional capital. It is located at the north-eastern part of the country and bordered by Burkina-Faso to the north, the Republic of Togo to the east, and the west by Sissala District in the Upper West Region and the south by the Northern Region. The land area is about 8,842 square kilometres and it has a population of 1046,545 according to the 2010 population census representing 4.2% of Ghana‟s population. In the age group of 15-49, there is an excess of females (44.3%) over males (39.2%). The regional level of illiteracy (78.1%) is also much higher than the national average of (45.9%). This problem of high illiteracy explains why majority of the people are predominantly engaged in the agricultural sector as they cannot secure any employment in the formal sector due to lack of requisite skills.

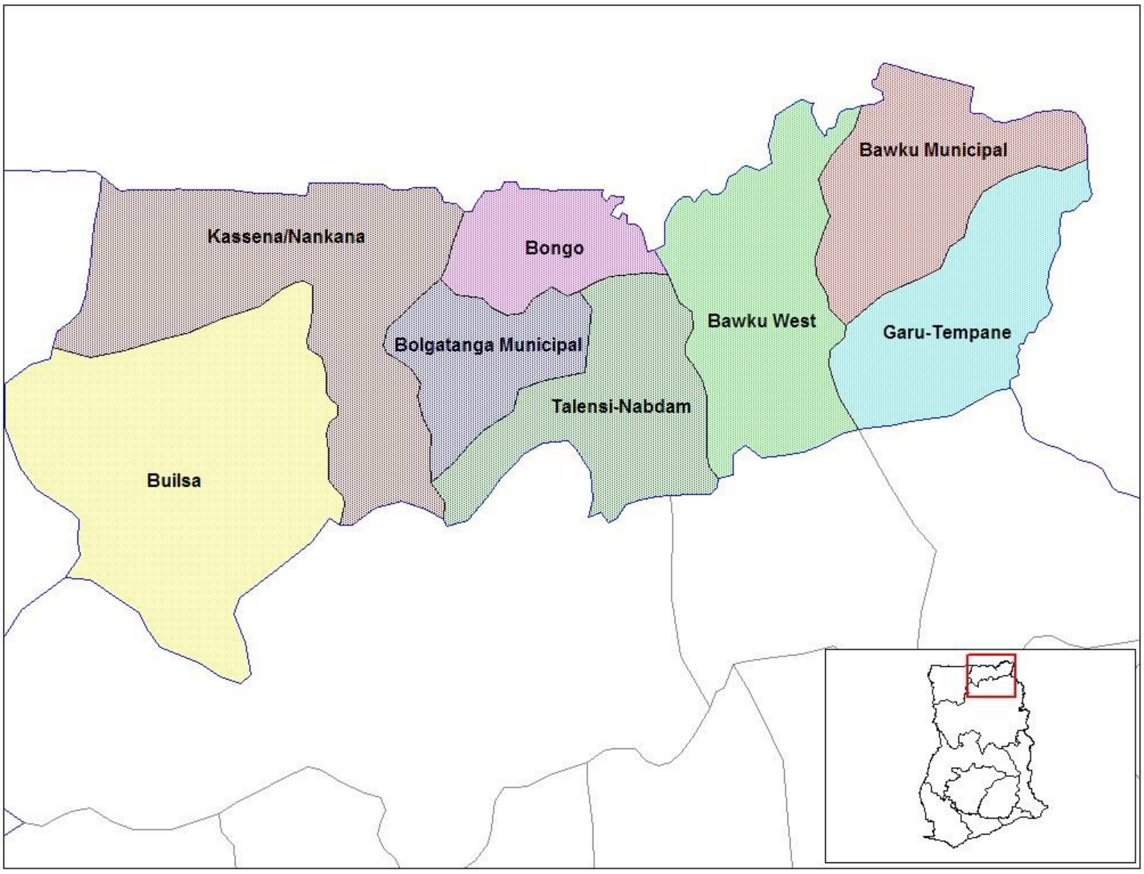

Figure 3.1 Map of the Upper East Region showing the study areas

Source: Adopted from (GSS, 2005)

3.2.1 Geographic Location

The Upper East region is located at the extreme north eastern portion of Ghana of between longitude 00° and 10˙ West and latitude 100° 30N and 110N with total area of about 8.842 kilometer‟s square representing only about 4 % of the total land mass of the country. The region predominantly lies within the Guinea Savannah Zones except at the North-Eastern corner where the Sahelian Savannah occupies a small portion of the land mass. The region is exposed to the harsh guinea savannah conditions for most part of the year. The region is characterized by poor and erratic climatic and soil conditions, unreliable rainfall pattern, degraded soils and dry land patterns, poor vegetation cover, prolong dry season as well as bad agricultural practices. These and other related problems and conditions have contributed to the exposure of the region to many environmental abuses that have in the past engaged a little attention of the various bodies including governmental and NGOs to find a lasting solution to them.

3.2.2 Vegetation

Upper East Region is a relatively low rainfall semi-arid savannah, divided into Guinea savannah along it southern limits, grading into Sudan savanna above the escarpment. The average annual rainfall in the region is about 430mm compared to 1800mm in the south. There has been a rainfall shortage in the whole basin sometime now leading to a quantitative reduction in water resources (GCI, 2001). The dominant tree species are locust („dawadawa‟) (Parkia biglobosa), shea (Vitellaria paradoxa) and kapok (Ceiba pentandra) with a ground cover of perennial grasses such as Andropogon gayanus. Further north, baobab (Adansonia digitata) and whitethorn (Faidherbia albida) predominate. However, much of the land area is an extreme anthropogenic landscape. The natural tree fauna has been severely depleted; in much of the UER almost every species except Parkiaand Vitellariahas been systematically eliminated from the farming areas (Hunter 1967b). Introduced mango trees are common in bush areas, as is the neem, which has assumed weed species. The bush fires that are set every year reduce all the large trees so that even in remote areas, the vegetation may consist of young trees. The practice of conserving sacred forests close to settlements has conserved a tiny proportion of the original biodiversity. Up-to-date figures for vegetation are not available.

3.2.3 Rainfall and Climate

The climatic regime of UER is semi-arid with annual rainfall some 700-1200mm.

Webber (1996a) describing the extreme north-east, quotes the mean for 1955-1992 as 956mm with a range of 682-1310mm. The climate is characterized by one rainy season from May/June to September/October. The mean annual rainfall during this period is between 800mm and 1.100mm. The rainfall is erratic spatially and in short duration. Rainfall can be very patchily distributed and farmers often plant seeds two or three times before the rains set in reliably. It is widely believed throughout the region, by farmers that the overall quantity of rainfall is declining and that the distribution is more unfavorable than before. However, analysis of rainfall data from six stations since 1991 does not suggest this is true. There is also a long spell of dry season from November to mid-June, characterized by cold, dry and dusty harmattan winds.

3.2.4 Bio-Physical Features

The region has a uni-modal rainfall. The rainy season being between middle of April to October and the remaining months are dry. The long term average annual rainfall is 1044mm (Obeng-Asiedu 2004 as cited in Yilma, 2008). The region faces very irregular and frequent dry spells during the planting periods of June and July. The rainfall condition during the planting time is particularly important since it affects crop growth very much. The soil is poor in organic matter content. It emanates from high temperature, which causes rapid decomposition of organic matter, and the burning of the vegetative cover, which reduces the amount of available organic matter. Agricultural productivity is very low and this is attributed mainly to the soils (Terbobri and Albert, 1993).

3.2.5 Soil and Drainage

The region‟s soil is "upland soil" mainly developed from granite rocks. It is shallow and low in soil fertility, weak with low organic matter content, and predominantly coarse textured. Erosion is a problem. Valley areas have soils ranging from sandy loams to salty clays. They have higher natural fertility but are more difficult to till and are prone to seasonal waterlogging and floods. Drainage is mainly by the White and Red Volta and Sissili Rivers.

3.2.6 Labour Force

The region has a large and youthful labour force, which, if properly managed, can become a great economic asset. About 56 per cent (55.7 percent) of the labour force is below 35 years. In the region, the labour force aged 15-34 years shrank slightly from 56.4 per cent of the total labour force in 1984 to 55.7 per cent in 2000, while those aged 35-64 increased marginally. These changes in the age structure of the labour force need to be taken into account in formulating short/medium and long-term policies and planned programmes.

3.2.7 Economic Activities

Agriculture, basket weaving, hunting and forestry are the main economic activities in the region. About eighty percent of the economically active population engages in agriculture. .Agriculture is the major stay of the population. It contributes about 65% of household income (GSS, 2000). Farmers in the region produce mainly for home consumption, while very small value of the total production is marketed. Only 12% of millet, 31% of Beans, 38.3% of groundnut and 46.9% of rice values are marketed in the rural savannah regions in general (GSS, 2000).

3.2.8 Farming Systems

Agriculture is predominantly on a smallholder basis in Ghana. About 90% of farm holdings are less than 2 hectares in size, and to a greater extent, in rice and maize.

Main system of farming is traditional. The hoe and cutlass are the main farming tools. There is little mechanized farming, but bullock farming is practiced in some parts of the region. Agricultural production varies with the amount and distribution of rainfall and nature of soil. Most food crop farms are intercropped. Mono cropping is mostly associated with larger-scale commercial farms as it is currently being done under the block farms.

3.2.9 Agriculture

Agriculture remains the dominant economic activity employing 80% of the population. Due to this dependency on agriculture, the region was the poorest of Ghana‟s ten regions but has moved up to the 9th position, largely due to improvement in the performance of agriculture. Agriculture, hunting, mining and forestry are the main economic activities in the region.

3.3 Conceptual Framework

Irrigation water is a critical production input in farmers production. It is an important socio-economic good with a positive role in poverty alleviation. Irrigation directly impacts on household incomes by increasing farm revenues. There are two potential ways through which irrigation increases farm revenues. Firstly, it increases annual revenue per acre of land through its direct positive effect on total crop production in a given cropping season. Irrigation enhances the use of agricultural inputs (such as fertilizer and high yielding varieties), which in turn improves the productivity of land (Gebregziabher *et al*., 2009). Moreover, irrigation water not only increases crop yields per hectare but reduces crop yield variability, thus stabilising household incomes (Tyler, 2007; Namara *et al*., 2008).

Secondly, irrigation may increase farm revenue by allowing a plot to be planted for an extra crop season for a given year, (i.e., irrigation induces the possibility of double cropping). Although it increases costs to the farmers (due to increased fertilizer use, water charges), the benefits of irrigation outweigh these additional costs. Irrigation water has high marginal returns, high enough to cover additional costs involved in water source development, scheme development and recurrent operating costs (Innocencio *et al*., 2007). The net result of these increased benefits and ncreased costs are significant profit margins to the farmers, leading to improved household incomes. The impact of irrigation on household incomes would increase household expenditure, *ceteris paribus* (Kuwornu and Owusu, 2012). Increased household income and expenditure implies improved food security and poverty reduction of the household. Indirectly, irrigation benefits the landless through higher wages as it results in higher marketed surpluses and increased employment opportunities (Jin *et al*., 2012). Moreover, irrigation benefits the poor as it may lead to lower food prices. Lower food prices are especially beneficial to the poor since the poor spend a disproportionally large share of their income on food (Jin *et al*., 2012). Therefore, irrigation scheme benefits not only the participants but the non-participants as well through these spill-over effects.

Irrigation participation although necessary, is not enough to induce farmers to produce more. It is mainly the irrigators that invest more on improved agricultural inputs and technologies, and thus enjoy more benefits from irrigation participation than the water insecure irrigators. Therefore, the study aimed to evaluate the impact of irrigation schemes on farmers income and livelihoods.

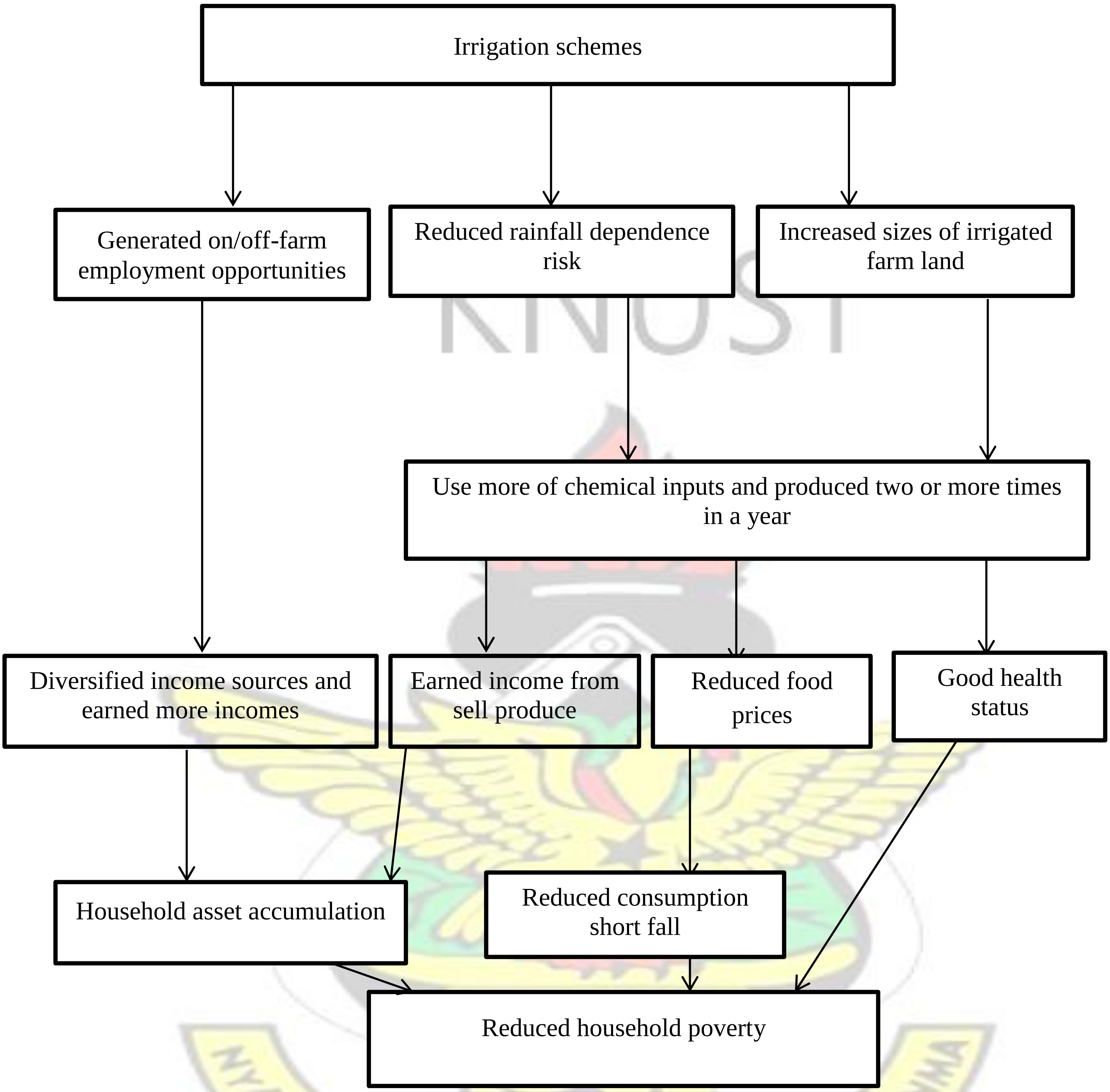

Figure 3.2 Conceptual framework

Source: Nugusse, 2013

3.4 Research Design

The study employed both quantitative and qualitative methods of data collection and analysis. According to Haque (2000) cited Wadel (1991), it is important to use the qualitative method to be able to describe social relations. The quantitative method is important to collect data on resources, income, and yield. This therefore explained the reason the study combined both methods in carrying out this research

3.4.1 Criteria used in selecting the study area and communities

In the region, irrigated crop production is carried out under large and small scale, dugouts, and hand-dug wells and along riverbanks. There are two large schemes run by ICOUR. The total irrigable area of 2490 ha and 850ha at Tono and Vea irrigation projects respectively, which in total benefit about 6000 smallholder farmers who have access to plots in the projects (ICOUR 1995). The two schemes were chosen for the study purpose because of level of the production and participation compared to others. The study communities were selected by sampling from a list of communities. Eight communities were each listed in the Kassena- Nankana district and Bongo district. These are all communities that have access to irrigation facilities. A simple random sampling of three (3) communities was made from each district. The names of all communities targeted were written on a piece of paper, folded and placed in a container. They were then mixed up. Each time a community was selected, it was withheld and the rest in the container mixed up again before the next selection.

Details are presented in the table below;

Table 3.1 List of sampled communities

Kasena –Nankana East District	**Bongo District**
Communities	**Communities**
Korania	Vea
Gia	Bongo Central
Bonia	Yorogo
Gani	Nyariga
Yewagnia	Gworie
Gognia	Adaboya
Nyangua	Dua
Telania	Zokko Gambrogo

Selected Communities	Selected Communities
Korania	Vea
Bonia	Yorogo
Gani	Gworie

Source: Field Survey, 2014

3.5 Population of Study

The study consisted of all farmers from the selected communities, Officials of ICOUR and MoFA.

3.5.1 Sampling Technique and Sample Size

The study employed a multi-stage sampling technique. Because of the special interest in irrigation farming; purposive sampling was used to select the two districts (Kassena-Nankana and Bongo,) where irrigation farming is also practiced. The Kassena-Nankana District has as much as 68.7% of its economically active population employed in agricultural activities (GoG, 2010). Although the district has the second largest irrigation scheme in the country it records high poverty incidences. Also the two irrigation projects, Tono and Vea cover areas of 2490 and 850 ha respectively (ICOUR 1995).

The second stage was to purposively select three (3) communities noted for irrigation farming from each of the two districts. The selection of the communities was done in the light of the objectives of the study. As argued by Laws *et al*., (2003) that selection of areas or people for study obviously need to be done in the light of the aims of the research. The third sampling stage involves the use of simple random sampling to select 30 farmers from each community. Respondents were randomly selected from the both irrigators and non-irrigators. A total of 90 respondents were sampled in each of the two districts. This amounted to a total of 180 irrigators and non-irrigators. Given the relatively small number of non-irrigators compared to the irrigators, 120 irrigating farmers and 60 non-irrigating farmers were considered adequate for comparison. In all 180 farmers were interviewed. STATA, SPSS and Excel were used to analysis data.

3.5.2 Types of Data and Methods of Data Collection

3.5.2.1 Primary Data

Primary data were collected from sampled the respondents using structured questionnaires and focus group discussions. Questionnaires were tested and modified accordingly before being administered. Information on basic characteristics of household heads such as sex, age, marital status, family size, years of experience and education level was collected using the questionnaire. The questionnaire also included measures of household wealth such as household assets, livestock, and type of houses; agricultural production activities; and household livelihoods, income amounts and sources. The same questionnaire was used for both irrigators and non-irrigators, but with extra sections to cover specific questions related to the irrigation activities. The approach adopted in the survey is in line with Jalan and Ravallion (2003), who suggested that in project impact evaluations it is important that the same questionnaire be administered to both groups, and that project participants and non-participants are from the same economic environment.

3.5.2.2 Secondary Information

Prior to primary data collection, a thorough review and analysis of published papers. Secondary information was obtained from documentary sources such as MoFA, Books, Journals, Newspapers, Reports, Articles and others. The essence of this was to review literature about irrigation, income and livelihoods etc.

3.5.2.3 Focus Group Discussion

Focus group discussion with farmers was one of the qualitative data collection methods in this study. Each focus group was within the range of 5 to 8 individuals who are found in the same village in the study area.

3.5.2.4 Key Informant Interview

Individuals who were considered knowledgeable and rich in experiences about irrigation activities, rural livelihood and poverty of their various communities in the study area were identified and interviewed. These were some officials from MoFA and ICOUR and some Assemblymen and Chiefs in the study area.

3.6 Data Analysis

Both descriptive and inferential analyses were used to measure the objectives of the study. The descriptive analysis was performed using averages and mean difference tests, T-test, Chi-square test, percentages to compare socio-economic characteristics of irrigators and non-irrigators. To estimate the impact of the irrigation scheme on household income, the Propensity Score Matching (PSM) econometric model was applied**.** In addition profitability was analyzed through gross margin analysis. Kendal Coefficient of Concordance was used to analyze constraints confronting the farmers in the study area.

3.7 Analytical Framework

Research question 1: Analysis of profitability of irrigation farming. The study adopted Gross Margin Analysis.

3.8 Gross Margin Analysis

Gross margin analysis is useful for production cycles of less than a year (Johnson, 1991) as this enables costs and returns to be directly linked to enterprise. It also allows us to establish profitability of an enterprise (Adegeye & Dittoh, 1985). The research study therefore will use a gross margin analysis per ha analysis as an indication of plot level performance, that is, how well farmers did on their land with the resources that were available to them. Gross margin is the difference between the total sales/gross income and the variable costs.

Gross margin = Total sales (Gross income) - Variable costs.

Where: Gross Income = Total Output (Q) x Price (P), and variable costs include the costs such as fertilizer, seed, agro-chemicals, marketing, transport, labour, water levy, etc that would have been incurred in the production process until the produce has reached the market.

A Gross Margin (GM) is the total revenue associated with a particular production (income) less the costs that clearly vary in direct proportion to the level of production - the direct or variable costs associated with the enterprise. Gross margin analysis is an accepted tool commonly used in the evaluation of farming enterprises (Barnard & Nix 1979) and is also used in the evaluation of the costs and benefits of irrigation (Gittinger 1984).

Meinzen-Dick *et al*., (1993) suggested that higher incomes for some schemes might simply be because farmers are allocated larger holdings rather than because those holdings are being used more productively. They suggest that, to account for differential resource endowments, especially land, the gross margin per holding be supplemented by examining the total gross margin per unit area.

3.9 Econometric Framework

3.9.1 Empirical Method

Research Question 2: The econometric analysis involved a PSM approach. To determine the impact of irrigation schemes on farmers‟ income PSM econometric model was used.

Ignoring the minor differences between logit and probit models, Liao (1994) and Gujarati (1995) indicated that the probit and logit models are quite similar, so they usually generate predicted probabilities that are almost identical. The choice between logit and probit models is largely a matter of convenience (Gujarati, 1995). But the logit model is computationally easier to use and leads itself to a meaningful interpretation than the other types (Pindyck and Rubinfeld, 1981; Gujarati, 1995).

3.9.1.1 Propensity Score Matching (PSM)

In analysing the impact of irrigation on outcome means, the method of matching based on propensity scores is applied. Analysing the impact of project interventions requires the establishment of the requisite counterfactual that represents what would have happened had the project not taken place or what otherwise would have been true (Baker, 2000). The establishment of this counterfactual often poses problems where before intervention situation remains missing. Under such circumstances appropriate estimation of the counterfactual is established by way of a comparative group that does not participate in the intervention. In projects, where participants were selected purposively rather than at random, the problem of "selection bias" is often encountered in evaluation of impacts. Therefore analysis of the impact based on a "with and without" approach yields inaccurate results (Friedlander & Robins, 1995), and any attempt to net out actual project impact must factor in the underlying selection process (Zaman, 2001).

Assignment to participate in irrigation in the study area was purposively done. Owing to this mode of assignment, the PSM framework is adopted for estimating the impact of irrigation access on household income. Impact through this outcome variable is obtained by matching an ideal comparative group (non-irrigating farmers) to the treatment group (irrigating farmers) on the basis of propensity scores (P-scores) of X. X is the set of observable characteristics that determine irrigation participation. By so doing the selectivity bias is largely eliminated.

To develop the PSM framework, let Y_i be the outcome variable of household *i*, such that Y_{1i} and Y_{0i} denote household outcomes with and without access to irrigation respectively. A dummy variable I_i denotes irrigation access by household *i*, where I_i = 1 if the household has access to irrigation and, $I_0 = 0$, otherwise. The outcome observed for household *i*, Y_i is defined by the switching regression (Quandt, 1972).

$Y_i = I_i Y_{1i} + (1 - I_i) Y_{0i}$......................................(1)

The impact of irrigation on household *i*'s income is given by;

$\Delta_i Y_i = Y_{1i} - Y_{0i}$....................................(2)

Where $\Delta i Y_i$ denotes the change in the outcome variable of household *i*, resulting from access to irrigation. A household cannot be both ways, therefore, at any time, either Y_{1i} (irrigating household) or Y_{0i} (non-irrigating household) is observed for that household. This gives rise to the selectivity bias problem (Heckman *et al*., 1997). The framework assumes heterogeneity in impacts of outcomes. The heterogeneity assumption is important because, practically all households with access to irrigation cannot benefit equally as a result of differing characteristics. The most commonly used evaluation parameters are averages (Heckman *et al*., 1997). Two means are common in the impact analysis framework, the average treatment effect, (ATE) and the average treatment effect on the treated (ATT). In the case of irrigation, ATE estimates the effect of irrigation on the outcomes of the whole population without regards to irrigation but the ATT estimates irrigation effects conditional on access to irrigation schemes. It is the latter which this study seeks to estimate and it is represented as

$$ATT = E(\tau \mid I_i = 1) = E[Y_{1i} - Y_{0i} \mid I_i = 1] = E[Y_{1i} \mid I_i = 1] - E[Y_{0i} \mid I_i = 1] \quad \text{...........(3)}$$

From equation (3), $E[Y_{0i} \mid I_i = 1]$ is the missing data representing the outcomes of irrigation participants in the absence of irrigation. One way to estimate this missing data is to use outcomes of a non-irrigating group. By using the outcomes of a nonirrigating farmers, (3) can be rewritten as

$$E(\tau \mid I_i = 1) = E[Y_{1i} \mid I_i = 1] - E[Y_{0i} \mid I_i = 1] \quad \text{......................................(4)}$$

Without controlling for the unobservable heterogeneity, (4) can be shown to consist of a bias in addition to the impact estimate. Subtracting and adding $E[Y_{0i} \mid I_i = 1]$ to the right hand side of (4) gives;

$$= E[Y_{1i} \mid I_i = 1] - E[Y_{0i} \mid I_i = 0] + E[Y_{0i} \mid I_i = 1] - E[Y_{0i} \mid I_i = 1] \quad \text{..........................(5)}$$

$$= E[Y_{1i} - Y_{0i} \mid I_i = 1] + \underbrace{E[Y_{0i} \mid I_i = 1] - E[Y_{0i} \mid I_i = 0]}_{Bias}$$

Rearranging (5) gives,

$$\tau = E(\tau \mid I_i = 1) - \left[E(Y_{0i} \mid I_i = 1) - E(Y_{0i} \mid I_i = 0)\right] \quad \text{..............................(6)}$$

Thus, a bias of the magnitude shown in (6) results when non-irrigating farmers are selected for comparison with irrigating farmers, without controlling for the nonrandom irrigation assignment (Cobb-Clark and Crossley, 2003; Ravallion, 2005).

The PSM method takes care of the bias, so that estimated irrigation impact is largely consistent. The method identifies and matches households within the irrigating farmers that are similar in observable characteristics X_i, to those of the non-irrigating farmers. This is done by deriving propensity scores from a binary logit estimation of irrigation participation model (Dehejia and Wahba, 2002). A binary logit model can be represented as,

$$\Pr(I_i = 1 | X) = \frac{1}{1 + e^{-\beta X}} = \Pr(X) \text{.......................................}(7)$$

Where X is a vector of explanatory variables including household demographic characteristics which are deemed to influence access to irrigation; Pr (X) is the propensity score. Based on the propensity scores of irrigating and non-irrigating farmers, the nearest neighbour matching and Kernel matching method are used to select the best non-irrigating farmers for the irrigating farmers. Rosenbaum and Rubin (1985) opine that, since exact matching is rarely possible, an issue of closeness must be considered. Matching therefore uses the expected outcomes of the irrigating farmers (with irrigation access), conditional on the propensity scores to estimate the expected counterfactual of the non-irrigating farmers (Cobb-Clark & Crossley, 2003). Thus the relation holds, only when the assumption of closeness of propensity scores is valid (common support assumption).

$$[E(Y_{0i} | I_i = 1, X_i = x)] = [E(Y_{0i} | I_i = 0, X_i = x)] \text{..............................}(8)$$

The “conditional independence” or “exogeneity” assumption must hold for this relation to be true. Rosenbaum and Rubin (1985) showed that once appropriate common support is established the conditional independence assumption becomes valid. They proved that, if outcomes without irrigation (Y_{0i}) are independent of participation in irrigation (I_i) given $X_i = x$, then participants are also independent of participation (I_i) given their propensity scores [P(X)]. In PSM irrigation participation characteristics are used to estimate a single value (P-score) which serves as the basis of comparison rather than the characteristics themselves. The latter could be very laborious; hence PSM solves the “curse of dimensionality”. Once common support is established for the irrigating farmers, the heterogeneous impact (ATT) of irrigation on household income can then be estimated using Equation (9).

$$ATT = E\left(\cdot \mid I_i = 1 \right) = \frac{1}{\ } I_i \left(Y I_{0i} \right)_i \frac{1}{\ } I_i \left(\cdot \right)_i I \quad \text{.......................(9)}$$

3.9.1.2 Nearest Neighbor Matching (NNM)

A case in the control group is matched to a treated case based on the closest propensity score. Each person in the treatment group choose individual(s) with the closest propensity score to them. The radius matching is to use not only the closest NN within each caliper, but all the individuals in the control group within the caliper.

3.9.1.3 Kernel Based Matching (KBM)

The KBM uses weighted averages of all cases in the control group to estimate counterfactual outcomes. The weight is calculated by the propensity score distance between a treatment case and all control cases. The closest control cases are given the greatest weight. Each person in the treatment group is matched to a weighted sum of individuals who have similar propensity scores with greatest weight being given to people with closer scores.

Table 3.2 Variable and their *a priori* expectations

Variable	**Measurement**	**Expected Sign**
Age of respondent	Continous	+
Gender of respondent	Dummy: 1 for male; 0 for female	+
Years of schooling	Continous	+
Years of experience	Continous	+
Household size	Continous	+
Household labour size	Continous	+
Cultivated land size (ha)	Continous	+
Access to credit	Dummy: 1 = yes; 0 = Otherwise	+/-
Access to inputs	Dummy: 1 = yes; 0 = Otherwise	+/-
Access to land acquisition	Dummy: 1 = yes; 0 = Otherwise	+/-
Access to market	Dummy: 1 = yes; 0 = Otherwise	+/-
Frequency of extension visit (number per year)	Continous	+
Land quality (fertility)	Dummy: 1 = Good; 0 = Poor	+/-

3.10 Kendall's Coefficient of Concordance *(W)*

Research Question 3: Kendall‟s Coefficient of Concordance ***(W)*** was used to measure the degree of agreement between the rankings of constraints confronting the farmers in the study area. The Kendall‟s Coefficient of Concordance test is a nonparametric statistical procedure used to identify a given set of constraints or problems, from the most influential to the least influential as well as measure the degree of agreement or concordance among the respondents. The constraints were ranked from the most influential to the least influential using numerals ***1, 2, 3........n*** in that order (where ***n*** is a positive integer). The total rank score for each constraint was computed and the constraint with the least score was ranked as the most pressing constraint, while the constraint with the highest score was ranked as the least constraint. The total rank score computed was used to calculate the Kendall‟s Coefficient of Concordance ***(W),*** which measures the degree of agreement between respondents in the ranking. The Kendall's Coefficient of Concordance ***(W)*** is computed as follows:

$$W = \frac{12\left[\sum T^2 - \frac{(\sum T)^2}{n}\right]}{nm^2(n^2-1)} \quad \text{.......................................(1)}$$

Where, ***W*** = Kendall"s Coefficient of Concordance, T = sum of ranks for constraints being ranked, m = total number of respondents (farmers), and n = total number of constraints being ranked. The Coefficient of Concordance (*W*) was tested for significance in terms of the F – distribution.

The F-ratio is given by; $F = W(m-1)/(1-W)$ ....(2)

Numerator degree of freedom, $(n-1)-(2/m)$

Denominator degree of freedom $(m-1)[(n-1)-(2/m)]$

If the test statistic ***W*** is **1,** then all the survey respondents have been unanimous, and each respondent has assigned the same order to the list of concerns. If ***W*** is **0,** then there is no overall trend of agreement among the respondents, and their responses may be regarded as essentially random. Intermediate values of ***W*** indicate a greater or lesser degree of unanimity among the various responses (Legendre, 2005).

3.10.1 Hypotheses Test

Null hypothesis (H_0): there is no agreement between the rankings of the constraints in the study area. Alternative hypothesis (H_A): There is agreement between the rankings of the constraints**.**

3.10.2 Decision rule

The null hypothesis is rejected if the calculated F-value exceeds the tabulated F-value, indcicating that farmers agree with each other on the ranking of the constraints.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter presents the main findings of the study concerning irrigation impact on household income, livelihoods,and poverty alleviation. The results presented in this chapter seek to achieve the first objective of the study, which is to evaluate the impact of irrigation on household income, livelihoods, profit margins of farmers and constraints confronting farmers in the study area. The treatment effect model was used to achieve impact of irrigation on farmers‟ income objective, while the PSM method was used to provide robustness checks of the treatment effect model. Also gross margin analysis and Kendall‟s Coefficient of Concordance (***W***) were used analysised profit margins and contraints confronting farmers respectively. This chapter, accordingly, presents the descriptive and econometric findings of the study and gives a brief overview of the constraints confronting of irrigation farming in the study area.

The results of data analysis are presented in the following sections. Chi-square and Tstatistic test were used to test whether they are statistically significance. The t-test is used to test the significance of the mean values of continuous variables of two groups of irrigators and non-irrigators while Chi-square is used to test the significance of the mean values of the potential discrete (dummy) explanatory variables. The next section presents descriptive statistics from both Chi-square and t-tests tests. The results from PSM analysis are then presented, followed by the results from the econometric model.

4.2 Socio-economic and Demographic Characteristics of Irrigators and Nonirrigators

4.2.1 Descriptive Statistics

The total number of respondents that were interviewed is 180, comprising of 120 irrigators and 60 non-irrigators. However, 9 respondents were discarded in the final sample for analysis due to missing information. The total sample size analyzed was thus, 171 comprising of 120 irrigation farmers and 51 non-irrigation farmers. The results of descriptive analyses are presented in Tables 4.1, and 4.2. Table 4.1 presents the results for the categorical variables while Table 4.2 presents the results for the continuous variables. Descriptive analyses of both categorical and continuous variables indicated that there were no significant differences between the irrigators and non-irrigators in terms of their demographics. The t-test results presented in Table 4.2 suggests for both groups an active age farmer population.

4.2.1.1 Age of Respondents

The ages of the household heads of the sampled respondents ranged from 28 and 80 years with mean of 41.6 years and standard deviation of 10.9 for irrigation farmers. The mean age of non-irrigators is 42.6 years with deviation 11.5 (Table 4.2). There is no significant difference in the distribution of household head age of the sampled respondents between irrigating and non-irrigating farmers, suggesting age has very little influence on the participation decision. This is attributable to the fact that both groups belong to the same population and the variable in question does not lend itself to change based on irrigation participation or otherwise.

4.2.1.2 Household Size

The average household size for the irrigators and non-irrigators is found to be 6.9 and 6.0 respectively. This result is statistically insignificant suggesting labor availability is not an important factor influencing households‟ decision to participate in irrigation farming in the study area.

4.2.1.3 Educational Level of Respondents

Education of the household head often influences adoption of technology positively (Hoag *et al*., 1999). This is attributed to the fact that household heads with more years of schooling would be expected to better visualize the benefits of technology. Similarly, education plays a key role for household decision in irrigation framing. It creates awareness and helps for better innovation and invention. The study revealed that (41%) of irrigators and (59%) of the non-irrigators of are with no formal education. Further analyse, showed that majority of the sampled respondents (46%) had no formal education, (16%) had primary education, (15%) of the respondents had JSS Education, (19%) had SSS/Technical Education while (4%) of the respondents had tertiary education (Table 4.1). The average schooling years of irrigators is 5.7 with standard deviation of 5.5, while non-irrigators have 4.3 with standard deviation 5.8 (Table 4.2). Weirs (1999) stated that, at least four years of primary schooling is required to have a significant effect upon farm productivity. Although there was no statistically significant difference between the educational level of irrigators and nonirrigators, discussions with the farmers indicated that more household members of irrigators are educated compared to non-irrigators. This result is consistent with Tesfaye *et al.* (2008), that money from irrigation is also being invested in services such as education for children.

4.2.1.4 Gender of Respondents

Gender of the household head is an important variable influencing participation decision in irrigation decision making. Table 4.1 shows that in total majority of the respondents (75%) were male with (25%) being female. The portion of female headed households who are irrigation users is (24%). Discussion with sample respondents revealed that male headed households hardly faced labor shortage for irrigation due to physical, technological and socio-cultural fitness to males than females. Table 4.1 indicates that the proportion of women irrigators was (24%), which implies that women‟s access to irrigation is by far below that of men. This conforms with Kinfe *et al*., (2012) that women‟s access to irrigation is limited in Northern Ethiopia. The reason is that when the scheme was established men were given preference over women and also, men felt that women could not cope with the demands of the scheme. Women only provided labour, especially during harvesting and other offfarm activities to supplement household income. Of the total respondents, (65%) are Christian and (80%) are married and the rest are either single or separated/divorced. The major occupation of the household heads in the study area was found to be farming constituting (83%) .

4.2.1.5 Respondents Years of Experience

With regard to farm experience of the households, findings compared that an average years of 18.7 with deviation of 9.9 of the irrigation users and an average of 20.4 with deviation of 10.7 non-irrigator. The t-test on experience between irrigators and nonirrigators of irrigation showed that there is no significant difference between irrigators and non-irrigators households at 5% level (Table 4.2).

4.2.1.6 Cultivated Land Size

Farmland is another socioeconomic variable that is vital for agricultural practice and livelihoods creation. The average cultivated landsize of irrigators and non-irrigators is (1.84) acres and (1.95) acres of irrigated and rain-fed respectively**.** Available data in the region show total irrigated area to be just about (0.26%) of total cultivated area (MoFA-SRID, 2007). According to MoFA (2007), more than 90% of the population in the region have land holdings less than (2.1)ha. This is consistent with Andah *et al*., (2005) that land sizes are usually small, often in the range of (1.2)acre in irrigated areas. A study by Oruonye (2011) in the Tigray region of Ethiopia shows that both irrigating farmers and non-irrigating farmers have an average land size of (1.1) and (0.63) ha, respectively. Thus, this study concluded that cultivated landsize is not a necessary condition to participation decision making in irrigation farming.

4.2.1.7 Extension Service

It was understood from previous studies that an increase in productivity is achieved through farmers‟ access to appropriate extension services. It is learnt that sampled farmers in the study area do have a better access to extension services that was illustrated by frequent visit of extension agents, participation in demonstration day, training of the farmers and above all initiatives of the farmers to knock the doors of the extension agents. According Madhusuda B. *et al.* (2002), agricultural extension services play a pivotal role in the motivation of farmers towards the adoption of improved irrigation practices. The introduction of high valued crops, efficient use of water and proper use of inputs have all been deemed as significant factors for crop production and productivity. Hence, the result of this study is consistent with that study which revealed that 51% of the irrigators and 33% non-irrigators get extension service (Table 4.1). The Chi-square test indicated that there is significant relationship between irrigation users and non-users with regard to extension service at 10% level of significance.

4.2.1.8 Access to Credit

Credit is an important institutional service to finance poor farmers for input purchase and ultimately to adopt new technology. However, some farmers have access to credit while others may not have due to problems related to repayment and down payment in order to get input from formal sources. Hence, some farmers avoid farm credit. The survey result indicated that 75% of the irrigators and 41% of the non-irrigators had taken credit .This was statistically significant at 1% level of significance (Table 4.1).

4.2.1.9 Land Quality

The percentage difference on land quality was statistically tested and it was found to be significant at 5% level of significance. This revealed that there was systematic association between land quality and irrigation participation. It shows that higher quality of land could increase participation in irrigation. This indicates that as land quality becomes fertile, household heads become eager to accept irrigation technology (keeping other variables constant). About 71% irrigators perceived their soils to be of good quality, while 47% of the non-irrigators felt that their soils were infertile. The results of this study reveal that this variable is significant at 5% level of significance.

4.2.1.10 Production Inputs

The average quantity of fertilizer (kg) and seeds (kg) by irrigators are 146.79kg and 5.38kg per acre respectively. The corresponding values for non-irrigators are 80.00kg and 21.00kg per acre respectively. The result further shows that there is significant difference in the average inputs used by the two groups of households at 5% level.

Table

4.1 Comparison of categorical Variables between Irrigators and Nonirrigators

Variable Definition		Irrigators		Non-irrigators		Total		□² -test
		Freq.	%	Freq.	%	Freq.	%	
Gender	Male	91	76	37	73	128	75	ρ = 0.65
	Female	29	24	14	27	43	25	
	Total	**120**	**100**	**51**	**100**	**171**	**100**	
Educational level	No formal education	49	41	30	59	79	46	ρ = 0.009***
	Primary	21	18	6	12	27	16	
	JHS/Middle	21	18	4	8	25	15	
	SHS/Technical	27	23	6	12	33	19	
	Tertiary	2	2	5	10	7	4	
	Total	**120**	**100**	**51**	**100**	**171**	**100**	
Religion	Christianity	84	70	27	53	111	65	ρ = 0.64
	Muslim	4	3	1	2	5	3	
	Traditional	32	27	23	45	55	32	
	Total	**120**	**100**	**51**	**100**	**171**	**100**	
Marital status	Single	8	7	6	12	14	8	ρ = 0.10
	Married	102	85	35	69	137	80	
	Divorced	1	1	1	2	2	1	
	Widow	9	8	9	18	18	11	
	Total	**120**	**100**	**51**	**100**	**171**	**100**	
Land quality	Good	85	71	24	47	109	64	ρ = 0.003***
	Poor	35	29	27	53	62	36	
	Total	**120**	**100**	**51**	**100**	**171**	**100**	
Access to land	Family/inheritance	64	53	49	96	113	66	ρ = 0.000***
	Community usage	12	10	2	4	14	8	
	Rented	2	2	0	0	2	1	
	ICOUR	42	35	0	0	42	25	
	Total	**120**	**100**	**51**	**100**	**171**	**100**	
Inputs market	Yes	114	95	30	59	144	84	ρ = 0.000***
	No	6	5	21	41	27	16	
	Total	**120**	**100**	**51**	**100**	**171**	**100**	
Access to credit	Yes	90	75	21	41	111	65	ρ = 0.000***
	No	30	25	30	59	60	35	
	Total	**120**	**100**	**51**	**100**	**171**	**100**	
	Yes	61	51	17	33	78	46	ρ = 0.04**
	No	59	49	34	67	93	54	

Table

Access to extension service?	**Total**	**120**	**100**	**51**	**100**	**171**	**100**	

Note: *** significant at 1%, ** significant at 5% and * significant at 10% of significance levels**.**

Source: Field survey, 2014

4.2 Comparison of continuous Variables between Irrigators and Nonirrigator

Variable Definition	**Irrigators (n =120)**		**Non-irrigators (n=51)**		**t-test**
	Mean	**St. dev.**	**Mean**	**St. dev.**	
Age	41.59	10.93	42.57	11.52	$\rho = 0.60$
Household size	6.93	2.70	5.98	2.50	$\rho = 0.03^{**}$
Years in schooling	5.68	5.54	4.29	5.80	$\rho = 0.14$
Years of Experience	18.7	9.9	20.4	10.70	$\rho = 0.56$
Cultivated land size (acre)	1.84	0.77	1.95	0.72	$\rho = 0.16$,
Family labour size	4.46	2.01	4.84	2.11	$\rho = 0.26$,
Quantity of fertilizer (kg)	146.79	74.61	80.00	35.53	$\rho = 0.000^{***}$
Quantity of seed (kg)	55.38	28.97	21.00	10.43	$\rho = 0.000^{***}$

Note: **** significant at 1%, ** significant at 5% and * significant at 10% of significance level*

Field Survey, 2014

From Table 4.3 below, to ascertain the level of diversification of livelihood activities, additional income generation activities came under the searchlight. A majority (65%) of the respondents reportedly had some form of others activities (e.g petty-trading, basket weaving, pito brewing and construction work) that they engaged in. These activities are also significant for poverty reduction as they imply a certain degree of livelihood diversification. It was revealed that these activities which are part and parcel of their livelihoods provided some income for the irrigation farming. However, only 45.1% of the non-irrigators are engaged in similar activities besides the rainy season farming. This is an indication that farmers in the rural areas could be stuck to a single livelihood pathway as livelihood diversification. The chi-sqaure was significant at 5% level.

Table

4.1 Income Generating Activities

Types of farming	Income Generating Activities				χ^2-test
	YES		NO		
	Freq.	%	Freq.	%	
Irrigators	78	65	42	35	ρ = 0.015**
Non-irrigators	23	45.1	28	54.9	
Total	101	59.1	70	41	

Note: *** significant at 1%, ** significant at 5% and * significant at 10% of significance levels

Source: Field Survey, 2014

4.3 The Role of Irrigation in Production, Employment and Poverty

Irrigation may lead to poverty reduction via increased yields, increased cropping areas and higher value crops and employment). Increased yields implies increased food supplies, higher calorie intakes and better nutrition levels. The study investigated that there were significant differences in levels of production, employment, asset endowment, consumption, and income between irrigation users and non-users.

4.3.1 Irrigation Farming and Yield (2013/2014) Production year

Comparative yields analysis by crop type could not be done because of lack of uniformity in the use of inputs. However, gross yield for major crops by access to irrigation schemes was presented in Figure 4.1. As expected, irrigation use has significantly contributed towards achieving household"s goal of increased production and this result is similar to other reports (Getaneh, 2011). Data analysis of major cereals and horticultural crops showed that mean crop yield per household for maize, tomato, and rice is highest for irrigation users than non-users. This evidence has ensured that irrigation use is a guarantee for increased food supply and ensured food security. Crops like tomato, vegetable, are only grown by those households with access to irrigation.

Table

This is also an indication of the fact that irrigation use increases crop diversification and intensity.

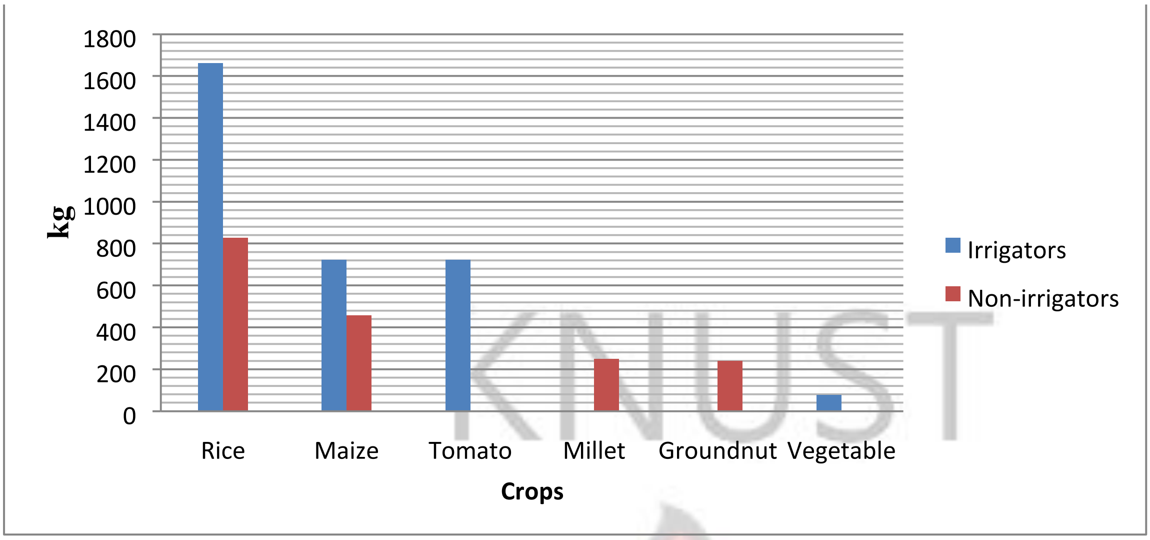

Figure 4.1 Average crop yield 2013/2014

Source: Field survey, 2014

Most farmers however preferred to grow other crops for various reasons. About 63% of farmers preferred other crops to what they were currently cultivating. Out of those farmers who preferred to cultivate other crops, 86% of them assigned a higher market value to their preferred crops than what they were cultivating. The rainy season is from June to November. In this period both irrigating and non-irrigating households produced rain-fed crops. The dry season is practiced from December to April. In this cropping season, only irrigating households can cultivate using water from irrigation. Access to irrigation has been regarded as a powerful factor that provides a greater opportunity for multiple cropping, cropping intensity, and crop diversification (Saleth *et al.*, 2003).

Crops grown by irrigators and non-irrigators were few in number (Figure 4.1), but there are different reasons why they are grown by irrigating and non-irrigating households. The major reasons for irrigating households were good production (98.8 %), better price

(86.7%) and easier to cultivate (42.5%) of the respondents. Seed availability accounted for (38.8 %) of the respondents (Table 4.4)

Table 4.2 Reason for selecting the major field crops

Reasons	Irrigators		Non-irrigators	
	Freq.	**(%)**	**Freq.**	**(%)**
Good production	118	98.3	50	98.0
Better prices	104	86.7	28	54.9
Disease tolerance	82	68.3	38	74.5
Easiest to cultivate	51	42.5	26	51.0
Seed availability	46	38.3	21	41.2

Source: Field survey, 2014

4.3.2 Description of Yields by Irrigators and Non-irrigators

From the table below, (59%) of the irrigated farmers indicated that the yield was good and (14%) indicated it was bad while (27%) reported that their yields could be described as average. The (14%) who reported their yields was bad in this case, indicated they did not consider irrigation scheme to be worth their efforts but for some reasons, they had to be involved in it. On the other hand, (33%) of the non-irrigated farmers said their yields were good, (51%) reported it was bad while the remaining (16%) noted it was average. Good yield to these farmers as they described it, meant the kind of yield that afforded them the ability to recoup their investment and have enough for the household consumption. Recouping their investment did not only depend on the yield but on the market prices offered if even there were buyers.

Table 4.3 Descriptions of yields by irrigators and non-irrigators

Farming type	Perception of yields			Total
	Good	**Average**	**Bad**	
Irrigators	71 (59.2%)	32 (26.7%)	17 (14.1%)	120 (100%)
Non-irrigators	17 (33.3%)	8 (15.7%)	26 (51.0%)	51 (100%)
Total	88	40	43	171

Field survey, 2014

4.4 Respondent Sources of Incomes

Table 4.6 describes different sources of incomes in 2013/2014 production year. From the total mean annual income of an irrigation households, irrigation contributes the highest income share (45%) followed by formal employment (20%) and petty trading and livestock follow with earnings (8%) and (7%), respectively. However, there is no significant difference between irrigating and non-irrigating households in their livestock and off-farm incomes. The total income significant difference arises from the irrigation farming income difference, which is suggestive of the degree to which irrigation access increases household incomes. Thus, irrigated land enables farming households to diversify their incomes (Asayehegn *et al.*, 2011). Other studies reported similar findings, for example, the income earned from irrigation farming in Taraba State (Nigeria) accounted for about 30-40% of the total income (Oruonye, 2011), the mean income from irrigation households in Ambo (Ethiopia) increased by 67% and by 22% for the rain-fed farmers between 2007 and 2010 (Asayehegn *et al*., 2011), irrigated income in Ghana accounted for about 30-50% of the household incomes

(Kuwornu & Owusu 2012), and incomes from irrigated plots in Oromia region (Ethiopia) shared 10-300% of the total incomes of the households (Eshetu 2010).

Table 4.4 Sources of household annual income

Sources of Income	Irrigators				Non – irrigators			
	Freq.	Total Annual Income (GH₵)	Average Annual Income (GH₵)	Mean %	Freq.	Total Annual Income (GH₵)	Average Annual Income (GH₵)	Mean %
Livestock	100	69,365.00	693.65	6.8	36	23,780.00	660.56	8.6
off-farm labor	20	12,360.00	618	2.9	18	3,430.00	190.56	2.5
Formal employment	15	84,676.00	5,645.07	19.8	23	118414.5	5148.46	66.7
Petty Trading	43	33,670.00	783.02	7.9	18	2,675.00	148.61	1.9
Remittances	28	17,570.00	627.5	4.1	25	9,050.00	362.00	4.6
Irrigation	120	193,460.00	1,612.17	44.9				

Rainy Season	120	17,415.00	145.13	4.1	51	60055.5	1177.56	15.3
Others	1	40	40	0.01	3	85.00	28.33	0.4
Total	**447**	**428,556.00**	**10,164.53**	**100**	**174**	**217,490.00**	**7716.08**	**100**

Source: Field survey, 2014

Formal employment was vital in non-irrigators with (66.7%) contribution to total income, compared to (19.8%) for irrigators. This is because more members from nonirrigating households are in regular employment as shown in (Table 4.6). The second highest income earner to non-irrigators is from rainy season farming, representing a contribution of (15.3%) compared to (4.1%) for irrigators. However, remittances tend to contribute almost equally to both irrigators and non-irrigators, with a contribution of (4.1%) and (4.6%) respectively. Irrigators have more income on average, GH₵ 10,164.53 against GH₵ 7716.08 for non-irrigators. This can be attributed to the contribution of both irrigation and rainy season farming they do as reflected by a proportion of (44.9%) and (9.6%) respectively.

Table 4.5 Some livelihood outcomes of respondents

Livelihood Outcomes Indicators	**Irrigators**		**Non-irrigators**	
	Freq.	**(%)**	**Freq.**	**(%)**
Education	119	99.2	40	78.4
Health Care	118	98.3	43	84.3
Social Service	108	90.0	25	49.0
Livestock	102	85.0	33	64.7
Assets	101	84.2	25	49.0
Employed farm labour	90	75.0	25	49.0

Source: Field survey, 2014

The study indicates that irrigated agriculture has brought positive changes on respondents incomes and expenditures, which enable them to send their children to schools, buy livestock, build up assets, cover medical expenses, buy more food and non-food items, employed farm labour, purchase inputs, and take balance diet. About 99% of the irrigators used part of their earnings for educational purposes as opposed to

(78.4%) by non-irrigators. Thus, access to irrigation schemes has considerable impact on household livelihoods and food security in the study area.

Table 4.8 Household food situation 2013/2014

Diet Coping	Irrigators		Non-irrigators	
	Freq.	(%)	Freq.	(%)
Worsened	15	12.5	19	3.7
Stayed	55	45.8	21	4.1
Improved	50	41.7	11	2.2

Source: Field survey, 2014

Further analysis was done to determine the respondent household food situation within the last twelve months. The food situation of respondents have either improved, stayed or worsened with farmers in the study area. About (41.7%), (45.8%) and (12.5%) of irrigator repoted of improved, stayed and worsened respectively. However, about (2.2%), of non-irrigators had an improvement, (4.1%) had their food situation remaind unchanged and (3.7%) reported of worsened food situation.

4.5 The Economic Status of the Respondents, Before and After Participation in the Schemes

The table below presents the estimated monthly income of the respondents before and after participation in the schemes. It can be seen that before their involvement in the irrigation scheme, 14% of the farmers reported an estimated monthly income of less than GH₵100.00, while 74% reportedly had an estimated monthly income of between GH₵ 100.00 to GH₵ 500. About 12% of the farmers reported an estimated monthly income of Gh₵ 501.00 to GH₵ 999.00. No farmer reported an estimated monthly income level of above GH₵1000.00+ before the participation in scheme. In essence, these figures show that majority of the people in this community had a monthly estimated income of less than a dollar a day. As seen in the Table 4.9 below, only 2%

of the farmers reported an estimated monthly income level of less than GH₵100.00 after the scheme. A great number had increased their income in this category. From (14%) of farmers whose income was at that level, it‟s now just (2%). Before the introduction of the schemes no farmer reported an estimated monthly income level above GH₵1000.00 There is significant improvement of (16%) in that category. Those who reported an estimated monthly income level of between Gh₵100.00 to GH₵ 500.00 constituted a (46%), an increase from the previous (2%) before participation in the schemes. Thirty-seven percent of the farmers at this time reported an estimated monthly income level of GH₵ 501.00 to GH₵ 999.00. This is yet another notable increase over the previous (11%) before their involvement schemes. Considering the statistics therefore, the level of farmer household income had increased remarkably with their participation in the schemes.

Table 4.9 Estimated monthly income before and after participation in irrigation schemes (2013/2014)

Participation	Estimated yearly income (GH₵)				Total
	<100	**100 - 500**	**501 - 999**	**1000+**	
Before	17 (14.1%)	89 (74.2%)	14 (11.7%)		120 (100%)
After	2 (1.7%)	55 (45.8%)	44 (36.7%)	19 (15.8)	120 (100%)

Source: Field survey, 2014

4.6 Irrigation Farming has Contributed to the Improvement of Status of Farmers

Asked whether the introduction of the irrigation scheme had brought any benefits to the respondents. There was an overwhelming positive response to this question. For instance, at Kasena-Nankana district, (88%) of the farmers said it was helpful to them in various ways. With regard to Bongo district (72%) of the farmers indicated it was helpful and the best thing to have happened since doing irrigation farming. However, improvement of their status in terms of general well-being, increased income, access to education and health depend on several other factors such as diversified livelihood activities in the communities.

4.7 Respondents Housing Improvement

About 73% of irrigation farmers and 61% of non-irrigators reported having made improvements to their house (new roof, walls or room) in the previous year. The findings also show that 12.5% of irrigators and 3.9% of non-irrgators were able to improve on their water or sanitation systems such as building a new well, drainage/sewage system or showers. On eleccticity and lighting it was indictaed that about 30.8% of irrigating farmers and 19.6% non-irrigators were able to improve on their lighting and electricity system.

Table 4.10 Housing improvement in 2013/2014 year

Housing improvements	Irrigators		Non-irrigators	
	Freq.	(%)	Freq.	(%)
Repair roofing, floor, walls	87	72.5	31	60.8
Sanitation system, drainage system	15	12.5	2	3.9
Lighting/Electricity	37	30.8	10	19.6

Source: Field survey, 2014

4.8 Comparison of Labour requirement between Irrigators and Non-irrigators

Irrigated farms are more labor intensive than rainfed farm land as shown in (Table 4.11). Family labor supply is not enough for irrigated farming in most cases while non-irrigators have almost (80%) enough aggregate labor needed for the farm operation. As a result hired labor has to be used by irrigation farmers. Labor is hired to overcome labor constraints. Hired labor is mostly used for transplanting seedlings, weeding and harvesting time. For other activities all physically able members of the household assist in farm work. The total labor required in man-days for irrigated crops is significantly higher than non-irrigated crops assuming that there is no quality difference between the labor inputs of the different age and sex groups (Table 4.11). Of this about, (44%) is supplied by the family and (56%) by hired labor for irrigated plot while (80%) supplied by the family and (20%) by hired for non-irrigated lands.

Guido (1983) found out that the labor requirement in most non-irrigated farms was about 100 man-days per acre.

Table 4.11 Comparison of labour requirement between irrigators and nonirrigators

Labour Source	Farming Type	
	Irrigators	**Non-irrigators**
Family (per/acre)	432 (44%)	411 (80%)
Hired (per/acre)	547 (56%)	100 (20%)
Total	**979 (100%)**	**511 (100%)**

Source: Field survey, 2014

4.9 Gross Margin Analysis of Farmers in 2013/2014 Farming Season

Gross margin analysis was used to compare the returns between irrigators and nonirrigators and to assess the profitability of the irrigation schemes. This technique was employed to access the profitability of irrigation farming in the study area. Total cost of production of irrigators was found to be in the range of GH₵ 32.00 and GH₵ 958.50 per acre with mean and deviation of GH₵ 349.54 per acre and GH₵ 198.13 respectively. The range of non-irrigators was GH₵ 52.00 and GH₵ 671.00 per acre with mean and deviation of 315.62 and 105.56 respectively. This implies that irrigation farming incurred more cost of about (59%) than non-irrigating farmers.

Total revenue for irrigators was also found to be in the range of GH₵ 50.00 and GH₵ 3218.00 per acre with mean and deviation of GH₵ 1419.17 and 758.20 respectively. On the other hand, the irrigators made total revenue of the range of GH₵ 50.00 and GH₵ 1900.00 per acre with mean and deviation of 647.56 and 471.16 respectively. Farmers realized an average net income/profit/ gross revenue ranging between GH₵

22.00 and GH₵ 2259.50 per acre from irrigation farming. While their counterparts, non-irrigators made a profit/loss ranging between GH₵ -2.00 and GH₵ 1229.00.

Similar profit levels were reported by Dittoh and Awuni (2012) and Laube, Awo, and Schraven (2008) in a survey of groundwater irrigators in north-eastern Ghana. It should be noted that irrigation is not done throughout the year and farmers reported an average period of 3-4months for which they are engaged in irrigation farming. The gross analysis for irrigators and non-irrigators suggestes that the irrigation farmers were in better position to afford enough food (rice, maize etc) to satisfy household requirement than non-irrigators. This result confirms (Meninzan-Dick *et al*., 1993) among farmers using irrigation, the majority were found food secure and have stable income. Rukuni (1984) carried out similar study and indicated that investment in irrigation development can have an important effect on both rural incomes and local food supplies. Also by Nhundu *et al*. (2010); Gebremedhin and Peden (2002) established that irrigation increases agricultural productivity and farm income. Dittoh (1991b) stated that various economics and investment analysis point to profitability and viability of irrigation schemes. You (2008) showed that irrigation schemes will results in much higher profits. All other things being equal, greater effort in irrigation farming will enhance income of the farmers.

Table 4.12 Gross margin analysis for irrigating farmers

Variable	Minimum (acre)	Maximum (acre)	Mean (acre)	Std. Deviation
Total cost seed	7.00	95.00	41.73	21.23
Total value fertilizer	10.00	140.00	66.63	35.34
Water payment	2.00	200.00	50.08	32.06
Cost ploughing	20.00	320.00	122.33	63.73
Cost of Labour				
i. Total Amount of land clearing	2	22.50	5.87	3.90
ii. Cost of planting	2	35.00	11.37	7.95
iii. Cost of weeding	2.00	48.00	17.11	12.04
iv. Total cost of fertilizer application	2.00	16.00	6.91	3.54
v. Total cost of harvesting	2.00	58.00	20.40	14.00
vi. Total cost of processing	1.00	24.00	7.13	4.34

Total labour cost	***11.00***	***203.50***	***68.79***	***37.82***
TOTAL PRODUCTION COST	**32.00**	**958.50**	**349.56**	**198.13**
TOTAL REVENUE	**50.00**	**3218.00**	**1419.71**	**758.20**
GROSS MARGIN	***22***	***2259.50***	***1070.15***	***560.07***

Source: Field survey, 2014

Table 4.13 Gross margin analysis for non-irrigating farmers

Variables	Minimum (acre)	Maximum (acre)	Mean (acre)	Standard deviation
1. Total cost of seed	10.00	80.00	35	18.61
2. Total cost of fertilizer	30.00	130.00	63.30	37.25
3. Cost of ploughing	15.00	240.00	112.94	51.90
4. Cost of Labour				
i. Total amount on land clearing	2.00	16.00	6.04	2.68
ii. Cost of planting	6.00	110.00	33.09	21.55
iii. Cost of weeding	12.00	100.00	37.36	18.48
iv. Total cost of fertilizer application	3.00	12.00	5.12	2.25
v. Total cost of harvesting	6.00	45.00	15.98	6.89
5. Total cost of processing	3.00	12.00	6.79	2.46
TOTAL COST OF PRODUCTION	***52.00***	***671.00***	***315.62***	***105.56***
TOTAL REVENUE	***50.00***	***1900.00***	***647.56***	***471.16***
GROSS MARGIN	***-2.00***	***1229.00***	***331.94***	***365.60***

Source field survey, 2014. Author‟s calculations

4.10 Factors Influencing Participation in Irrigation Schemes

As explained in the methodology section, the first step of the econometric approach is to estimate the propensity score, i.e. the probability to participate in irrigation conditional on observable variables. To generate the propensity scores for the matching process, the probability of a household to adopting irrigation was estimated using the logit model. The variables included in the model are gender of the household head, age of the household head, household size, cultivated land, size of adult labor, education level of the household head, and access to extension services, experience of the household head, perception of land fertility, access to market, access to credit and good prices for produces. The estimation results are presented in (Table 4.14) below.To identify the factors that affect households‟ participation in irrigation schemes in the study area, the Logit model was used to generate propensity scores for the matching algorithm. The Pseudo R-square indicates that about 55% of the variation in the irrigation decision model can be explained through the included explanatory variables. The overall model is statistically significant at a P-value of 0.000. Hence, the chosen observable characteristics adequately explain the probability of participation. Among the factors assumed to affect the household participation decision in the irrigation scheme in the study area are family labour size, years in schooling, land acquisition, market access for inputs (e g chemical, fertilizer), market access to sell farm produce, good prices, extension service and land size holding. Household size, age, marital status, access to credit and perception of land quality affected participation decision in the irrigation schemes positively but no statistically significant between irrigators and non-irrigators. This partially agrees with a study by Kumornu & Owusu (2012) and Adeoti *et al*. (2007).

The model was statistically significant and the regression coefficients give the change in the z-score for a unit change in the predictors. Moreover; the value of Pseudo-R^2 (0.549) indicates that there was no systematic difference in the distribution of covariates between irrigators and non-irrigators in the study area. The logit regression revealed that variables such us the household size, education of the household of head, family labour, land acquisition cultivated land size, access to credit, good price of produces and access to extension services positively affect the probability of participation in irrigation farming significantly.

The Logit estmates indicate that gender of household heads positively and significantly (at 10% level) affects the probability of participation in irrigation. This implies that male headed households are more likely to participate in irrigation schemes than female headed households. This is due to land ownership where femaleheaded households have limited land and resource access and males have more exposure to other social and economic activities, the above result shows this effect.

This result is contrary to the study conducted by Denison and Manona, (2007); Mnkeni *et al*., (2010); Sikhulumile *et al*., (2014). The studies found that female headed households are more likely to participate in irrigation schemes.

Age positively and insignificantly affects the probability of participation on irrigation schemes. As the age of the household head increases by 1 year up to a certain level, the probability of participation in irrigation would increase by 1.9% marginal effect, other variables in the model remaining constant.

Household size was statistically significant (at the 1% level of significance) and it is positively associated with the probability of participation in irrigation farming. The possible reason is that household with larger family size can probably have more labor to engage in irrigation schemes. Since households with larger household size can perform various agricultural activities without labor shortage. Hence, households with larger household size can probably choose to participate in irrigation farming in the area. A unit change in family size of the household the probability of participation would increase by 73%. Other variables in the model remain constant at their mean value. This finding is consistent with the study conducted by Sikhulumile *et al*. (2014); Haile (2008); Shimelis (2009) that household size positively increases the probability of participation in irrigation farming. This suggests that the increase in the household size implies a cheap labor and has a higher chance to participate in irrigation schemes.

The results indicate that households with large cultivated land size where less likely to participate in the irrigation scheme. This was shown by negative coefficient of cultivated land size (-1.63) and significant at 1% significance level. Such negative relationship between cultivated land size and participation in irrigation schemes is consistent with other studies in Epthiopia (Gebrehawaria *et al*., 2009; Tewodros, 2010).

The finding also shows that, access to extension service was statistically insignificant but has a positive effect on probability of participation in irrigation farming. The positive effect of extension service shows that households who get more extension service are more likely to participate in irrigation schemes than households with no or little extension service. That is household with extension service are 74% more likely to participate in irrigation than household heads with less extension service. This study partially agrees with (Phoebe *et al*., 2000) that farmers access to extension service and information leads the probability of adopting new technology, since they can use the resources wisely for better production and productivity of high value crops, (Madhusuda, B. *et al*., 2002; Sikhulumile *et al*., 2014). In addition (Gebregziabher *et al*., 2009) reports that the household heads with higher extension service are more likely to participate in irrigation schemes.

Access to credit had a positive and statistically significant (at 5% significance level) relationship with irrigation participation, suggesting that the farmers with credit availability have higher opportunities to engage in irrigation farming otherwise. Access to credit played an important role in improving household livelihoods. Households with access to credit purchased more inputs (fertilizer, improved seed variety, agro chemicals) than those without. Access to credit support also ensures that farmers can secure inputs in time. This leads to improved agricultural output, resulting in increased farm income. Machete *et al*., (2004) suggest that one of the most critical problems threatening the viability of irrigation is the lack of credit.

From the table, access to market was statistically significant (at the 5 percent level of significance) and it positively affects the irrigation participation of the household head. This implies farmers with access to the market have a higher likelihood of participating in irrigation farming. The farmers who reported that the market is easily accessible have above 100% chance of being irrigators than those who reported otherwise. As irrigation is meant to enhance productivity and marketable surplus, it is not surprising that those farmers with better market access are more likely to participate in irrigation schemes. This means that the better the households head had access to market the more probable they would participate in irrigation schemes. A study by Adeoti *et al*., (2007) on adoption of treadle pumps and poverty impact in Ghana, found markets as significant determinants of participation in treadle pump irrigation.

Years of schooling of the household head returned a positive and significant coefficient but statistically insignificant. This is consistent with prior expectation as more educated farmers have better knowledge on the importance of adopting new technologies.

The results indicate that the perceived quality of land has a positive influence on irrigation participation. Those farmers who perceived their soil fertility to be good had a 21% more chance of being irrigators than those who felt that their soils were infertile. This result is not unexpected, as irrigation comes at a cost such that only those farmers with good land quality expecting better yields would engage in irrigation farming. This is consistent with results from (Bacha *et al*., 2011; Tesfaye *et al*., 2008).

Perceived quality of land has a positive influence on irrigation participation. Those farmers who perceived their soil fertility to be good had a 43% more chance of being irrigators than those who felt that their soils are infertile. This result is not unexpected, as irrigation comes at a cost such that only those farmers with good land quality expecting better yield would engage in irrigation farming. This is consistent with results from Bacha *et al* (2011) and Tesfaye *et al.* (2008). The results also show that access to the market increases the likelihood of farmers participating in irrigation farming.

Table 4.14 Logit model predicting probability of irrigation participation.

Propensity score estimation results

Variable	Coefficient	Standard Error	z	*P*>|*z*|
Constant	2.069492	2.338395	0.89	0.376
Age of respondent	0.0189307	0.0473391	0.4	0.689
Gender of respondent	1.155598	0.691522	1.67	0.095
Years in schooling	0.0054362	0.0617102	0.08	0.935
Marital status	0.9276251	0.6984986	1.33	0.184
HH size	0.7302537	2265404	3.22	0.001***
Family labour size	-0.708149	0.2717252	-2.61	0.009***
Yrs of experience	-0.0574207	0.0516599	-1.11	0.266
Freq. of irrigation	-0.6487952	0.7350124	-0.88	0.377
Cultivated land size (ha)	-1.630677	0.4758094	-3.43	0.001***
Land quality	0.4344395	0.5678194	0.77	0.444
Land acquisition	-2.695766	0.9305338	-2.9	0.004***
Mkt access (inputs)	1.709514	0.7405209	2.31	0.021**
Mkt access to sell	-0.2068529	0.747477	-0.28	0.782
Credit access	1.852082	0.7176332	2.58	0.01**
Access to extension	0.74119	0.6268245	1.18	0.237
Good price (last yr)	-1.754748	0.6480025	-2.71	0.007***
Logistic regression		Number of Obs	=	171
		L R Chi2 (17)	=	114.41
		Prob > Chi2	=	0.000
Log likelihood = -46.996528		Pseudo R2	=	0.549

Note: *** significant at 1%, ** significant at 5% and * significant at 10% of significance levels

Source: Field survey, 2014

4.11 Estimation of Treatment Effect: Matching Algorithms

The second step of the econometric analysis is matching treated households with households from the control group on the basis of their propensity scores. To assess the causal effect of irrigation farming on household income, one outcome variable was employed; household income. Accordingly, the ATT was estimated using nearest neighbor, and kernel matching algorithms. The subsequent sections present the impact of irrigation on the outcome variable of interest, household income.

4.11.1 Impact of Irrigation Schemes on Household Income

Table 4.11 presents results from the PSM model that was estimated for comparison purposes with the treatment effect model results. The propensity score matching results indicate that irrigation has a significant impact on the livelihoods status of irrigators. Irrigators" income is found to be between GH₵ 1986.11 and GH₵ 1990.65 more than the non-irrigators based on the matching method adopted. Two matching estimators, the nearest neighbor and the Kernel based matching algorithms were employed as robustness checks.

Table 4.15 Matching methods to measure impact of irrigation on household income

Matching Algorithms	Number of Treated	Number of Control	Household Income			Standard Error	t-stat
			Matched treated	Matched Control	ATT		
Nearest Neighbor	108	46	1986.11	651.02	1335.09	133.17	10.03***
Kernel matching	107	44	1990.65	636.78	1353.87	209.14	6.47***

Note: *** significant at 1%, ** significant at 5% and * significant at 10% of significance levels

Source: Field survey, 2014

The Nearest Neighbor matching method identified 46 comparable control households, while the Kernel matching method identified 44 control households from the nonirrigators. The average income estimated using the Kernel matching algorithms is higher than that of the Nearest Neighbor matching algorithms, indicating that the Kernel matching algorithms is somewhat conservative. Thus, both matching methods indicate that irrigation schemes play an important role in the creation of livelihoods as well as poverty reduction in the area.

Comparing the results across the different matching methods indicate that the estimated irrigation impact is robust.

The results imply that irrigated farmers get between GH₵ 1335.09 (US$ 4272.29) and GH₵ 1353.87 (US$ 4332.38) more than the non-irrigated farmers depending on the matching method used. This is consistent with the findings of previous studies (Tesfaye *et al*., 2008; Gebregziabher *et al*., 2009; Bacha *et al*., 2011; Kuwornu and Owusu, 2012; Sikhulumile *et al*., 2014). This indicates that access to irrigation schemes has led to significant increase in household income.

Figure 4.2 and 4.3 show a visual presentation of density distributions of the estimated propensity scores for the two groups. These histograms illustrate the number of respondents who are on irrigation support and those off support. It can be seen that the common support condition is satisfied. There is an overlap in the distribution of the propensity score of both irrigation (treated) group and non-irrigation (untreated) group. The upper havles of the histograms show the propensity score distribution for the irrigato while the bottom halves refer to that of the non-irrigators.

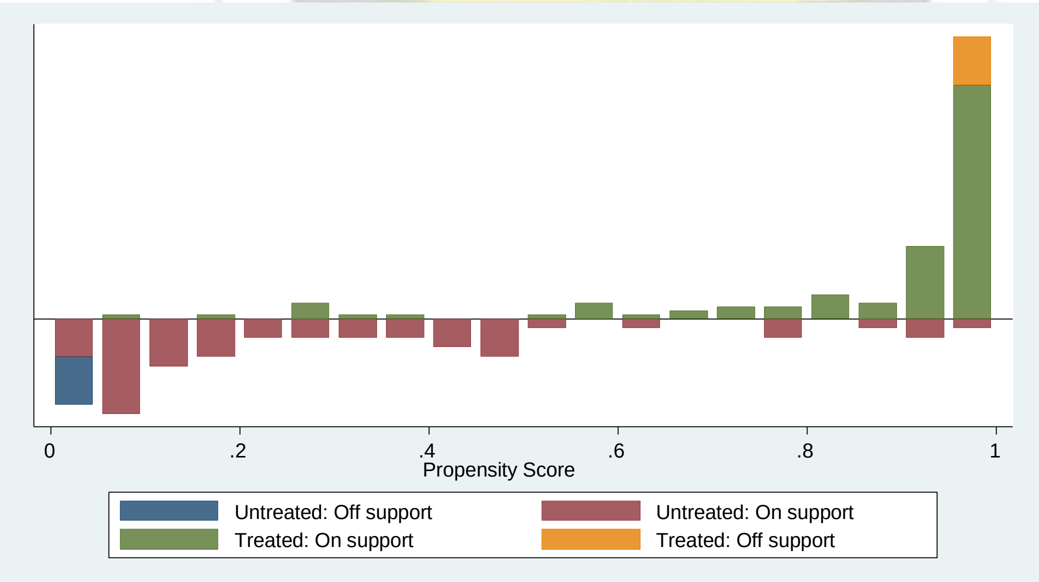

Figure 4.2 Density distributions of propensity scores using Nearest Neighbor

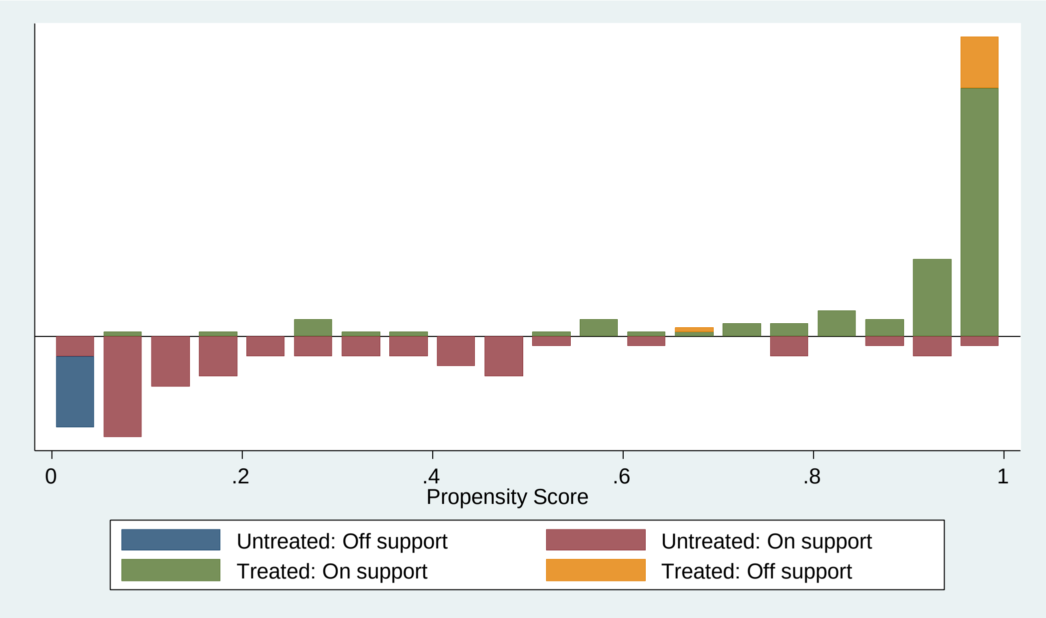

Figure 4.3 Density distributions of propensity scores using Kerel matching

4.12 Constraints Confronting Farmers

The result from the Kendall‟s Coefficient of Concordance analysis showed cost of inputs (high cost of fertilizer, pesticide, seed and tractor services), credit, water shortage, land and exploitation by market queens as the main irrigation farming constraints in the study area (Table 4.16). Labour, pest and diseases, crop damage by animals, poor extension service and theft were the least occurring irrigation farming constraints in the study area. The null hypothesis $\boldsymbol{(H_o)}$ that there was no agreement among the respondents over their ranking of the constraints to irrigation farming was rejected at the 5% significance level because the calculated F-value (150.2) was greater than the critical **F-value** (1.5). Hence, there was agreement among farmers on the ranking of the constraints. The Kendall‟s Coefficient of Concordance (***W***) analysis showed that 47% of the farmers were in agreement on the ranking of the constraints facing irrigation farming.

Table 4.16 Constraints Confronting Irrigation Farmers

Constraints	Mean Rank	Position
Inputs	3.37	1st
Credit	3.48	2nd
Water shortage	3.53	3rd
Land	4.39	4th
Marketing	4.82	5th
Labour	5.53	6th
Pest and diseases	5.88	7th
Crop damage by animals	6.24	8th
Poor Extension service	8.25	9th
Theft	9.52	10th
M =171	***p* = 0.000**	
Kendall's (*W*) = 0.47	**df = 9**	

Source: Field survey, 2014

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

The government of Ghana has given attention to irrigation schemes so as to reduce the frequent drought and food insecurity problem in the region. The objective of this study was to evaluate the impact of irrigation schemes on farmers‟ income in the study area. A multi-stage sampling was employed. The study purposively selected Kasena-Nakana and Bongo districts. Thevsample size was 180 respondents comprising of 120 irrigating farmers and 60 non-irrigators. Data for the study were collected from randomly selected farmers using semi-structured questionnaire in two districts. Although the irrigators and non-irrigators had the same demographic cherateristics, the income of the irrigation farmers was found to be higher than that of non-irrigators.

Logit estimation and PSM method were employed to access the participation decision of farmers and the impact of the irrigation schemes on farmers‟ income respectively. Propensity score matching (PSM) was favored because it minimizes problems associated with selection bias. NNM and KBM algorithms were used to estimate ATTs. The ATTs result shows that the average income of irrigators was significantly higher which is GH₵ 1986.11 and GH₵ 1990.65 compared to non-irrigators of GH₵ 651.02 and GH₵ 636.78. A positive and significant ATTs was reported in relation to the impact of irrigation schemes on farmer income. The average farmer income for irrigating households was found to be GH₵ 1335.09 and GH₵1353.87 using the NNM and KBM algorithms respectively. Thus, it can be concluded that irrigation schemes enabled farmers to increase yield, to minimize crop failure and hence to enhance productivity and farm income.

The Kendall‟s Coefficient of Concordance (***W***) result shows that the major constraints confronting irrigation schemes were high cost of inputs (3.37), credit (3.48), water shortage (3.53), land (4.39), marketing (3.82), labour (5.53), pest and disease (5.88), crop damage by animals (6.24), poor extension (8.25) and theft (9.52).

5.2 Conclusion

From the research findings, it could be concluded that irrigation schemes play a crucial role in ensuring increase household income in the region. Farmers have affirmed that they benefit greatly from these schemes and that has improved their income, livelihood to ensuring food security in the region.

5.2 Recommendations

These results indicate that irrigation schemes have a profound effect on household income and livelihoods. Hence, such schemes need to be encouraged. The following recommendations, which can possibly be applied in other rural areas in the regions were drawn based on findings of the study results in the two districts;

- Agriculture particularly crop production is by its very nature a risky business. The lack of up-to-date market prices and demand information could push irrigation farmers producing for markets to produce the wrong products, at the wrong time, and in the wrong quantities. This could deter farmers from producing high value crops and to shift their production to low yield and low income giving crops. The success of irrigation farming depends on the existence of an efficient marketing system. Thus, for irrigation farming to have an impact on income, livelihood and poverty reduction, linking farmers with markets and marketing systems would be the most urgent action required. In this regard, farmers must have reliable and quality information about markets in sufficient time before planting, to enable farmers to adjust their temporary crop mix to accord with market demand and price signals so that farmers could sell the crops they grow more easily. Hence, it is recommended for local and central bodies and non-government organizations to work together to improve the existing marketing system which includes the institutional arrangements, education of farmers regarding the market, and developing market facilities such as storage and other services.
- Also the study recommends that, market access for farm inputs such as chemical, seeds, fertilizer and access to credit should be improved to enghance participation in irrigation schemes as well as improve market access conditions and marketing infrastructure as a form of incentive for irrigating farmers to increase effectiveness of irrigation schemes.

- The gender dimension of access to irrigation is not uniform. From the descriptive analysis it was reported about 24% of irrigating households were female headed. This could be due the uneven access to resources and decision making powers between males and females. Therefore, interventions that ensure gender equity and empowerment should be introduced to enable female headed households benefit from irrigation farming.
- The present agricultural extension service available to those farmers utilizing the irrigated lands is extremely limited and ineffective, both in terms of numbers of staff and in relation to the quality of the advice they are able to provide to farmers. Interviews with ICOUR and MoFA officers confirmed that extension agents are not well-equipped to undertake their task effectively.

  Thus, the likelihood of irrigators receiving useful services from extension agents is limited. To make irrigation farming more successful, it is therefore recommended that special attention should be given to strengthen the capabilities of the existing extension system by assigning additional extension agents as well as equipping them with the necessary technologically appropriate equipment such as motor cycles, mobile phones etc.
- Finally, the study suggested for expansion of irrigated areas (small-scale, medium and large scale schemes), adoption of modern technologies and formulation of farmers‟ friendly policies.

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APPENDICES

Appendix 1. Logit Estimation for Participation in Irriagtion

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. db psmatch2

. psmatch2 Types_Farming Age Gender Schooling_years Marital_Status HH_Size Famil
> y_labour_size How_long_farming Often_irrigation Land_quality Land_acquisition
> Land_cultivated Market_access Access_to_sell Credit_acces Extension_access Goo > d_price
Yield_of_crop, outcome(Yearly_Income) index logit odds neighbor(10) ai > (10) ate common
caliper(10)

Logistic regression                               Number of obs   =        171
                                                  LR chi2(17)     =     114.41
                                                  Prob > chi2     =     0.0000
Log likelihood = -46.996528                       Pseudo R2       =     0.5490
```

Types_Farm~g	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Age	.0189307	.0473391	0.40	0.689	-.0738522	.1117137
Gender	1.155598	.691522	1.67	0.095	-.1997607	2.510956
Schooling_~s	.0054362	.0671702	0.08	0.935	-.126215	.1370874
Marital_St~s	.9276251	.6984986	1.33	0.184	-.441407	2.296657
HH_Size	.7302537	.2265404	3.22	0.001	.2862426	1.174265
Family_lab~e	-.708149	.2717252	-2.61	0.009	-1.240721	-.1755774
How_long_f~g	-.0574207	.0516599	-1.11	0.266	-.1586723	.0438309
Often_irri~n	-.6487952	.7350124	-0.88	0.377	-2.089393	.7918025
Land_quality	.4344395	.5678194	0.77	0.444	-.678466	1.547345
Land_acqui~n	-2.695766	.9305338	-2.90	0.004	-4.519579	-.8719534
Land_culti~d	-1.630677	.4758094	-3.43	0.001	-2.563246	-.6981077
Market_acc~s	1.709514	.7405209	2.31	0.021	.2581197	3.160908
Access_to_~l	-.2068529	.747477	-0.28	0.782	-1.671881	1.258175
Credit_acces	1.852082	.7176332	2.58	0.010	.4455472	3.258618
Extension_~s	.74119	.6268245	1.18	0.237	-.4873634	1.969743
Good_price	-1.754748	.6480025	-2.71	0.007	-3.024809	-.4846861
Yield_of_c~p	.0221671	.5747256	0.04	0.969	-1.104274	1.148609
_cons	2.069492	2.338395	0.89	0.376	-2.513679	6.652662

```
There are observations with identical propensity score values.
The sort order of the data could affect your results.
Make sure that the sort order is random before calling psmatch2.
```

Variable	Sample	Treated	Controls	Difference	S.E.	T-stat
Yearly_Income	Unmatched	2089.16667	608.823529	1480.34314	155.392105	9.53
	ATT	1665	500	1165	329.442786	3.54
	ATU	500	1665	1165	329.442786	3.54
	ATE			1165	329.442779	3.54

Note: Sample S.E.

psmatch2: Treatment assignment	psmatch2: Common support Off suppo	On suppor	Total
Untreated	49	2	51
Treated	110	10	120
Total	159	12	171

Appendix 2 Survey Questionnare

SURVEY QUESTIONNAIRE

THE IMPACT OF IRRIGATION SCHEMES ON FARMERS INCOME AND LIVELIHOODS IN THE UPPER EAST REGION

Department of agricultural Economics, Agribusiness and Extension-KNUST

The questionnaire is prepared to undertake a study *The Impact of Irrigation on Farmers Income and Livelihoods in the Upper East Region***.** The purpose of the questionnaire is to gather information on irrigating and non-irrigating household‟s socio-economic, agricultural and non-agricultural activities, access for services and other important information. Dear respondents, the result of this study will help different stakeholders and policy makers to make appropriate measures on irrigation development in the future. Your responses are confidential. Therefore, you are kindly requested to provide genuine responses. Thank you for your time and cooperation!

Questionnaire No………………………...   District…………………....……………

Village……………………………………. Name of Interviewer……….……………

Date of Enumeration……………………..   Mob. No…………………...……………

SECTION A: DEMOGRAPHIC CHARACTERISTICS

1. Name of respondent …………………………….. 2.
Gender Male = 1 Females = 2
3. Age of respondent………………………………..
4. Number of years in School……………………..
5. Level of formal education 0= No Formal Education 1= Primary 2= JHS
3= SHS/Technical 4 = Tertiary
6. Religion ……… 1= Christian 2= Muslim 3= Traditional 4= Others Specify
7. Marital status - a) Single b) Married c) Divorced d) Separated e) Widow
8. Household size …………………

Table 1: Household composition (number of people living under respondent care)

Age Group & other measures	Gender		Total	Number not earning income	Number of adults
	Male	Female			

Under 15 yrs					
15-30 yrs					
> 30 <65yrs					
Above 65 years					
Total					
Dependency ratio	Dependency ratio: Number earning income/ number not earning income				
Adult Equivalent	= 1+0.7(N1) +0.5(N2) where N1= number above 15 years, N2= Number above 15 years				

SECTION B: IRRIGATION FARMING AND LIVELIHOODS

Participation in Irrigation

1. Which season(s) farming do you undertake? 1= irrigation farming 2= rainy season farming
2. Are you engaged in other income generation activities apart from irrigation/rainy season farming? Yes = 0 No = 1
3. Besides the irrigation/rainy season farming, what are the other activities you do to earn you income?
4. Which of these activities earns you more income?
5. How long have you practiced irrigation/rainy season farming?………(years).
6. How often do you practice irrigation farming? 1= Once in 5 years 2= Between 2- 3 times in 5 years 3= between 4 – 5 times in 5 years
7. Which of these farming activities are you involved in? 1= Production 2= processing 3= marketing 4= Combination
8. What are your main objectives for doing irrigation? (Rank according to importance) 1= to gene rate cash income 2= to produce food for the household 3= produce livestock feed 4= others (specify)……….

Land Acquisition for Irrigation Farming

1. Do you have access to irrigated land? 0=Yes 1= No
2. If yes, how did you get access to irrigated land?
   1= family/ inheritance, 2= community usage right, 3=Purchased 4= rented from ICOUR
3. How much irrigated land do you have access to?………………..acres

4. If you do not have access to irrigated land, have you ever tried to access land and you did not get? 0= yes 1= No
5. What are some of the problems you encounter when trying to access irrigated land?……………………………………………………………..

Table 2: Contribution of Irrigation to Rural Household Livelihood Outcome

Respondents sources of income and their proportionate contribution to HH income

S/N	Source of income	Yes	No	Period Undertaken	Income per cycle	Income per Month	%contribution to HH income
1	Livestock keeping						
2	Off – farm casual labour						
3	Formal employment						
4	Remittances (from relatives)						
5	Trade in off- farm goods						
6	Irrigation farming						
7	Rainy season farming						
8	Others (specify)						

Respondent physical assets

Table 3 Now I have some questions about items that your household might own. *(An appropriate list of assets must be created for each site)* I will read a list of items and I would like you to indicate if you or anyone in your household owns any of these items

Item (Read across by row a.-c. item by item)	a. Does anyone in the Household own this item and it is in a good working or use condition? (read and Check box if *"yes"*)	b. Was this item(more of this item) acquired during the last 12months*(Mark with √)*		c. Were you undertaking dry season farming when this item (or more of this item was acquired	
		1= Yes	0= No	1= yes	0= No
Consumer Assets of Relative Modest Value- On Average worth less than GH¢100					
Bicycle					
Radio or Tape					
CD/DVD player					
Chairs/benches/ tables					
Consumer Assets of Mid – range Value- on average worth more than GH¢100 but less than 1000GH¢					
Stove/refrigerator					
Television					
Frame bed/mattress					

Consumer Assets of High Value- on average worth more than GH¢1000			
Motorcycle			
Car/pick up			
Tractor			

Table 4 If you own any of these assets kindly state the quantity and how much you would sell them now?

no	Item	Quantity	Resale value (GH¢)	Item	Quantity	Resale value (GH¢)
1	**Radio/ cassette/CD player**					
2	**Telephone (mobile)**					
3	**Telephone (fixed)**					
4	**TV**					
5	**DVD player**					
6	**Refrigerator**					
7	**Freezer**					
8	**Gas cookers, stoves, coal pots**					
9	**Electric irons**					
10	**Lanterns, gas lights**					
11	**Utensils/cutlery/ Buckets**					
12	**Car/trucks (commercial)**					
13	**Motorcycle**					
14	**Bicycle**					
15	**Car(private)**					
16	**Bedstead**					
17	**Mattresses**					
18	**Room furniture**					
	Total Value					

HOUSEHOLD LEVEL WELFARE INDICATORS: HOUSING IMPROVEMENTS

1. During the last two years, were any repairs, improvements or additions made to your home at a cost? 1=yes 2=No 99=Don‟t know

Table 5: *(If yes to #1)* which of the following have you done in the last two years?

Housing Repairs, Improvements, or Additions*(for clients, read across the row by item)*	a. *("Read and check if yes")*	Where you undertaking dry season farming when this was done?*(mark with √)*	
		1=yes	2=No
a. House repairs or improvements (e.g., fixed or improved existing roof, floor, or walls)			

b. House expansion (e.g. Built new room, shed, attic, or fence			
c. improve water or sanitation system (e.g. new well, drainage/sewage system, or showers-latrine)			
Lighting/electricity			

HOUSEHOLD LEVEL WELFARE: DIET COPING WITH DIFFICULT TIMES

1. During the last 12 months has your households diet *(read the answers and indicate response).* 1= worsened 2= stayed 3= improved 99=don‟t know
2. (if worsened)How has it worsened?…………………………….
3. (*if improved)*How has it improved?*(Do not read answers. Multiple answers possible.probe by asking. "and anything else)*

   1= Able to buy more cereal stables

   2=Able to buy more Animal /dairy products- Fish,meat,milk,eggs

   3= Able to Buy more condiments,vegetables, legummes to eat with staples

   4= Able to buy more Convinienient foods Like gari, Kulikuli, zumkum

   5= Able to buy more cooked foods

   6=able to eat better during the hungry season

   7=Able to eat 2 meals in a day

   99=Don"t know
4. Did you produce enough for your household consumption from rain fed and irrigation during 2013/2014? 1= yes; 0 = no
5. If **no**, how much of your household food requirement was met from 2013/2014 produce (months)?
6. During the last 12 months, was there ever a time when it was necessary for your household to eat less or eat else where either because of a lack of food or a lack of money to buy food? 1=yes 0=No 99=don‟t know
7. How long did this period last? Specify number of months……… 99=don‟t know
8. What did your household do to get through this difficult situation?*(read answers. Multiple answers possible)*

   1= Borrowed money /food from family/friend at no cost

   2=Borrowed money/ food at cost

3= Sold personal property

4= Self or some one else in the family left area to seek empolyment

5= Self or someone else in the family got local employment

Table 6: Household Welfare Indicators; Social Services

In the last 12 months have you been able to assess the following?	Yes/No	Were you able because of your involvement in irrigation farming? Yes/ No		Is there any change in your livelihood outcomes because of irrigation? If yes, which way?
Education				
Health insurance				
Social benefits				
Livestock				
Asset				
Employed farm labour				

PRODUCTIVITY OF IRRIGATION AND PROFIT MARGINS

Table 7: Cost and profit margins for both irrigators and non-irrigators

Cost of production	**Quantity (kg)**	**Unit price (GHC)**	**Total value (GHC)**
Seed			
Bags/creates			
Transport			
Land hiring			
Water payment			
Tractor services			
Fertilizer			
Extension charges			

Table 8: RESPONDENT LABOUR COST ON FARM PRODUCTION

Farm Operation	Type of labour		Cost per man-day	Total amount GHC
	Family **No of Persons**	Hire **No of person**		
Land clearing				
Ploughing and harrowing				
Levelling				
Planting				
Weeding 1 and 2				
Fertilizer application				
Harvesting				

Processing				
Total				

CROP PRODUCTION IN THE IRRIGATION

Table 9 Crop production in irrigation (Nov 2013- June 2014)

No	**Type of Crops**	**Plot size (acres)**	**Total Production (kg)**	**Consumed at (kg) Home**	**Sold**		
					Amt(kg)	**Value (GHC)**	**Average Price**
1.							
2.							
3.							
4.							
5.							
6.							
Total							

1. Why do you select the above type of crops for your irrigation farming?

   1 = Better price 2 = Good production 3 = High disease tolerance 4 = Easiest to cultivate

   5 = Seed availability 6 = Others (Specify)…………….

2. Did you get reasonable price for your produce at the place you used to sell to?

   0 =Yes 1 = No

3. How would you describe the yields of the crops? (Good, Bad and Average)………
4. Before you started this irrigation farming, what was the estimated monthly income of your HH?.......
5. What is the estimated monthly income of your HH now?..................................
6. What is the estimated monthly expenditure of your HH now?...........................
7. In which specific way(s) has this irrigation farming being help to you?
8. From the above, can you say that you are better off with the introduction of the irrigation scheme than before?

CONSTRAINS CONFRONTING IRRIGATION FARMERS

1. Do you face constraints in irrigation farming? Yes/ No

Table 10: Below is a list of constraints. Rank each constraint by assigning 1 to the most pressing constraint and 2 to the next pressing constraint in that as shown in the table.

Constraint	Rank	Remarks
water		
Land		
Labour		
Inputs		
Credit		
Marketing		
Theft		
Crop damage by animals		
Poor extension services		
Pest and diseases		
Others (specify)		

2. How does each constraint affect your participation in irrigation farming Give possible solution to each constraint stated above

   ……………………………………………………………………………………

MARKETING OF FARMING PRODUCED

1. In what way do you market your farm produce? Any problems? If yes what are these problems?
2. Where do you sell your produce? 1=Yes, 2=No
3. What challenges do you face in marketing your produce?
4. Do you get market information about prices and demand conditions of agricultural inputs and out puts? 0 = No 1 = Yes, if yes indicate the source of information………………………………
5. How far do you travel to get local market?…………………..km?