UNIVERSITY FOR DEVELOPMENT STUDIES, TAMALE

ASSESSMENT OF THE ECOSYSTEM, GENDER AND IRRIGATION NEXUS IN THE BAWKU WEST DISTRICT OF GHANA: A LIVELIHOOD APPROACH

DELIGHT KOMLA TENDEKU

2017

UNIVERSITY FOR DEVELOPMENT STUDIES, TAMALE

ASSESSMENT OF THE ECOSYSTEM, GENDER AND IRRIGATION NEXUS IN THE BAWKU WEST DISTRICT OF GHANA: A LIVELIHOOD APPROACH

BY

DELIGHT KOMLA TENDEKU (B.Sc. In Agribusiness)

(UDS/MEC/0027/14)

THESIS SUBMITTED TO THE DEPARTMENT OF AGRICULTURAL AND RESOURCE ECONOMICS, FACULTY OF AGRIBUSINESS AND COMMUNICATION SCIENCES, UNIVERSITY FOR DEVELOPMENT STUDIES IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF PHILOSOPHY IN AGRICULTURAL ECONOMICS

MARCH, 2017

DECLARATION

Student

I hereby declare that this thesis is the result of my own original work and that no part of it has been presented for another degree in this University or elsewhere:

Candidate's Signature: ……………………………. Date: ………………………………

Name**: DELIGHT KOMLA TENDEKU**

Supervisors'

We hereby declare that the preparation and presentation of the thesis was supervised in accordance with the guidelines on supervision of thesis laid down by the University for Development Studies.

Principal Supervisor's Signature: ………………………… Date: …………………………

Name**: DR. MAMUDU A. AKUDUGU**

Co- Supervisor's Signature: …………………………….. Date: …………………………..

Name**: PROF. SAA DITTOH**

ABSTRACT

In many drier countries around the world including Ghana, irrigation is one of the key strategies being used as climate change adaptation. This is however, being done without an adequate understanding of how the use of irrigation for livelihoods development affects the ecosystems. The purpose of this study therefore is to examine the irrigation, ecosystems and livelihoods nexus in the Bawku West District of the Upper East Region of Ghana. The study relied mainly on primary data collected from 304 respondents randomly sampled across four irrigating communities in the Bawku West District of Ghana. The data collected were analysed descriptively and quantitatively using probit and treatment effect models. The study results revealed that there is a strong link among irrigation, ecosystems and livelihoods of farmers. Whiles ecosystem provides important source of livelihoods through provision services such as food, income and good health, livelihood strategies, particularly irrigation are over-stretching it leading to the decline in its capacity to continue to support sustainable livelihoods. Age, marital status, market availability, extension contact and farm size, were found to significantly influence farmers' decision to participate in irrigated agriculture, which improves the livelihood of farmers in the study area. Farmers in the study area are constrained with labour, pest and disease infestation, limited access to credit, high cost of inputs, low price of farm produce, limited access to technologies and poor water supply. This notwithstanding, potentials for the upscaling of irrigated agriculture exist – availability of land, accumulation of wide range of experience in farming and the willingness of farmers to venture into agriculture as a business (entrepreneurial skills). The study recommends among other things, the need for farmers to employ ecosystem friendly practices in their irrigation activities to ensure sustainable livelihoods in the long term.

ACKNOWLEDGEMENT

My greatest appreciation goes to the Almighty God for His grace and provisions throughout this program. My deepest gratitude and thanks also go to my supervisors –Dr. Mamudu A. Akudugu and Prof. Saa Dittoh for their directions, guidance and constructive criticisms, which helped to produce this work. Indeed, I am very grateful for all your support. I further wish to express much gratitude to all Senior Members in the Department of Agricultural and Resource Economics, University for Development Studies, who in diverse ways assisted to get this work done. To my colleague students of the Department, I thank you very much for your valuable contributions to this thesis. My deepest thanks also go to Ghana Irrigation Development Authority (GIDA) and University for Development Studies (UDS) for supporting this research under the Water, Land and Ecosystem Project. To all members of the research team, I acknowledge your support and counselling. In addition, I wish to acknowledge Mr. Dennis Ehiakpor and Mr. Franklin Mabe for their contributions and support throughout my study.

God richly bless you all.

DEDICATION

This thesis is dedicated to my father, Mr. Delali W. Tendeku and mother, Mrs. Wilhemina Beatrice A. Kpenge.

TABLE OF CONTENTS

Contents **Page**

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

ACRONYMS	MEANING
ADB	Agriculture Development Bank
AERC	African Economic Research Consortium
AIDS	Acquired Immuno-Deficiency Syndrome
ATE	Average Treatment Effect
BWD	Bawku West District
DFID	Department for International Development
DoA	Department of Agriculture
EPA	Environmental Protection Agency
FAO	Food and Agricultural Organisation
FGT	Foster Greer Thorbecke
GHC	Ghana Cedi
GIDA	Ghana Irrigation Development Authority
GSS	Ghana Statistical Service
HIV	Human Immune Virus
IDS	Institute for Development Studies
IFAD	International Fund for Agricultural Development
IWMI	International Water Management Institute
JHS	Junior High School
MHa	Million Hectares
MoFA	Ministry of Food and Agriculture
METASIP	Medium Term Agricultural Investment Plan
MSLC	Middle School Leaver Certificate
NFTP	Non-Forest Timber Products
NGO	Non-Governmental Organisation

SEND	Social Enterprise Development
SHS	Senior High School
SWOT	Strengths, Weaknesses, Opportunities and Threats
UDS	University for Development Studies
UNCED	United Nation Conference on Environment & Development
UNDP	United Nation Development Programme
UNEP	United Nation Environmental Programme
USD	United States Dollar
WB	World Bank
WIAD	Women in Agriculture Directorate

CHAPTER ONE

INTRODUCTION

1.1 Background information

Food insecurity is one of critical challenges facing many developing countries and has been a global issue. Thus, the global community over the past decades tried to address this challenge by focusing on massive technological advancement in agriculture, which led to the green revolution with Asia leading the pathway for other continents like Africa (Otsuka & Kalirajan, 2006). This era experienced the introduction of high yielding crop varieties, fertilizer and pesticides intensification, which apparently led to increase in agricultural productivity. Consequently, both consumers and producers benefitted from the introduction of these productivity-enhancing technologies through increased farm incomes for producers and food availability for consumers (Fraiture *et al.,* 2010). This however, brought about the depletion of natural resources resulting in unsustainable use of ecological resource. Thus, most countries are already battling with food insecurity, low-income growth and high poverty (Huang *et al.*, 2006). The situation may even become worse with the declines in global food production that present far reaching consequences to poor rural households in food deficit countries (AERC, 2009; De Schutter, 2014). This is likely to be exacerbated by the adverse effects of climate change and variability, which could be mitigated using appropriate water harvesting technologies for irrigation.

Globally, irrigation farming plays a crucial role in not only food production but also, livelihood improvement. Although current irrigated land area is less, irrigation farming provides more than one-fifth of the world's food (Sebastian, 2014). Thus, irrigation can compensate for inadequate precipitation, especially in semi-arid regions like Sub-Saharan Africa where vagaries in weather patterns, limiting water supply and growing population continue to threaten food security. Thus, there have been massive development in irrigation infrastructure with corresponding expansion in irrigated area; increasing from 139 million hectares in 1961 to 277 million hectares in 2003 (FAO, 2003 in Fraiture *et al.,* 2010). This has led to a remarkable improvement in irrigation infrastructure across continents with irrigation accounting for 95 percent of all water withdrawal in most parts of developing countries with its importance closely connected to food provision and food security (Siebert *et al.,* 2013). A global map on irrigation for 2013 indicates that, the total area equipped for irrigation is estimated at 307.6 million hectares out of which 83 percent were irrigated. This is an increase of 33.6 million hectares over that of the year 2000 (Siebert & Doll, 2007; Siebert *et al.,* 2013). Out of the total area, irrigated surface water registered the largest form of water withdrawn (62%), and ground water (38%). Asia accounts for the highest area irrigated worldwide with 73 percent of their equipped irrigated areas put under cultivation as compared to only 4 percent in Africa (Siebert *et al.,* 2013). The statistics indicate that irrigation might have played critical roles in the green revolution experienced in Asia.

In the specific case of Ghana, crop production is predominantly rain-fed and characterized by farm holdings less than one hectare. Meanwhile, the sector employs as high as about 40 percent of the active labour forces mostly located in the rural areas (GSS, 2012). Consequently, crop farmers continue to risk poverty due to changes in the production environment, especially rainfall. Ghana currently has an irrigation potential of 1.9 million hectares however, only 50,000 hectares is actually equipped for irrigation out of which 94 percent is actually used for irrigation (FAO in Kyei-Baffour & Offori, 2006). Another account revealed that, total equipped area for irrigation consisted of 8,887 hectares of in 22 public schemes, 10,413 hectares of private as well as 40,000 of peri-urban irrigation. These consist of formal irrigation schemes that mostly use surface water whiles informal irrigation use different source like shallow wells, streams, waste water or pipe-borne water (mostly in urban and peri-urban areas). The METASIP (2010) outlines its strategy to rehabilitate existing dams and increase irrigable crop fields by 11, 000 hectares (Adomako & Ampadu, 2015). The importance of irrigated agriculture have been felt and reported in the areas of food and nutrition security, employment and poverty alleviation (Hussain & Biltonen 2001; Hussain & Hanjra 2003; Mangisoni 2003; Namara *et al.,* 2005; Namara *et al.,* 2011; Dittoh *et al.,* 2013). A highlighting challenge with irrigation includes the negative externalities to environment. These externalities include ecosystem degradation, fragmentation and desiccation of rivers, and drying of up of wetlands (Molden & de Fraiture, 2004).

Agriculture systems function in a broader scope called ecosystem services. According to Millennium Ecosystem Assessment (2005), ecosystem services are defined as the benefits derived from ecosystems, which include provisioning services, such as food, water, timber and fibre; regulating services, such as climate regulation, flood regulation and pollination; cultural services, such as aesthetic values, spiritual values and recreation; and supporting services, such as soil formation and nutrient cycling. Irrigation and ecosystems are intrinsically linked with livelihoods. They comprise of interwoven networks that reinforce each other (van Hoeve & van Koppen 2005). For instance, ecosystems support livelihoods through provision services such as food, fibre, water for agricultural facilitated by supporting and regulating services such as soil fertility and pollination. Furthermore, ecosystems through other regulating and cultural services provides scenic beauty, flood control, recreation and tourism that contribute to human well-being such as adequate livelihoods, sufficient nutritious food, health, secure resource access and security from disaster (UNEP, 2011). De Fraiture *et al.* (2010) also added that agricultural, natural resource and ecosystem services are intimately linked with livelihoods, food security and poverty reduction.

The concept of livelihood have been discussed among researchers and institutions. Proponents of livelihood argue that, livelihoods are not limited to only economic outcomes but stretches toward ecological and social factors (Krantz, 2001). According to Carney *et al.* (2000), livelihood comprise of the capabilities, assets and activities required for a means of living (Akudugu *et al.*, 2012). The term sustainable livelihood was first used by the Brundtland Commission on Environment and Development in 1983 as a way of linking socioeconomic and ecological considerations in a cohesive, policy-relevant structure. According to Akudugu (2011), livelihoods is the ability of individuals and households to take care of their health, educational, food, social and cultural needs and to make savings for future use. The same author opines that individuals, households and communities engage in a number of activities and strategies in other to earn their livelihoods. Important among these livelihood activities and strategies especially in rural areas of limited alternative livelihoods is irrigated agriculture supported by ecosystems. Ensuring a healthy functioning of ecosystems will guarantee the resilience of agriculture to meet the stress of growing demands for food productions.

The increasing recognition of gender in agricultural production cannot be over-emphasized. As against the previously conceived notion of development policies, the benefits accrued from agricultural resources affect beneficiaries differently based on their socio-economic factors. Men and women play different roles in agriculture and they face different barriers to their participation (Ogunlela and Mukhtar, 2009). Additionally, the use and management of agricultural resources is shaped by the different needs of men and women (CGIAR WLE, 2014). Empirical evidence points to the fact that, agricultural development interventions were hitherto not able to sufficiently target the poor partly because of their inability to link these interventions with production characteristics of agriculture and available natural resource with gender needs in other ensure equity. More so because of the complex linkages with environment and agriculture where gender relations in natural resource are tied to livelihoods (Hussain and Biltonen 2001; Dittoh *et al.,* 2015).

The contribution of women to agricultural food production and processing cannot be underestimated. Women smallholders in sub-Saharan Africa produce about 70-80 percent of the total food both for household consumption and sale and providing about 60-80 percent of farm labour(Ogunlela and Mukhtar, 2009; FAO, 2011). Thus, women's knowledge and supply of labour are very essential for sustaining food production. Furthermore, the participation of women in agricultural production is increasing due to temporal or permanent migration of men to urban areas for employment leaving women behind to do farm work. Other factors responsible for increasing women participation in agriculture include ease of handling, lack of alternative occupations, acquisition of technical know-how, and husbands influence (Gurung *et al.,* 2006; Ogunlela and Mukhtar, 2009). However, factors constraint women in agricultural production than men. In most cases, women are involved in food production while the men are involved in farm decision making and control of productive resources (Ogunlela and Mukhtar, 2009). Additionally, discriminatory practices women especially face in access and control over resources such as water, land, credit, technologies through extension and information are likely to prevent from adopting sustainable production practices (van Koppen 2002; Gurung *et al.,* 2006; Namara *et al.,* 2011; De Schutter, 2013; Dittoh *et al.,* 2015). It is important to appreciate that, social norms, intra-household decision making and bargaining influences the participation of men and women in sustainable agricultural initiative and the benefits they obtained from it and hence, addressing gender issues in a more comprehensive manner i.e. supporting efforts to shift away from discriminatory practices, to ones that are more equitable, would yield more for sustainable productions systems (CGIAR WLE, 2014). This is more important because, it has the potential of increasing agricultural food production of women by 2.5 – 4 percent and ultimately reducing malnutrition by 10 – 17 percent (FAO, 2011).

The Bawku West District of the Upper East Region of Ghana is notable for the existence of irrigation facilities which justifies its contribution to livelihoods. Despite the existence of irrigation facilities, there exist limited study on this subject. Understanding the interrelationship that exists between ecosystem and irrigation for sustainable livelihoods development is critical.

1.2 Problem statement

Over the years, irrigation has played an important role in promoting rural livelihoods, especially for those who depend on agriculture and in areas where non-farm income generating activities are limited (Hussain & Hanjra, 2003). Literature has however, established that access to irrigation facilities and irrigable land for irrigation activities are not equitable between men and women, as men tend to have greater access and control of these resources over women (Hussain & Biltonen, 2001; Dittoh *et al.*, 2015). Despite programmes and interventions of gender inclusiveness to ensure that there is gender equity in the sharing of ecosystems services and irrigation investments benefits, the gap continues to exist. The main problem however, is that there have been limited studies on this and even those studies that attempt to look at the issues under consideration were not holistic and are limited in scope and depth. For instance, while Namara *et al.* (2011) in their study focused on food security and poverty effects of ground water irrigation in the Upper East Region, it did not clearly provide the poverty effects on both men and women as it relates to their livelihoods. Faulkner (2006) studied profitability of small-scale irrigation schemes in the Upper East Region without considering impact of irrigation on environment and its effects on livelihoods. Ayitio and Dinye (2013) looked at the effects of Tono irrigation scheme on the poverty in the Upper East Region. All these studies including many others have demonstrated the direct effect of irrigation on productivity, employment and incomes but did not provide any insight on the level of synergy among ecosystems, livelihoods and gender. Thus, the need for this current study which looks at the connectedness or otherwise of ecosystems services, gender and irrigation as they relate to livelihoods development within irrigated landscapes. The essence is to provide the requisite information that will guide policy makers and implementers in taking the relevant decisions to strengthen the weak linkages in ecosystems services, gender and irrigation investments and sustain the stronger ones.

Women continue to have limited access and/or control over productive resources such as irrigable land and water (Hussain & Biltonen, 2001; Dittoh *et al.,* 2015), inadequate inclusiveness in decision making and agricultural water institutions (van Koppen, 2002) to be able to benefit equitably from irrigation development investments (Mehta & Srinivasan, 2000). The fact that women continue to benefit less from ecosystem services and irrigation investments, despite years of concerted efforts to improve their benefits thereof raises some fundamental questions on whether policy makers and implementers understand the ecosystem services, gender and irrigation nexus. Understanding the interrelationships existing among ecosystems services, gender and irrigation investments for sustainable livelihoods development is critical in ensuring equity. To do this, the research questions in the next subsection are pursued in this study.

1.3 Research questions

To address the problem identified, the study sought to provide answers to the following specific questions:

i. What are the perceived linkages among irrigation, ecosystems and livelihoods?
ii. What factors influence the involvement of men and women in irrigated agriculture?
iii. What are the effects of irrigation farming on livelihoods?
iv. What are the prospects, opportunities and constraints of involvement of men and women in irrigated agriculture?

1.4 Study objectives

1.4.1 The main objective

The main objective of the study was to assess how ecosystems, gender and irrigation linkages promote or otherwise livelihoods development in the Bawku West District of Ghana.

1.4.2 Specific objectives

Specifically, the study aimed to:

i. Assess the perceptions of farmers about the linkages among irrigation, ecosystem and livelihoods of men and women in BWD.

ii. Identify and estimate the factors influencing the involvement of men and women in irrigated agriculture.

iii. Examine the effects of farmers' involvement in irrigation farming on livelihoods.

iv. Examine the prospects, opportunities and constraints of men and women involvement in irrigated agriculture.

1.5 Justification of the study

There is increasing recognition of irrigation as not only a means of meeting food needs but also source of multiple benefits for livelihoods as well as an entry point for improving gender relations in agriculture. This research provides in depth knowledge about the benefits of irrigation to livelihoods within the broader framework of the ecosystem, which they exit in the study area. Although the findings of the study is limited to four communities in the district, it may be applicable to other communities and other parts of the country where socio-cultural, psychological and economic situation of the people do not differ much from those of the study area with little modifications and/ or adaptations. Considering the importance of irrigated agriculture to rural livelihoods, results from this research will assist policymakers both at local and national level to identify and adopt appropriate strategies for improving this resources to yield maximum benefits to livelihoods.

Findings on ecosystems and irrigation synergies will assists GIDA to incorporate ecosystem concerns into its policies and plans at not only the national level for planning irrigation infrastructure but also other irrigation and water management decision-making organizations. This will help achieve the institutions aim to develop irrigation infrastructure within a sustainable environment to benefit livelihood strategies. Besides, with the mandate to support livelihood development and well-being, particularly of women, in the agricultural sector, findings on the gender impacts of irrigation and ecosystem sharing will help WIAD in designing and packaging skills for capacity building in areas of gender and equity in irrigated agriculture.

The institution is involved in developing water management solutions to increase food production whiles achieving sustainable irrigation water use with specific interest on marginalized and vulnerable groups. This research complements that of IWMI by contributing to agricultural water management and the impact on livelihoods and health of ecosystems. The research may also contribute to planning and decision making in other institutions such as Environmental Protection Agency (EPA), Department of Agriculture (DoA), District Assembly and agricultural related Non- Governmental Organizations (NGOs). The study will add knowledge on ecosystems, irrigation and livelihoods and will be beneficial to researchers and academicians whiles it provides a background to further probe in the subject area.

1.6 Limitation of the study

The study had some limitations. First, the researcher would have wished to study in at least four (one each in the Kusaasi, Frafra, Kassena-Nankana and Builsa areas) of the 13 districts in the Upper East region however, the study was restricted to only a district in the Kusaasi area. This might limit the extent of generalization of the study results for the region. Second, there was also a language barrier as the researcher did not speak the local dialect (Kusaal). To overcome this limitation, interpreters were recruited and trained on the data collection instruments. That notwithstanding, there is high possibility that the true meaning of some of the key concepts (e.g. ecosystems services) that the study explored could be lost in translation thereby causing some distortions. Despite the above limitations, steps were taken to ensure reliability and validity of the data and study results.

1.7 Organisation of the study

Chapter one introduces the study. Chapter two presents the literature review where relevant literature on the study concepts are discussed. Chapter three outlines the methodology adopted for this study. Chapter four presents results and discussion of findings and finally chapter five focuses on the summary of key findings, implications, and conclusion and recommendations base on the findings of the research.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter focuses on how various authors and authorities have defined the concepts involved in this research. The relevant issues discussed under this chapter included; agricultural water development and irrigation system, gender participation in agriculture, agriculture, ecosystems and livelihoods, role of irrigation in livelihood improvement and sustainable livelihood framework.

2.2 Agricultural water development and irrigation systems

On the global scale, agricultural sector is noted to be the largest water user accounting for estimated 70 percent of withdrawals from rivers and aquifers. It is worth noting that, irrigated agricultural land comprises of less than a fifth of the total cropping area of the world but produce about one-fifth of the world food (Siebert *et al.*, 2013).

Asia continues to be the largest continent equipped for irrigation with an estimated 69 percent, 17 percent in America, 8 percent in Europe, 4 percent in Africa and 2 percent in the Oceania regions. By country, China represents the largest area equipped for irrigation with an estimated 62.4 million hectares followed by India with 61.9 million hectares and the United States of America with 28.4 million hectares. The major crops irrigated worldwide include rice (103 million hectares), wheat (67 million hectares), maize (29 million hectares) and cotton (16 million hectares) (Sebastian, 2014).

Africa represents the fourth largest in terms of area equipped for irrigation after Europe (Siebert *et al.*, 2013). Africa and other developing nations witnessed the most investment in irrigation between 1960s and 1970s with an area expansion of 2.2 percent per year reaching an estimated area of 155 Mha in 1982 (Carruthers *et al.*, 1997 in Ofosu *et al.*, 2014). According to Ofosu *et al.* (2014) citing Faures *et al.* (2007) the rate of investment has since declined due to many factors including underperformance and inefficiencies (Chambers, 1988), concerns over the negative social and environmental impacts, changes in competing water use and declining food prices (UNEP, 2011). Following this decline was a shift to private development of groundwater and shallow tube wells invented in India and Pakistan. FAO (2005) cited in Ofosu *et al.* (2014) noted that, this technology was adopted in most rural, urban and peri-urban areas in response to higher demand for fresh fruits and vegetables by growing cities. Sebastian (2014) recounts that, the total area equipped for irrigation in Africa is 13.5 million hectares out of which 11.5 million hectares are actually irrigated. The largest developed irrigated areas are in Egypt representing 3.5 million hectares, Sudan and South Sudan representing 1.9 million hectares, South Africa representing 1.5 million hectares and Morocco representing 1.5 million hectares. These countries represent 60 percent of equipped irrigated area in Africa. In addition, the region of highest density of irrigated land (about 50%) are located in Northern Africa in the Nile River basin (Egypt and Sudan), and in countries next to the Mediterranean Sea (Morocco, Algeria, Tunisia and Libya) (Ibid).

Irrigation constitutes a very small proportion of crop cultivation in West Africa. FAO (2005) remarked that irrigated agriculture contribution to agricultural production in the sub-region is estimated at 3 percent. It is worth noting that, West Africa is the second least developed irrigated area after Central Africa. Although there is potential for increasing investments in irrigation, the already existing irrigated agriculture has not yielded expected benefits. For instance, the FAO/The ENPLAN Group of 2004 revealed that irrigated agriculture contributed about 0.9 percent to grain production and 2.3 percent to vegetable production during the 2003/2004 production season in Nigeria –a country that records an estimated 58 percent of total irrigated area in the sub-region (FAO/The ENPLAN Group 2004 in Dittoh *et al.*, 2013).

Over the years, development programmes have focused on formal irrigation than the informal sector. In recent times, the latter has been given some attention following its significant contribution to agricultural production in the sub-region. Whiles the formal irrigation schemes normally concentrate on staples like rice, maize and wheat, informal irrigation characterized with small scale production systems are more prominent with vegetable production (Dittoh *et al.*, 2013). With the promise of increasing the future food demands with the scale informal sector, the sub-region faces a challenge of water scarcity since both surface and ground water have been reducing due to inefficiencies of most irrigation infrastructures (FAO, 2011).

Ghana's agriculture like semi-arid regions in West Africa is predominantly rain-fed characterized by farming households with farm holdings less than two hectares and employing substantial number of active labour force mostly located in the rural areas (MOFA, 2013). Irrigation thus presents an important tool for increased food production and poverty alleviation especially in many parts of the country where there are prolong dry spells and alternative sources of livelihoods are limited. Although the potential of irrigation's contribution has long received recognition its realization remains a dream because of the country has not done much to release the full potential. Currently, the country holds equipped areas of 50,000 hectares out of which 94 percent is actually irrigated area although it has an irrigated potential of 1.9 million hectares (FAO, 2005 in Kyei-Baffour & Offori, 2006). Siebert *et al.* (2013) also revealed that the total equipped area for irrigation consisted of 8,887 hectares of in 22 public schemes, 10,413 hectares of private as well as 40,000 of peri-urban irrigation. These consist of formal irrigation schemes that mostly use surface water whiles informal irrigation use different source like shallow wells, streams, waste water or pipe-borne water (mostly in urban and peri-urban areas). The Medium Term Agriculture Investment Plan (2010) outlines its strategy to rehabilitate existing dams and increase irrigable crop fields by 11, 000 hectares (Adomako & Ampadu, 2015).

2.3 Agriculture, ecosystem services and livelihoods

Agriculture systems function in a broader scope called the ecosystem services. The linkage among agriculture, ecosystems and livelihoods has been well established (Bhattarai *et al.*, 2007; Chandara *et al.*, 2012; Boon & Ahenkan, 2012; UNEP, 2010, 2011, 2012). An ecosystem is a complex system of plant, animal, fungal, and microorganism communities and their associated non-living environment interacting as an ecological unit (CBD, 2009; Bond *et al.*, 2009 in Boon & Ahenkan, 2012). The ecosystem provides services that are significant for human sustenance and development. Ecosystems provide a variety of services critical for sustainable livelihoods such as food production, timber production, genetic resource and medicine, fiber, waste management, water purification, pollination control, pest and disease control, protection of habitats and biodiversity, air quality regulation, carbon sequestration, tourism, flood control, cultural services, recreational, aesthetic values, and as well as supporting services such as soil formation and nutrient cycling (MA, 2005).

The benefits obtained therefrom contribute to various aspects of human well-being, such as adequate livelihoods, sufficient nutritious food, health, secure resource access and security from disasters especially the poor and vulnerable that have special relationship with ecosystems relating to their livelihoods (UNEP, 2011). Agriculture is one of the most important consumers of ecosystem services in terms of providing water to support farming systems and supporting genetic resources (Molten & de Fraiture, 2004). Despite the benefits derived from the ecosystem, agriculture continue to pose threat to the ecosystem functions limiting the ability to support life functions (Wezel *et al.,* 2009; UNEP, 2011).

According to United Nations Environmental Programme (2011), agriculture ecosystem aim at maximising the provisioning services of the ecosystems with little attention to all other functions of the ecosystems leading to decrease productivity. For instance, increase in food production have brought about land-use changes, which have affected the climate regulation services, hydrological cycles, pest and diseases control, nutrient losses affecting livelihoods. The Millennium Ecosystem Assessment (2005) reports that about 60-70 percent of the worlds ecosystems are deteriorating with dire consequences, and ability of agriculture to meet the growing demands for food production (FAO, 2008). Thus, increased food production is closely linked to ecosystem decline. Major challenge is how to meet the growing food demand of an increasing population without comprising the health of ecosystems.

2.4 Gender participation in irrigated and rain-fed agriculture

The contribution of agriculture to increase food security and poverty reduction cannot be underestimated particularly in sub-Saharan Africa where agriculture sector is considered to employ majority about 70 percent of labour force. (FAO, 2010; Team & Doss, 2011). Most farmers, especially in sub-Saharan Africa operate at the subsistence smallholder level in an extensive agricultural system. A chunk of this group of people lives in the rural areas where they obtain their livelihood from agriculture and related activities. As perceived over the years, most development programmes presume that, agricultural activities are normally dominated by men hence women farmers are normally not targets and where possible regarded as second best (De Schuter, 2013). Extant literature however, suggests that labour composition in agriculture is gradually shifting to female dominance (Pehu *et al.*, 2009). Factors responsible for this changing trend include diseases such as HIV and AIDS and migration of youth especially men whiles women are left behind with children due to reproductive roles. Pehu *et al.* (2009) indicate that, men are more likely to abandon agricultural work at home and migrate to seek for other sources of incomes leaving agricultural roles in the hands of women. A situation described as feminization of agriculture. Majority of these producers are rural women, playing triple roles in agricultural households: productive, reproductive and social. The productive role performed by both men and women, focuses on economic activities; the reproductive role, almost exclusively done by women, includes child bearing and nurturing; household maintenance, including cooking, fetching water, and fuelwood; and the social role or community building, often dominated by women, which includes arranging funerals, weddings, and social events.

In Africa and most developing nations, women play significant roles in the production and processing of agricultural products. Women produce over 70 percent of the world's food (FAO, 2010). Ekong (2003) added that, food security in Sub-Saharan Africa is largely dependent on women playing significant roles in land preparation for farming, planting of crops and vegetables, weeding, harvesting, processing of harvested crops and storage, transportation of agricultural produce by head porterage, fishing, fish processing and marketing of sea foods, processing and sale of dairy products and homestead livestock husbandry.

Women participation in agricultural activities are very significant providing labour in both food production for household consumption and for sale with crops either through rain-fed or irrigated agriculture. FAO (2002) revealed that, more men than women are involved in irrigated agriculture. Where women are involved, they perform the most tedious and time consuming farm operations such as planting, weeding, fertilizer application, processing marketing sometimes aided with simple tools that prolong drudgery in farm operations (Alade *et al.*, 2013). Even in situation where women are not involved in irrigation they are substantial source of labour for their male counterparts. It has been established that, most women who are engaged in irrigation benefits households more than their male counterparts since majority of their produce is for household consumption and for sustenance of livelihoods. Similarly, SEND Ghana (2014) also reports that if women farmers in Ghana have the same level of resources as men, their farm yields could increase by 20-30 percent and national output by 4 percent thus reducing hunger by 17 percent. Extant literature (van Koppen, 2002; Fortmann, 2009; Namara *et al.*, 2011; De Schutter, 2013; SEND Ghana, 2014; Dittoh *et al.*, 2015) has established that, most women involved in irrigation farming are confronted with numerous challenges as compared to their male counterparts. Furthermore, considering the tedious nature of irrigation activities, women are confronted with a dual task of allocating labour between agricultural activities and their already existing biological domestic tasks.

A study conducted among irrigating women by Alade *et al.* (2013) revealed that, about 57 percent of women do not own water pumps hence depend on family labour for farm operation which are normally tedious. The study revealed that due to the high number of children (average of 5 children) in the households, women engage in irrigation farming to augment food needs. The high numbers at the same time provides family labour. Also, about 80 percent of farmers will have to rely on their already stressed household resources to support their farming due to their inability to access credit facilities. Most farmers were involved in vegetables production that are consumed in their homes with lesser number cultivating staples like grains and cereals due to challenges associated with procuring the necessary inputs for their cultivation. Also, women highly participate in harvesting, processing, marketing, storage and transportation of produce most notable of them is planting (83.3%) and weeding (80%). The study also concluded that, participation in irrigation increased income, food production and security. Challenges confronted by women in the study area included lack of reliable water supply, lack of modern irrigation facilities, lack of credit facilities and political marginalization (Alade *et al.*, 2013).

Although both men and women play equally significant roles in agricultural production, access to resources and opportunities that will enable them to move from subsistence to higher value agriculture are disadvantaged to the latter group. Women are significantly constrained in terms of market access, access to key productive assets and services: land, labour, financial services, water, rural infrastructure, technology and other inputs as compared to their male counterparts. For instance, available evidence points to the fact that, about 70-90 percent farmlands in most part sub-Saharan Africa belongs to men (Doss 2005; Quisumbing, Estudillo, and Otsuka 2004 cited in Pehu *et al.*, 2009). Similarly, Oyiwigbo (2014) reported that, until the Women in Agricultural programme, women were constrained with production resources.

Most of the labour provided by women on the farm is usually left unpaid for and in circumstances that they are paid they receive low incomes as compared to men. The percentage of women unpaid workers to total women agricultural workers is 79 percent in Yemen, 66 percent in Syria, 60 percent in Egypt, and 45 percent in the West Bank and Gaza. Syrian women are paid 41 percent of what men workers were paid (Pehu *et al.*, 2009). Relating to the triple role of women, the issue of time constraint: the amount of time dedicated to farm work reduces as compared to their male counterparts because of the need to meet both households, food production and social demands. A study conducted by Ayoola *et al.* (2011) suggested that since majority of farmers were in their reproductive age, multiple roles of women are likely to hinder their effective participation in agriculture production. Pehu *et al.* (2009) opined that, the constraints and vulnerabilities these women face are attributed to existing structures in households and the society as a whole. For instance, land administration can be a major source of gender inequality and largely, social inequality by supporting those who are already advantaged by wealth, power or custom at the expense of the most vulnerable. In addition, constraints in terms of ownership, access and control of livelihood assets negatively affect women roles in food production.

More often than not women only enjoy land use rights than ownership, which may lead to suboptimal production decisions leading to lower yields than would otherwise be expected if these resources were allocated efficiently. Fortmann (2011) for instance have justified that; equity and inclusiveness are important issues concerning women producers. A study conducted by World Bank (Work Bank, 2005) reported that, distribution of productive resources, labour and fertilizer between men and women plot could increase output by 10 to 20 percent in Burkina Faso whiles, giving women farmers the same amount of input and education as men could increase yields by more than 20 percent. Reducing the time burden of women could increase cash incomes for smallholder coffee and banana growers by 10 percent. Whiles in Zambia allowing women farmers to access the same level of capital investment in agricultural inputs such as land as men will potentially increase output by 15 percent.

It is an undeniable fact that, development, food security and poverty alleviation cannot be achieved without rapid agricultural growth. This will include among other things assisting the rural poor to achieve their income and food security i.e. growth in output, income distribution and improved food security in a sustainable for all groups (FAO, 2002). Thus, enhancing women's roles as agricultural producers as well as the primary care takers of their families.

2.5 Role of irrigation in livelihood improvement

Irrigation farming have been identified as significant aspect of rural agriculture with some documented effects on livelihoods of rural folks including income, health, nutrition, food security, and employment (Hussain & Biltonen, 2001; Hussain & Hanjra, 2003; Mangisoni, 2003; Namara *et al.*, 2005; Namara *et al.*, 2011; Dittoh *et al.*, 2013). It has been established that poverty impacts of irrigation are significant, especially in settings where communities and households depend on agriculture for their livelihoods, and access to livelihood opportunities in the non-farm sectors are not available or limited. For instance, Namara *et al.* (2005) found out that, irrigation technologies lead to poverty reduction through substantial increase in farm income due to an increased area of cultivation, better crop yields, enhanced output quality, early crop maturity and hence higher unit prices and reduced costs for other agronomic practices. Their technical and economic efficiency estimates show that, micro irrigation in the cultivation of banana, cotton and groundnut is both technically, and economically justifiable.

According to Namara *et al.* (2005), micro irrigation has significant effect on cropping patterns and intensity, improved access to income, food and nutrition security, decision-making power of women adopters. Similarly, a literature review by Hussain and Hanjra (2003) revealed that, irrigation affect poverty through intermediate variable such as cropping intensity, land and water productivity of crops, labour employment, household income etc. Evidence from scores of studies on irrigation-poverty linkage revealed that, cropping intensity ranges from 111-242 percent for irrigators as compared to 100-168 percent for rain-fed. Again, the review revealed that, irrigated lands have higher productivity 3.0-5.5 tons per hectare of rice paddy than that of rain-fed which yields an average of about 4.0t/ha. Furthermore, income inequality was lower under irrigated settings with Gini values of 0.53 than that of rain-fed settings with Gini value of 0.61. (Hussain & Hanjra, 2003). In another study, Namara *et al.* (2011) found out that, irrigating farmers had either lower poverty or fewer food shortages as compared to rain-farmers. By employing the Foster-Greer-Thorbecke (FGT) indices with consumption expenditure as a proxy to measure poverty and inequality indices, their result suggested that, although poverty levels are generally higher (57%) in the study area than the national average, poverty indices is lower (0.46-0.58) in irrigating households as compared to rain-fed households (0.62).

Similarly, a study conducted in the Tono Irrigation Scheme in Ghana by Dinye & Ayitio (2013) found that, the effect of irrigation on the income levels of farmers were moderate. Although majority of farmers in the irrigation fall under middle-income brackets, most of the farmers were not satisfied with the effect on their economic status and their general livelihood. Findings from their research also revealed that, irrigation has no positive effect on food security. This is because farmers are not able to store their perishable products hence compelled to sell them early with normally low prices making food scarce at other times of the year. The study concluded that, as modest as it is the gains of the project on participants in reducing poverty was not as expected due to an array of challenges such as lack of support services and marketing difficulties. Hussain and Hanjra (2003) and Ofosu *et al.* (2013), remarked that poverty impacts of irrigation is dependent on a number of factors which include but not limited to predictable and stable input/outputs markets, favorable policies and effective institution, reliable farmers support environment production technology, cropping patterns and crop diversification and equity in land distribution.

2.6 Conceptualisation of the study

2.6.1 The concept of sustainable livelihoods

The term sustainable livelihood was first used by the Brundtland Commission on Environment and Development in 1983 as a way of linking socioeconomic and ecological considerations in a cohesive, policy-relevant structure. This was further expanded by the 1992 United Nations Conference on Environment and Development (UNCED), especially in the context of Agenda 21, and advocated for the achievement of sustainable livelihoods as a broad goal for poverty eradication. It asserted that sustainable livelihoods could serve as broader framework, which allows policies to address development, sustainable resource management, and poverty eradication at the same time (UNDP, 1997).

There is a growing assertion that, the manifestations of poverty are multifaceted which include factors and processes that are economical, ecological and social (Krantz, 2001). Proponents of livelihood argue that, livelihoods are not limited to only economic outcomes but stretches toward ecological and social factors. To this end, Chambers and Conway (1991) added that, sustainable livelihoods must be environmentally and socially sustainable –an aspect that deals with the social exclusion and vulnerability aspects of poverty. An environment will be sustainable if it can maintain or improve the local and global assets on which it depends, and has a net benefit to other livelihoods (ibid). Also, a livelihood will be socially sustainable if it can withstand and recover from stress and shocks and retain its ability to continue to provide for future generations.

Krantz (2001) explained the term ‘livelihood’ which literary is a means of making a living is usually applied to households level, but it can however, be modified and extended to suit intra-household levels as well as extended family, social and community levels. According to Avnimelech (1998) cited in Sheheli (2012), a livelihood consists of people, their capacities and activities for ways of living, which include tangible and intangible assets. Marchetta (2011) added that, the degree to which individuals depend on each one of the livelihoods varies according to the portfolio of assets. Krantz (2001) emphasized the assets which these individuals make a living is complex. These assets are classified into tangible assets and intangible assets. Tangible assets include stores (food stocks, valuables, and cash savings) and resources (land, water, tress and livestock). The intangibles assets include ones' ability to demand or claim and access to resources such as technology, employment and information.

Several definitions have been proposed by authors/institutions for sustainable livelihood. According to Chambers and Conway (1992), sustainable livelihood 'comprises livelihood capabilities, assets (stores, resources, claims and access) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, and provide sustainable livelihood opportunities for the next generation; and which contributes net benefits to other livelihoods at the local and global levels and in the short and long term. Krantz (2001), noted that the concept has however, undergone refining and modification most notable of them include Institute for Development Studies (IDS) and the British Department for International Development (DFID). From a modified definition from Scoones (1998; pp. 5), 'a livelihood is sustainable when it can cope with and recover from stresses and shocks, maintain or enhance its capabilities and assets, while not undermining the natural resource base." The main difference between this definition and the earlier one elaborated by Chambers and Conway is that it does not include the requirement that for livelihoods to be considered sustainable they should also 'contribute net benefits to other livelihoods'. In this sense the IDS version is less demanding but, presumably, more realistic. It should be noted that, with some minor changes, this is also the definition of SL adopted by DFID (Krantz, 2001). Akudugu (2011) defines livelihood as the ability of individuals and households to take care of the health, education, food, social and cultural needs and to make savings for future use. For this research, the definition of livelihood adapted from Akudugu *et al.* (2011), "a livelihood is the ability of individuals and households to meet their basic health, education, food, social and cultural demands and to save surplus resources for future needs'.

2.6.2 The Sustainable Livelihood Approach (SLA)

The sustainable livelihood approach was developed in response to the weaknesses identified in the conventional approaches to poverty reduction by development agents (Krantz, 2001; Morse *et al.*, 2009). Krantz (2001) highlights three reasons why the sustainable livelihood approach seems to be a better option to poverty reduction in recent times. Firstly, to reduce poverty, economic growth is a necessary but not sufficient condition. There are no direct effects on each other since the two depend on the capabilities of the poor to take advantage of expanding economic activities. Thus, it is important to find out what precisely it is that prevents or constrains the poor from improving their lot in a given situation, so that support activities could be designed accordingly. Secondly, there is the general assertion that, poverty is multi-dimensional. Thus, poverty is not just a matter of low income but also includes other dimensions of livelihood such as bad health, illiteracy, lack of social services as well as a state of vulnerability and feelings of powerlessness in general. It has been realised that there are important links between different dimensions of poverty such that improvements in one have positive effects on another. For instance, raising people's educational level may have positive effects on their health standards, which in turn may improve their production capacity. Thirdly, the recognition that the poor themselves often know their situation and needs best and must therefore be involved in the design of policies and projects intended to better their lot. Thus, having a say in design and implementation improves the intervention.

The sustainable livelihood approach adopts a holistic approach to poverty, improve livelihoods and decrease vulnerability by identifying most important issues for intervention. According to Morse *et al.* (2009), sustainable livelihood approach are based on whim that development interventions must build foundations that underpin livelihoods. The use of it is now common among development workers in terms of its framework although variations in methodology and use differ from one Organisationto the other. Krantz (2001) however, identified three basic features, which most approaches have in common. The first is that the approach focuses on the livelihoods of the poor since poverty reduction is at its core. The second is that it rejects the usual sectorial entry point (e.g. agriculture, water, or health) and instead begins with an analysis of people's current livelihood systems to identify an appropriate intervention. The final feature is its emphasis on involving people in the identification and implementation of activities where appropriate.

For this study, to be able to understand how farm households draw on capabilities and assets to develop livelihood strategies made up of a range of activities, the sustainable livelihoods approach was adopted through the use of the sustainable livelihoods framework. The use of the framework facilitates holistic thinking about things that the poor are vulnerable to, the resources that might help them strengthen assets, enhance capabilities and reduce vulnerability and the policies and institutions in the wider environment which affect their livelihoods (DFID, 2001). Scoones (1998) hinted that researchers using the framework needed to address an important question; 'given a particular context (of policy settings, politics, history, agro-ecology and socio-economic conditions) what combination of livelihood resources (different types of capital) result in the ability to follow what combination of livelihood strategies (agricultural intensification/extensification, livelihood diversification) with what outcomes?' Livelihood models may differ from one researcher to the other, however, they have been identified to point at five key elements (Scoones, 1998; Carney, 1998 in Marchetta, 2011; Sheheli, 2012). These include the context; resources; policies, institutions and processes; livelihood strategies; and livelihood outcomes each of which is briefly discussed in the proceeding subsections.

2.6.2.1 Vulnerability context

The context refers to the environment, which the household exists and which is responsible for conditions. These include social, economic, political, and environmental dimensions, conditions and trends (Sheheli, 2012). Marchetta (2011) also added that, the external contextual factors can be subdivided into two groups –trends and shocks. Trends consist of population changes, climate conditions, technology, terms of trade, macro policies, national and world economic trends. While shocks include droughts, floods, pests, diseases, civil wars, but also sudden price changes.

2.6.2.2 Capital assets

These may also be referred to as assets and capabilities. It describes the set of resources people can dispose to achieve their objectives. There are five types of capital identified in the framework. These include natural, physical, human, financial and social capitals. Natural capital refers to all types of natural resources that are useful to people as the means of living. As per Marchetta (2011), natural capital is particularly important to rural livelihoods because most of the shocks that hit people are caused by damages suffered by their natural assets. Physical capital refers to the infrastructures people can have access to. We define financial as the stock of liquid assets people can assess which includes savings and loans. Human capital is the labour force that can be employed. The quality of labour force depends largely on education, skills, health (Marchetta, 2011). Social capital is defined as the networks of relationships among people who live and work in a particular society, enabling that society to function effectively.

2.6.2.3 Policies, institutions and processes

These are institutions, organizations, policies and legislation that determine individuals assess to assets and choice of livelihood strategies as well as shape expected outcomes from them. They are also referred to as transforming structures and processes.

2.6.2.4 Livelihood strategies

Livelihood strategies refer to ways and processes, which individuals' households rely on in order to achieve their own objectives. Per Scoones (1998) and further elaborated in Marchetta (2011), there are different ways by which individuals can move to choose the combination of strategies that can better suit their proposed objectives in farming and non-farming activities given the available resource. They further explained that, within each direction, a household is confronted with further choices (e.g. it has to choose the kinds of crops and farming techniques to adopt, the degree of diversification in income sources).

2.6.2.5 Livelihood outcomes

It is the expectation of every individual that, livelihood strategies should translate to more improved well-being such as improved income at sustainable levels. These include better health, nutrition, water, shelter, education among others increased well-being, reduced vulnerability and more sustainable use of the natural resource base. Marchetta (2011) added that, these outcomes need to be sustainable. The sustainability is measured by some criteria; they are able to recover from shocks, do not depend on external sources, they do not erode over time, they do not conflict opportunities of subsistence actors and are environmentally friendly.

2.6.3 The conceptual framework for the study

The conceptual framework abstracts the researcher’s view of the linkages of the concepts and variables explored in this study (Figure 2.1). The conceptual framework on which this study is anchored is the link between ecosystem services and livelihoods of irrigating communities through their provisioning; regulating; supporting; and cultural and recreational services. To enhance understanding of the link between these complex concepts and their interrelationships, the study employed the sustainable livelihood framework as discussed in the preceding section. The main argument behind this approach is that ecosystem services provide foundation for livelihoods and human wellbeing. A change in an ecosystem therefore has consequences for the supply of ecosystem services and livelihoods improvement.

The livelihood capitals (capital assets) such as human, social, physical, financial and natural on which individuals (farmers) draw on to construct their livelihood strategies form inputs in the type of ecosystems services such as provision, regulatory, supporting and cultural available to the farmers. The availability and access to ecosystem services influence the type of livelihood strategies engaged in by farmers. Thus, whether to engage in irrigated agriculture, rain-fed agriculture or both. For instance, the regulatory and supporting services of the ecosystem determines the type of agriculture to engage in. Also, available resources provided by the provision services of the ecosystem influence the participation of farmers in other income generating activities such as the harvesting of forest and non-forest timber products. On the other hand, the livelihood strategies directly affect agricultural ecosystem and their role in maintaining and supporting the production of ecosystem goods and services to further support livelihood strategies of farmers.

The type of livelihood strategies adopted farmers, hence have influence on their livelihood outcomes (food availability, sanitation, income, education, good health). Meanwhile, the outcomes of livelihood pursued by farmers also influence the type of livelihood venture to engage in. These livelihood outcomes also feedback to the livelihood assets (capital assets) and the cycle starts again.

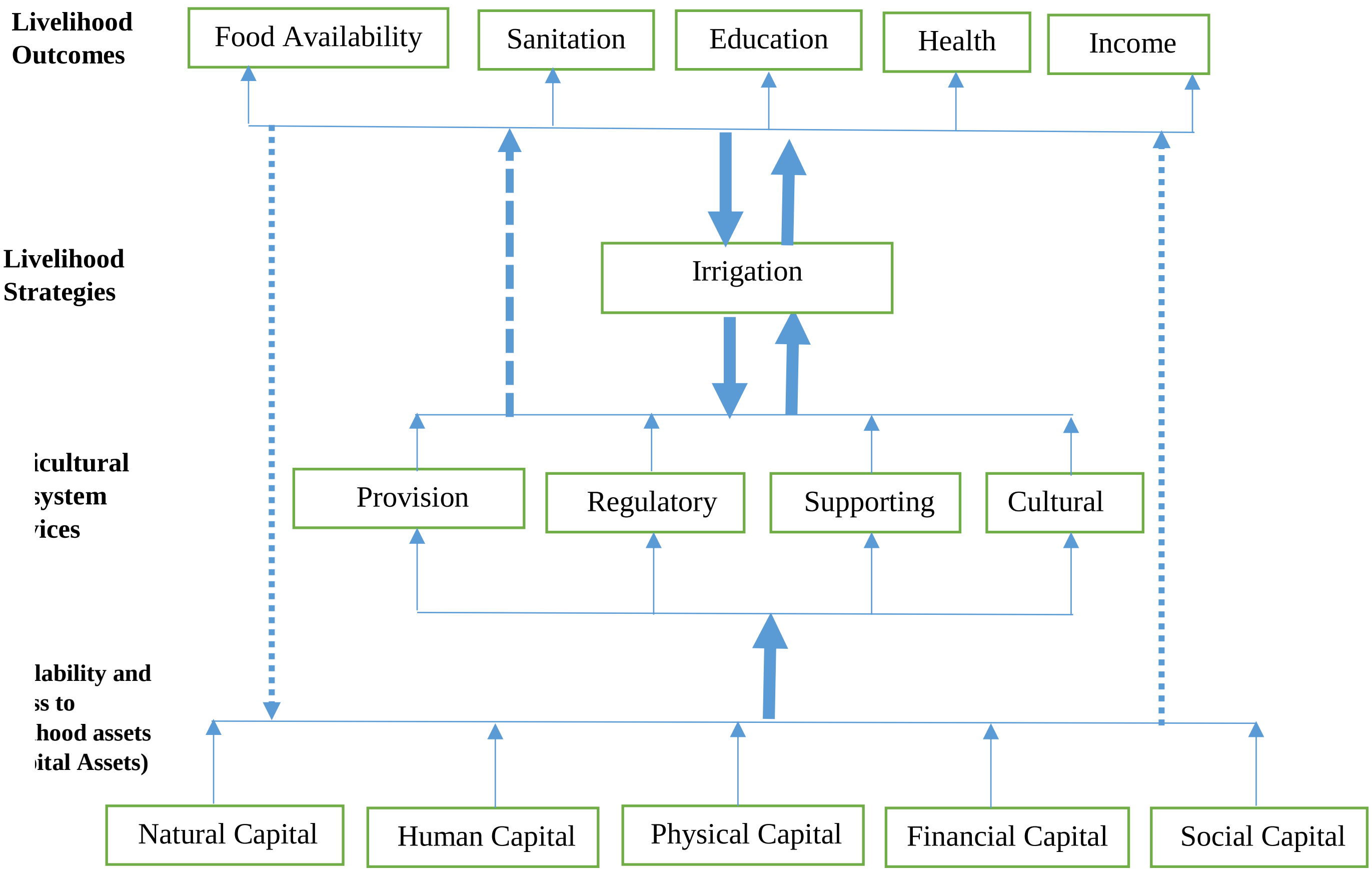

Figure 2.1 Conceptual Framework

Source: Adopted and modified from, Akudugu (2011).

2.7 Summary of gaps in the literature and conclusion

This chapter provided both theoretical and empirical review of the relevant subjects to the study. From the review, the livelihood impacts of irrigation in terms of increased food production, increased income, and dietary diversity are clearly documented in the empirical literature. Also, the literature highlights some of the environmental impacts of irrigation on the ecosystem. However, there exist little information on the impact of irrigation on the livelihood of farmers as it relates to their financial, social, human, physical and environmental well-being, especially in the Volta Basin including the Bawku West district. Most findings are skewed towards immediate poverty impacts of irrigation without considering the impacts on the ecosystems and ecosystems services. This study fills in the gap by integrating the social and environmental effects of irrigation as it relates to the livelihoods of farmers. Thus, this study generate knowledge on the direct and indirect effects that connects irrigation, livelihoods and ecosystem services as well as the effect on gender. The gaps identified in the literature therefore reinforces the research questions and objectives stated earlier in Chapter of this thesis.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter focuses on the procedures and techniques used for the study in order to answer the research questions. These include the research design, study area, source of data, sampling technique, and model used for data analysis. The model included the probit model and the average treatment effect (ATE) model.

3.2 Research design

Burns and Grove (2003) describe a research design as ‘a blueprint for conducting a study with maximum control over factors that may interfere with the validity of the findings.’ Contingent on the hypothesis and research questions that guide the study, the research design could be that of experimental study, descriptive study, historical research, an assessment or evaluation. Brannen (1992) cited in Hudu (2009) outlines three kinds of methodological approaches to research namely: qualitative, quantitative and mixed or multiple approaches.

This study seeks to understand the relationship between irrigation, ecosystems and livelihoods. This process requires in-depth analysis of farmers’ social, cultural and economic relationships as it influence their livelihood activities. These variables were explored through qualitative methods such as observations and personal interviews with semi-structured questionnaires. This helped the researchers among other things uncover the thoughts, perceptions and feelings experienced by informants (Minichiello *et al.,* 1995).

In order to overcome the weakness characterized with both approaches outlined above, the study combine both qualitative and quantitative methods such that social relations and perceptions can be assessed on one hand and quantitative variables such as livelihoods indicators can also be measured on the other. This is to compensate for the weakness in one for the alternative method. Literature has documented such approach as method triangulation as explained by Mikkelsen (1995) as, triangulation or multiple strategies is a method that is used to overcome the problems associated with researches that rely on only one theory, single method and single data set. Methodological triangulation involves "within method" triangulation, in which case the same method used on different occasions and "between method" triangulation when different methods are used in the same study (Hudu, 2009).

3.3 Study area

The study was carried out in four irrigating communities in the Bawku West District of the Upper East region of Ghana. The Upper East region covers 8,842 km2, an estimated 7% of the total land area of Ghana. The total population is about 1 million. With a population density of approximately 113 people per square kilometer, it is the most densely populated area in northern Ghana.

The district lies between latitudes 1000 30' N and 1100 10' N, and between longitudes 000 20' E and 000 35' E. The district shares administrative boundaries with Burkina Faso to the North, Bawku Municipality to the East, Talensi/Nabdam District to the West and East Mamprusi District to the South.

The District covers an area of approximately 1,070 square kilometers, which constitutes about 12 percent of the total land area of the Upper East Region. It is the fifth biggest district in the Upper East Region in terms of land area. The district is drained by both White and Red Volta and their tributaries. Two important tributaries of the Volta River namely the White and Red Volta ran contiguous to the Districts' Eastern and Western boundaries respectively. The rivers over flow their banks during the rainy season (April-October). During the dry season, there is always an inflow of water from the Bagre dam, which makes it possible for farmers to pump for irrigation from the White Volta.

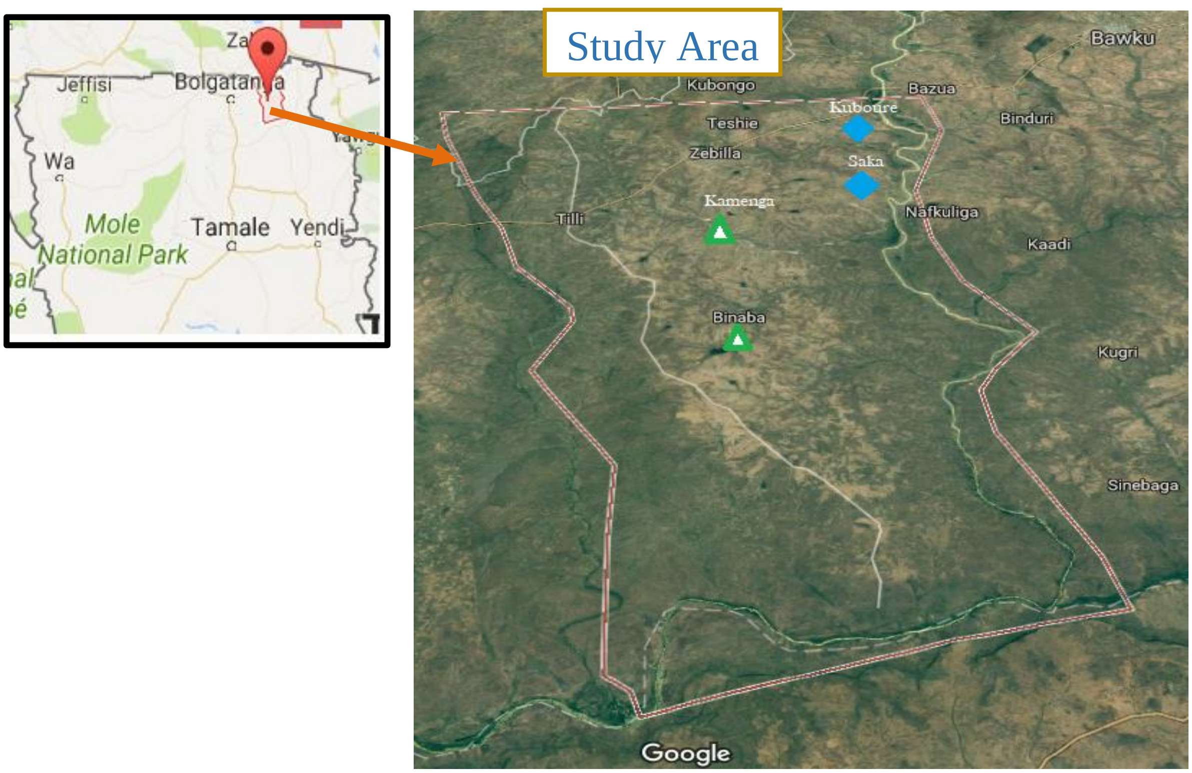

Figure 3.1 The Bawku West district map

Source: http://www.googlemap.com –accessed on 23/09/17

The natural environment is highly degraded by land clearing for farming, fuel wood harvesting, overgrazing, bush fire and harvesting of poles for construction. The gold deposits found in the rocks north of Zebilla and south of Sapelliga has increased the desire for mining by the youth. This is very clear in the Widna –Teshie zone where illegal surface mining and stone quarrying are prevalent, resulting in serious land degradation and the pollution surface water bodies. At present the main sources of domestic water supply in the district are from rivers, springs, wells, boreholes, ponds and dams.

Agriculture plays an important role in the socio-economic development of the Bawku West District. It provides incomes and employment for over 80 percent of the population. The total cultivable area is 58,406 Ha and uncultivable area of 33,687 Ha. With relatively limited productive land, subsistence agriculture is the main occupation of the people (www.ghanadistricts.com). Namara *et al.* (2011), identified that there are two types of farms in the BWD; (a) compound farms, which lie immediately around the house; and (b) bush farms, which may border on the compound farm or be located several kilometers away from the main village. In addition to the crop farming, farmers mostly keep livestock such as cattle, sheep and goats and poultry such as chicken and guinea fowl. The cattle are kept for security reasons or as capital investments. The main food crops are cereals (rice, sorghum, millet) and pulses (groundnuts, cowpea and Bambara beans). Vegetables, particularly onions and tomatoes are produced in the dry season with the bulk being sold for cash to supplement household needs. Irrigation is an important aspect of farming in the study area.

The major crops include cereals (millet, sorghum, maize, and rice), fruits and vegetables (onions, tomatoes, pepper, okra, leafy vegetables and watermelon), legumes (cowpea, soybean, bambara nuts, groundnuts), tree crops (mangoes, cashew) Industrial crops (sheanut trees, dawadawa) roots and tubers (sweet potatoes, Frafra potatoes). Irrigated agriculture constitutes an important component of agriculture in the district. The types of irrigation dominant in the area include river (Volta river basin), ground water and dams. Communities living along the White Volta Basin normally engage in river irrigation. Farming activities along the river is made possible by the use of motor pumps and long water hoses that are used to draw water from the river into farm plots drained by canals. On the other hand, communities not located near the White Volta but with low water tables irrigate their crops from dams or dugouts.

3.4 Source of data

This study relied on primary data obtained from irrigators and non-irrigators in four irrigating communities in the Bawku West District namely Saka, Kubore, Binaba and Kamega. This included information relating to their socio-economic characteristics such as sex, age, educational, attainment, economic occupation, household size, income, civil status. These enabled the researcher examine the personal characteristics of farmers that influence their decision to participate in irrigated agriculture and the effects on their livelihoods. Furthermore, data was collected on views of respondents on the prospects irrigated agriculture and their perception on the importance of ecosystem to their livelihoods.

3.5 Study population

The target population for this study is defined as all households involved in both irrigated and non-irrigated agriculture in the four irrigating communities of the Bawku West District. A household in this study is defined as a group of people who eat from the same 'pot' and share common resources (Beaman & Dillion 2012). The objective of the interviewer is to solicit views on farmers' perceptions of ecosystems and the linkages with their livelihoods as well as factors influencing their involvement in irrigated agriculture. In a household, either men or women were interviewed since both men and women are involved in agricultural activities.

3.6 Sampling technique and sample size

A three-stage sampling technique was employed in the study. In the first stage, communities in the district were categorized into irrigating and non-irrigating communities. The irrigating communities were further categorized into dam irrigating communities and river irrigating communities. Simple random sampling technique was used to select four (4) communities (2 communities each for dam and river irrigation). At the second stage, the households in the communities were stratified purely into irrigating and non-irrigating households. At the third stage, each household was stratified into males and females in each of the households. Simple random sampling was used to select nine (9) respondents from each of the strata. The Ghana Youth Policy standard was used to isolate the economically active group in each of the selected households, thus only household members 15 years and above were interviewed. In total, 304 respondents were sampled for the study.

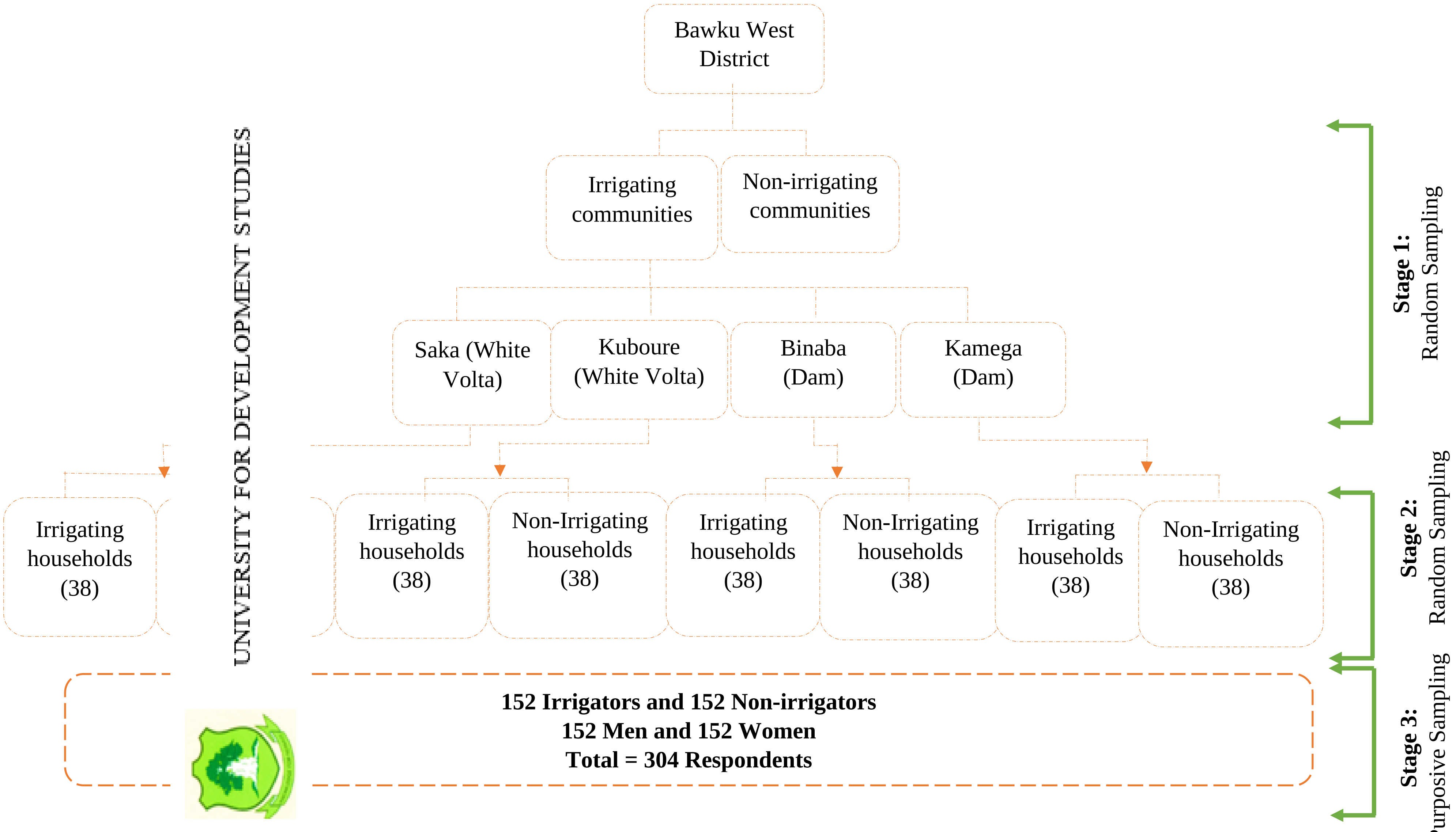

Figure 3.2 Sampling Technique

3.7 Method of data collection

The study used primary data collected from farmers using semi-structured questionnaires prepared in line with the study objectives. The questionnaires contained both closed and open-ended questions. The closed ended questions permit respondents to select from a set of responses provided while the open-ended questions allowed respondents to give answers using own discretions. The face-to-face interview was employed since it gives chance to interviewers to interpret questions to respondents. This helps to obtain accurate information necessary for the study. Besides, it provides opportunity for the two (interviewer and interviewee) to educate each other on the subject matter beyond the questions captured in the questionnaire through discussions.

The study adopted both quantitative and qualitative methods in soliciting views on the social, cultural, economic and environmental factors that affect respondents' livelihoods. Participatory tools employed included observations and face-to-face interviews and key informant interviews. Data were collected on respondents' knowledge about ecosystems, importance of ecosystems to their livelihoods, state of ecosystem services in their communities, farm practices that affect ecosystems, factors influencing participation in irrigated agriculture, challenges and prospects in irrigated agriculture. The questionnaire was administered in native language to respondents since majority do not understand English.

Prior to the data collection, the enumerators were trained to ensure that they all had a common understanding of each question. Also, the questionnaire was pre-tested to ensure that it captured adequate information for the study. During pre-testing, ambiguities in the wording of the questions as well as relevance of questions were detected and resolved while additional answers were assimilated for coded questions.

3.8 Survey instrument

The survey was conducted during dry season cropping period which spans from November, 2015 to late April, 2016. The data collected included both demographic and socioeconomics characteristics of farmers. The survey questionnaire was designed into 5 sections as they relate to the objectives of the study. Section A captured information on the demographic characteristics of the respondents. Section B covered farm characteristics and production systems used by the farmers. Section C covered the perception of farmers on the link between irrigation, ecosystem and livelihoods. Also, the section entailed the effect of irrigation farming on livelihoods using outcomes such as food availability, income security, employment, health security, and education among others. In each indicator, specific effects were identified and respondents assessed them using a weighted scale. For instance, under food availability, a farmer was asked to indicate the level of effect (say, high=3, average=2 and low=1) of irrigation farming in enhancing farmers' ability to supply household food needs. These weighted results on a number of indicators were added to represent the average livelihood score for each farmer. Section D covered the involvement of farmers in livelihoods activities and the livelihood status of farmers in terms of food availability, housing condition, water facilities, heath care, and sanitation. The Section E covered the constraints and prospects of irrigation farming.

3.9 Analytical framework

3.9.1 Linkages of irrigation, ecosystems and livelihoods

The first objective of the study was to assess the perception of farmers about the linkages among irrigation, ecosystems and livelihoods of men and women. The importance of ecosystem service was determined using weighted scores through Likert scale of one (1) to five (5) with five (5) been most important. The ecosystem service weighted were provision services, regulatory services, supporting services and cultural services. To get the aggregate score for each ecosystem service, the highest possible score that can be attained by the ecosystem service divided the total score for

that particular ecosystem service. Mathematically, to measure the level of importance the i^{th} farmer attached to j^{th} ecosystem service:

$$LP_{ji} = \frac{the\ total\ score\ of\ the\ level\ of\ importance\ for\ the\ j^{th}\ variable\ for\ i^{th}\ farmer}{highest\ possible\ score}$$

Therefore, the average level of importance is given as;

$$ALP_{ji} = \frac{\sum_{i=1}^{i=n} LP_{ji}}{n}$$

Where;

i= the farmer assessing the ecosystem services, j= the ecosystem services measured by a farmer,

LP_{ji}= level of importance an individual farmer is attaching to ecosystem services being measured

ALP_{ji}= the average level of importance of ecosystem services measured by all farmers (n),

n= the total number of farmers.

3.9.2 Impact of gender involvement in irrigated agriculture on livelihood

The second objective of the study was to identify and estimate the factors influencing the involvement of men and women in irrigated agriculture whilst the third objective was to examine the effects of farmers' involvement/participation in irrigation farming on livelihoods. To identify factors influencing farmers' participation in irrigation and estimate the effects of their participation on livelihood, this study used the Average Treatment Effect (ATE) model proposed and used by Heckman (1979). ATE model is used to compare the effect (impact) of patronising an intervention or adopting a technology (in this study irrigation) on a particular outcome variable. It can be applied to randomised observational data or experimental data. The engagement of farmers in irrigation agriculture is a self-selection decision. In using observational data, one is confronted with selectivity bias because of endogeneity since unobservable factors can affect both the decision to participate (selection) and the outcome variables (Maddala, 1983). The average treatment effect model allows for the estimation of two models simultaneously to resolve selectivity bias. One main advantage of the average treatment effect model is that it measures the direct effect of the selection variable (irrigation farming) on the outcome variable (livelihood of farmers). In the following subsections, a step-by-step procedure for estimating average treatment effect model is provided.

3.9.2.1 Theory of diffusion of innovation and adoption

The research on diffusion can be traced to a French sociologists Tarde (1903) studying adoption (Curos & Kresten, 2003). Tarde (1903) was also the first to use the S-shape to attribute the rate of adoption. The S-shape was used to identify innovations with fast rate of adoption (steep slope) and those with slower rate of adoption. Diffusion theory represent a complex number of sub-theories that describes the process of adoption. According Rogers (1983), diffusion is a 'process by which an innovation is communicated through certain channels over time among members of a societal system'. Hall & Khan (2002) also define diffusion as 'the process by which something new spreads throughout a population'. This differentiates invention of a new technology, which happens in single event form diffusion of that technology which involves continuous process.

According to Vanderslice (2000), the most recognized literature of diffusion theory is Rogers (1983) seminal work, *Diffusion of Innovations*. Rogers (1995) work therefore formed the basis for most adoption studies. Rogers (1995) definition of innovation process highlighted four elements; (1) the innovation; an idea, practice or object that is perceived as new by an individual or group of adopters; (2) communication channels; the 'means' by which innovations move from individual to another or group to another; (4) a social system; a set of interrelated units that are engaged in joint-problem solving activities to accomplish a goal. Rogers (1995) also differentiated diffusion process from adoption process. He explained that, while diffusion process infuses through groups or society, the adoption process mostly relevant to an individual. Rogers (1995) identified five steps that involves the adoption process of an individual; (1) knowledge (awareness), (2) persuasion (interest), (3) decision (evaluation) (4) implementation (trial) and; (5) confirmation (adoption). He further explained that, throughout the process, individual seeks relevant knowledge and skill that lead to final adoption of the innovation of rejection. Thus, Rogers (1995) defined adoption process as 'the mental process through which an individual passes from first hearing an innovation to final adoption'.

3.9.2.2 The S-shape adoption curve

The adoption curve is used to describe the pattern of adoption among individuals. Among researchers, adoption curve is represented by a bell-shape or s-shape. The bell shape describes the normal distribution curve when it is plotted over the frequency distribution. However, when the cumulative adoption is plotted, it yields the s-shape. (Rogers, 1983; Beal & Rogers, 1960). The rationale behind the S-shape is that the distribution rises slowly at the first when there are few adopters in each period. This category of people Rogers classified "early adopters" This increases to a peak where half of the people (early majority) adopt the innovation and then increases at a slower rate as the remaining few (late majority) begins to finally adopt he innovation.

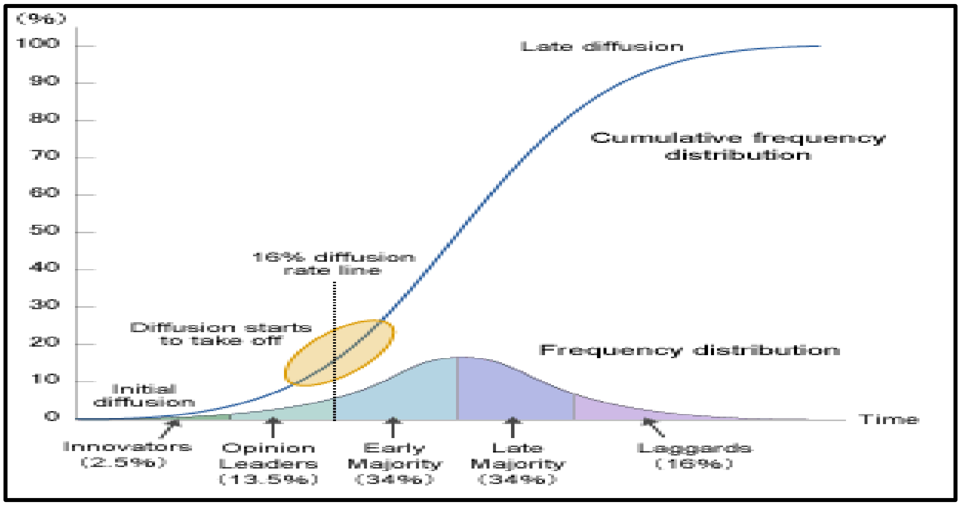

Figure 3.3 Rogers adoption curve

Source: http://www.google.com –accessed on 31/06/16

3.9.2.3 The adoption model

Primarily, estimating the determinants of irrigation farming is an adoption model since it involved a decision making. Adoption models have been studied in the framework of discrete choice modelling where farmers' decision to adopt a particular technology is dependent on several factors including resource endowment, socioeconomic characteristics, expectations (Ansah *et al.*, 2015). As cited in Ansah *et al*. (2015), Feder *et al.* (1985) demonstrated that a technology can only be adopted if and only if one of the components of the technology is benefiting the client. In such a case like agriculture, the decision to use a particular technology is discrete; either adopt or do not adopt. Such discrete decisions are often studied using random utility model, which falls under the theory of utility maximization (Becerril & Abdulai, 2010). In adoption model, a farmer faces a choice among *j* alternative actions, thus adoption or non-adoption. The farmer would obtain a utility or profit from each alternative action chosen. The utility (u) that the *ith* farmer derives from choosing alternative j is given by u_{ij} whereas the utility for not adopting the technology is given by u_{ik}. According to Becerril & Abdulai (2010), a farmer will only choose *jth* technology if and only if the maximum utility or benefit derived from such option is greater than the maximum utility or benefit from the alternate technology. In other words, the utility maximising farmer will adopt irrigation farming if and only if at least the benefit (be it economic, financial, managerial, easiness of work, etc.) from the adoption is greater than the costs of adopting the technology. In this type of studies the commonly used methodologies is the probit and logit models (Greene, 2003; Udoh *et al.*, 2008). However, using binary in a stage two regression model, probit models are used because the probit model assumes that the error term follows a standard normal distribution.

3.9.2.4 Probit model

The probit model is specialized regression model of binomial response variables. For instance, the researcher sought to understand why some farmers decide to participate in irrigated agriculture and others do not. This concludes that there are only two categories of respondents under study: irrigators and non-irrigators, which leads us to a dichotomous situation. The probit model allows for estimating this choice situation. According to Sienso *et al.* (2014), many researchers have adopted discrete choice models to identify and explain factors influencing the individual's choices between two or more alternatives. The purpose of the discrete choice model is to estimate the probability that an observation with a particular characteristics would fall into one specific category or the other.

Mathematically,

$$y_i = \beta' x_i + u_i \qquad (3.1)$$

Where y_i is a binary response variable with the basic assumption that the u_i will show the same dispersion around the mean (Koutsoyiannis, 2003) is violated (Maddala, 1983). It is no longer appropriate to use the Ordinary Least Squared (OLS) for these estimations since it would produce inefficient β_s (Maddala, 1983).

Stating the underlying response variable as y^*

$$y_i^* = \beta' x_i + u_i \qquad (3.2)$$

Where x_i is a vector of exogenous variables that influence y_i, β_i is vector of parameters and u_i is the noise term having constant variance and zero mean. In practice, y^* is not observed, instead a dummy variable that is defined as below is observed:

$$y = 1 \; if \; y_i^* > 0 \qquad or \qquad y = 0 \; if \; otherwise \qquad (3.3)$$

The respective probability of these events becomes $-\beta' x_i$ and $1 - \beta' x_i$. In this case $\beta' x_i$ is no longer the $E(y_i/x_i)$ as in OLS (y_i^*/x_i).

From equation 3.2 and 3.3,

$$Prob(y = 1) = Prob(u_i > -\beta' x_i)$$

$$= 1 - F(-\beta' x_i) \qquad (3.4)$$

Where F is the cumulative distributive function u_i. Depending on x_i, the probabilities given in equation 3.4 may vary, hence the likelihood function is:

$$L = \prod_{u_i=0} F\,(-\beta' x_i) \prod_{y_i=1} [1 - F(-\beta' x_i)] \quad (3.5)$$

Since the probit model assumes that u_i is normally distributed $[N(0, \sigma^2)]$, we have:

$$F = (-\beta' x_i) = \int_{-\infty}^{-\beta' x_i/\sigma} \frac{1}{(2\pi)^{1/2}} exp\left(\frac{-t^2}{2}\right) dt \quad (3.6)$$

From equations 3.5 and 3.6, we can now estimate $-\beta' x_i/\sigma$ instead of β_s and σ separately.

The marginal effect of x_i is estimated as:

$$\frac{\partial}{\partial x_{ij}} \Phi(x_i \beta') = \emptyset(x_i \beta')\beta_j \quad (3.8)$$

3.9.2.5 Selectivity bias and Heckman two-stage procedure

In estimating factors influencing gender participation in irrigation and the effect of participation on livelihood separately, it is expected that sample selection bias will arise for two reasons: (1) there may be self-selection by the individuals being investigated; (2) when some respondents do not have observable values for dependent variables (Heckman, 1979). For instance, we can observe irrigation output for irrigators but not for non-irrigators. Also, there may be certain characteristics that affect participation but cannot be observed by the researcher for instance entrepreneurial abilities and fertility of soil thus leading to selectivity bias. Similarly, there can be observable livelihood score for both irrigators and non-irrigators, but the selection of the respondents in both categories may follow discretionary pattern by the researcher and not random. This means that irrigators may have unmeasured characteristics that themselves are related to their livelihood score.

Estimating the livelihood equation with adoption as one of the explanatory variables is inappropriate. According Heckman (1976) this would result in biased parameter estimates and this would mean that the true effect of adoption on livelihood would not be known. This is the argument for selectivity bias.

Mathematically,

$$y_i = \beta' x_i + u_i \quad (3.9)$$

Given equation 3.9, $E(U_i) \neq 0$ since all values of the $y_i = 1,\ u_i = 1 - \beta' x_i$ but for all values of $y_i = 0,\ u_i = 1 - \beta' x_i$. This implies that the OLS assumption of constant variance is violated. Due to truncation in equation 3.9, its estimation would produce biased estimates. To resolve this, Heckman (1976) suggested a two-stage procedure where, $E(U_i)$ is evaluated and substituted into equation 3.9. From equation 3.9, the nonzero observation of y_i is given as:

$$E\left(\frac{y_i}{y_i}\right) > 0 = \beta' x_i + E\left(\frac{u_i}{u_i} > -\beta' x_i\right)$$

$$= \beta' x_i + \sigma \frac{\emptyset_i}{\Phi_i} \quad (3.10)$$

Where $\emptyset_i$ and Φ_i are respectively the density and distribution functions of the standard normal that is evaluated at $\beta' x_i / \sigma$.

Redefining equation 3.9 by inserting the estimated $E(U_i)$ from the probit model gives:

$$y_i = \beta' x_i + \sigma \frac{\emptyset_i}{\Phi_i} + v_i \quad (3.11)$$

From equation 3.11, $E(v_i) = 0$, hence it can be estimated by OLS. However, the limitation is $\emptyset_i$ and Φ_i are unknown. Since we earlier said the likelihood function of the probit model is well behaved, Heckman suggested that a dummy variable be defined and estimated by the probit model as:

$I_i = 1 \; if \; y_i \geq 0$

$I_i = 0 \; if \; otherwise$

Using the maximum likelihood (ML), we obtain the estimates of β/σ and use this value to estimate the unknown $\emptyset_i$ and Φ_i. So, instead of $\emptyset_i$ and Φ_i, we have $\widehat{\emptyset_i}$ and $\widehat{\Phi_i}$. Using $\widehat{\emptyset_i}/\widehat{\Phi_i}$ as an explanatory variable in equation 3.11, we can obtain consistent estimates of β and σ. From Maddala (1983), Heckman suggested that if all observations were used rather than only nonzero observations$(y_i \geq 0)$, we have:

$$E(y_i) = Prob\,(y_i > 0) * E\left(\frac{y_i}{y_i} > 0\right) + Prob(y_i < 0) * E\left(\frac{y_i}{y_i} \leq 0\right)$$

$$= \Phi_i\left(\beta' x_i + \sigma \frac{\emptyset_i}{\Phi_i}\right) + 0$$

$$= \beta'(\Phi_i x_i) + \sigma \emptyset_i \qquad (3.12)$$

Thus after getting estimates of $\emptyset_i$ and Φ_i, we estimate equation 3.12 to obtain β and σ. This study used the treatment effect model, an extension of the Heckman two-stage method discussed in this section.

3.9.2.6 Treatment effect model

There are various ways by which researchers have solved the problem of sampling selection resulting from nonrandom sampling can be resolved. One of these special cases of the Heckman's model is the treatment effect model. One main advantage of the average treatment effect model is that it measures the direct effect of the selection variable (in this case irrigation farming) on the outcome variable (average livelihood score) in addition to resolving the problem of selectivity bias. Like the Heckman model, the application of this methodology involves two-step estimation.

Given:

$$livelihood = X_i'\beta + \delta A_i + \varepsilon_i \qquad (3.13)$$

Where X_i' is a set of factors that influence livelihood status, A_i is a dummy variable capturing adoption (irrigators) and non-adoption (non-irrigators). Estimating equation 3.13 with OLS may not be adequate. This is because although the $X_i'\beta$ may be correctly specified, δ may not measure the true value (effect) of A_i. The actual effect of using OLS for this estimation is that the parameter estimate for δ will overestimate the treatment effect, A_i. To remedy this effect, the treatment effect is modeled following Greene (2003) as follows:

$$A_i^* = w_i' + u_i \qquad (3.14)$$

$$A_i = 1 = if\ A_i^* > 0, 0\ if\ otherwise$$

However, the ε_i and u_i are correlated. To correct this, we first estimate the treatment equation (3.14) before estimating equation 3.13 since A_i is influenced by some set of variables. Therefore, the two equations (equations 3.13 and 3.14) are extrapolated as

$$E\left[\frac{y_i}{A_i} = 1, x_i, \quad z_i\right] = X_i'\beta + \delta + E\left[\frac{\varepsilon_i}{A_i} = 1, \ x_i, \ z_i\right]$$

$$livelihood = x_i'\beta + \delta + \rho\sigma_\varepsilon\lambda(-w_i'\gamma) \quad (3.15)$$

$$\lambda = \frac{-\phi(w_i'\gamma)}{1-\phi(w_i'\gamma)} \ is\ the\ Inverse\ Mills\ Ratio\ (IMR)$$

The two-step estimator provides a follow-up result of δ which accounts for the self-selection or treatment problem. It should be observed that equation 3.15 is only defined if $A_i = 1$. In the case of the non-participants:

$$E\left[\frac{y_i}{A_i} = 1, x_i, \quad z_i\right] - E\left[\frac{y_i}{A_i} = 0, \ x_i, \ z_i\right]$$

$$= \delta + \rho\sigma_\varepsilon\left[\frac{\emptyset_i}{\Phi_i(1-\Phi_i)}\right] \quad (3.17)$$

The omitted λ is what OLS would have estimated to measure the value on the treatment A_i. As indicated earlier, this would overestimate the treatment because all terms in treatment because all terms in equation are positive.

3.10 Constraints, prospects and opportunities of involvement in irrigated agriculture

3.10.1 Constraints in irrigated agriculture

The fourth objective of the study was to examine the prospects, opportunities and constraints of men and women involvement in irrigated agriculture. To achieve this objective, farmers were asked to identify the constraints in irrigated agriculture. The identified constraints were then ranked in order of importance using the Kendall's coefficient of concordance. The Kendall's Coefficient of Concordance (W) analysis is a statistical procedure used to rank (in this context) a given set of constraints in irrigated agriculture from the most important to the least important, and then measures the degree of agreement/concordance between the respondents (Edwards, 1964 cited Donkoh & Awuni, 2011). The formula for the coefficient of concordance (W) is given as:

$$W = \frac{n[\sum T^2 - (\sum T)^2/n}{nm^2(n^2-1)} \; or \; \frac{nT}{nm^2(n^2-1)} \tag{3.18}$$

Where T = sum of ranks for the factors being ranked; m = number of respondents; and n = number of factors being ranked. W is an index that measures the ratio of the observed variance of the sum of ranks and the maximum possible variance of the sum of ranks. The maximum variance (T) is given by:

$$T = \frac{m^2(n^2-1)}{12} \tag{3.19}$$

$$VarT = \left[\sum T^2 - \frac{(\sum T)^2}{n}\right] \tag{3.20}$$

Where the variables are as defined. The idea behind this index is to find the sum of ranks given to each item (in this case constraints) being ranked by respondents and then examine the variability of this sum. If the rankings are in perfect agreement, the variability among these sums will be a maximum. The constraints are ranked according to the most important to the least important using numerals 4,3,2,1 ...n, in that order. The least score rank is the most important while the one with the highest score is ranked as the least important. The total rank score computed is then used to calculate for the Coefficient of Concordance (W) to measure the degree of agreement in the rankings. The limits for W cannot exceed 1.00 and cannot be negative. That is, it can only be positive in sign and ranges from 0 to1. The coefficient of concordance equals 1.00 when the ranks assigned by each respondent are the same as those assigned by other respondents.

3.10.2 Prospects in irrigated agriculture

To assess the prospects and opportunities for men and women involvement in irrigated agriculture, the study employed the SWOT analytical tool. SWOT is a tool used to analyze an organization's or industry's (in this case irrigated agriculture) internal and external environment for strategic decision-making. SWOT analysis summarizes the most important internal and external factors that may affect the organization's future. SWOT stands for "strengths, weaknesses, opportunities and threats". The SWOT analytical process involves a comprehensive analysis of internal and external factors that irrigated agriculture is confronted with. The internal factors consist of strengths and weaknesses in irrigated agriculture whiles the external factors consist of opportunities and threats in irrigated agriculture. Strengths is defined as competitive advantage and other distinguishing competencies, which can be exploited in irrigated agriculture. Weaknesses is defined as limitations that hinder farmers' involvement in irrigated agriculture.

Opportunities is defined as the potentials existing for growth or improvement in irrigated agriculture. Threats is defined as existing hazards that are outside the control of farmers likely to affect irrigated agriculture. The obtained information is represented systematically in a matrix.

3.11 Determining existing livelihood status

Determination of farmers' livelihood forms an important component of this study. Livelihood status of farmers reflects the living conditions of households as it relates to their socio-economic status in the area under study. For the purpose of this study, current livelihood status of farmers was measured by computing an Average Livelihood Score (ALS) for each participating farmer in the study. The ALS was determined by identifying eight (8) livelihood indicators, namely food availability, housing condition, water facilities, health situation, sanitation, participation in social activities, freedom in cash expenditure and health of ecosystem services. These eight indicators were first systematically measured and the ALS consequently developed. Similar approach was used by Sheheli (2012) to determine the cumulative livelihood score of rural women engaging in income generating activities. A brief discussion of each of the livelihood indicators is presented in the following subsections:

3.11.1 Food availability

Food availability was measured based on accessibility to basic food throughout the whole year for the family. Scoring for availability of food was '3' for sufficient, '2' for insufficient and '1' for extreme shortage of food. The cumulative scores of twelve months indicate the food availability of the farmers' family. Therefore, the possible food availability score varied from 12 to 36, where 12 indicates the 'lowest' and 36 indicates the 'highest' level of food availability (see appendix I for further details).

3.11.2 Housing condition

This indicator refers to the present situation of the house inhabited by the participating farmers. To determine the housing conditions, four characteristics of houses were considered, namely ownership of house, proportion of roofed rooms, proportion of room with cement blocks and general impression. The overall housing condition of each respondent was calculated by summing the scores obtained from these four characteristics of the house. The possible score could vary from 4 to 13, where 4 indicates a 'very poor' and 13 indicates a 'very good' housing condition.

3.11.3 Water facilities

Three sub-dimensions, including water sources, drinking water availability and quality of drinking water, measured the water facilities' indicator. The score of water facilities of each respondent was calculated by summing scores of the above three sub-dimensions.

3.11.3.1 Source of water

Source of water was measured based on the type of water source a farmer mainly depend on for cooking, drinking, bathing and domestic washing etc. Total number of water sources were four (4), which includes borehole/pipe, mechanized well, uncovered well and river/pond. Therefore, the possible score for water sources varied from 1 to 4.

3.11.3.2 Availability of drinking water

Availability of drinking water was measured on based on the abundance of clean water throughout the year. The scoring of drinking water availability for each month was '3' for adequate, '2' for inadequate and '1' for scarcity of drinking water. The scores of twelve months obtained from each respondent were added to yield a drinking water availability score, which varied from 12 to 36.

3.11.3.3 Quality of drinking water

Quality of water was measured using 3 scales. I to 3 which includes 3=good, 2=clean but smells or hard and 1=unclean. To compute the total scores, the scores of the three dimension of water facilities were summed which falls between 14 and 43 whereby 14 indicates a very poor water facility and 43 indicates a very good water facility.

3.11.4 Health situation

Health situation was defined and measured by three sub-dimensions, namely health status, access to health treatment and ability to access health treatment. The summation of three sub-dimensions score yielded the health situation score. (see appendix I for further details).

3.11.4.1 Health status

Health status defines the current state of health of the farmer. This indicator was measured under three scores; 3=good, 2=short illness and 1=frequent illness.

3.11.4.2 Access to health treatment

The opportunities of farmer to get treatment from different providers available in the study area were determined. Three health providers available in the study area were identified. Scoring for availability of health treatment providers was 3= frequently, 2=sometimes and 1= not at all. Health treatment ability was measured by summing scores of three items and the possible score varied from 1 to 9.

3.11.4.3 Ability to access treatment

This measures the financial opportunities available for the farmer to access health treatment in the study area. Scoring for this included; 3=have an active health insurance card, 2=inactive health insurance but afford and 1=inactive health insurance card and cannot afford. Ability to access health treatment was measured by summing scores of the dimension that range from 1 to 3. Finally, the score of the health status of the farmer is computed which varies from 5-15 whereby 5 indicates very bad and 21 indicates very good health situation.

3.11.5 Sanitation

Sanitation was defined and measured by two sub-dimensions, namely possession of a toilet and toilet condition. The sanitation score is then computed by summing the two sub-dimension.

3.11.5.1 Possession of a toilet

This indicator refers to the ownership of a toilet in the household. Three different scores were identified under this section. This include 3=owned toilet, 2=community toilet and 1=none. Total score then range from 1 to 3.

3.11.5.2 Toilet condition

This indicator refers to the physical condition of the toilet possessed by rural women. The scale considered to measure the condition of toilet include hygienic=3, better=2 and unhygienic=1. The scores thus obtained were added together to yield the toilet condition score. The range of a possible toilet condition score varied from 2 to 6; whereby 2 indicates a 'very bad' and 6 indicates a 'very good' toilet condition.

3.11.6 Participating in social activities

This is defined as the extent to which the farmer is involved different social activities in their community apart from main occupation. It was measured by computing a 'social participation score' based on the level of participation in any social event. Scoring of participation was 2=freedom to participate in any gathering and 1=limited freedom to participate. Therefore, the total scores for participation in social activities could vary from 1 to 2, whereby 1= indicates low level of participation and 2=high level of participation. (see appendix I for further details).

3.11.7 Freedom in cash expenditure

This refer to the extent to which farmers have the freedom to spend money on various aspects of their family affairs. In this study 5 aspect of family expenditure were identified and scored. A 4 point scale was used to define the freedom of cash expenditure where 4=farmer (s/he), 3=farmer and spouse, 2=spouse and 1=extended family. Finally, the total score was obtained by summation of score of all eight aspects. Possible score could vary from 4 to 16, where 4 indicate 'low freedom in cash expenditure', i.e., the respondent depends highly on other family members to take decisions, and a score of 16 indicates 'high freedom in cash expenditure', i.e. the respondent takes all decisions by him/herself. (see appendix I for further details).

3.11.8 Health of ecosystem services

This refers to the state ecosystem about the services they provide to the community. The various services that are common in the study area were identified. A three point scale was used to define health of the ecosystem where 3=improved, 2=sustained and 1=deteriorating/worsened. Finally, the total score was obtained by summation of score of all 10 products of the ecosystem. Possible score could vary from 10 to 30 where 10 indicates deteriorating ecosystem services and a score of 30 indicates improving ecosystem services.

3.11.9 Calculating the Average Livelihood Score (ALS)

In determining the livelihood score, the eight dimensions or indicators of livelihoods were indexed. To develop the average livelihood score, a two-stage procedure is employed. In the first stage, a percentage score for each of the eight livelihood indicators was determined and at the second stage the average livelihood score was computed based on the scores of the eight indicators. The percentage score for an individual farmer is computed as the individual farmer field score divided by the corresponding possible maximum score and expressed as a percentage. The following formula was used to determine the individual rural woman's percentage score:

$$IFPS_i = \frac{IFFS_i}{IFPMS_i} \times 100$$

Where, IFPS= Individual farmers percentage score, IFFS=Individual farmers' field score, IFPMS=Individual farmers' possible maximum score.

The average livelihood score was calculated by dividing the sum of individual percentage field score of livelihood indicators by the number of indicators (8).

$$ALS = \frac{\sum IFPS_i}{LI}$$

Where, ALS= average livelihood score, $\sum IRWPS_i$= Sum of individual percentage field scores, LI = Livelihood indicators (8).

3.12 Empirical model of factors influencing participation in irrigation

The theoretical model is translated to the following empirical model of factors influencing participation in irrigation and its effect on livelihood.

$$Adopt = \beta_0 + \beta_1 Age + \beta_2 AgeSqd + \beta_3 Marital\ Status + \beta_4 Household\ head + \beta_5 Market\ Availabilty + \beta_6 Extension\ Contact + \beta_7 Rainfed\ Income + \beta_8 Farmsize + u_1 \quad (3.21)$$

$$lnALS = \alpha_0 + \alpha_1 lnTotal\ Income + \alpha_2 lnHousehold\ size + \alpha_3 Location + \alpha_4 Remittances + \alpha_5 Educatio + \alpha_6 Irrigation + u_2 \quad (3.22)$$

Table 3.1 Definition of variables used in the estimation of the selection model

Variable	Measurement	Description	A priori Expectation
Age	Years	Age of the farmer	-/+
Gender	Dummy; 1 if male and 0 if female	Gender of the farmer	-/+
Marital Status	Dummy; 1 if married and 0 if single	Marital status of the farmer	-/+
Household Head	Dummy; 1 if male and 0 if female	Sex of household head.	+
Market Availability	Dummy; 1 if market available and 0 if no available market	Whether the farmer have access to market the produce	+
Extension Contact	Number of years	The number of visits by an extension staff in a cropping year	+
Farm size	Size in acres	Size of rain-fed land cultivated	+
Rain fed Income	Amount in Ghana cedis	Total revenue from rain-fed farm	+

Source: Field Survey, 2016

Table 3.2 Definition of variables used in the estimation of the treatment model

Variable	Measurement	Description	A priori Expectation
Education	Dummy; 1 if formal education and 0 if no formal education	Whether the farmer have access to formal education	+
Household size	Number of people	The number of people in the farmers household	+
Location	Dummy; 1 if river and 0 if dam	Source of water for irrigation	-/+
Remittances	Dummy; 1 if received remittances and 0 if no remittances received	Whether the farmers have received any external support	+
Total Income	Amount in Ghana cedi	Total revenue in the previous cropping season	+

Source: Field Survey, 2016

3.13 Summary and conclusion

This chapter discussed the methodology employed in this study to achieve the study objectives. The research was conducted in four irrigating communities in the Bawku West District of the Upper East Region of Ghana. The study relied mainly on primary data with households as the target population where a farmer represents a household. The study employed multistage sampling method. The study used both qualitative and quantitative tools to address the objectives. The first objective was measured using weighted scores through Likert scale. Treatment effect model was used to measure objective two and three and this solved the problem of possible selectivity bias and also measure the direct effect of irrigation on livelihoods of farmers. To determine the livelihood score for an individual farmer, 8-point indicators was indexed. The SWOT analytical tool was used to measure the fourth objective in addition to descriptive statistics.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents findings and discussion of data collected from 304 farmers in the Bawku West District in the Upper East Region of Ghana. Results are presented as frequencies, percentages and means, as well as analysis from probit model and average treatment effect model. The following are sub-sections discussed under this chapter included: respondents' demographic and socio-economic characteristics, perceived importance of ecosystem to farmers' livelihoods, factors influencing male and female participation in irrigation and effect on livelihoods and constraints, prospects and opportunities of men and women involvement in irrigated agriculture.

4.2 Demographic and socio-economic characteristics of research participants

This section presents findings of selected social and economic characteristics of the sampled population. The social and economic characteristics selected are those deemed relevant to the purpose of this study as informed by available literature on the issues explored. The variables captured in the study include age, civil status, literacy level, educational attainment and household headship, household size, income, farm size and farm experience.

4.2.1 Sex distribution

The sample of farmers considered included 152 males and 152 females. This is because of the researcher's decision to interview proportionate number of male and female farmers since both sexes play significant roles in agricultural activities as a means of livelihood. Hence, the researcher will be able to assess their engagement on livelihood. In the study area, men are normally involved in land preparation, weeding, fertilization, transportation and storage. This is due to the labour intensive nature of these activities on the field. Women on the other hand mainly engage in planting, processing, watering and marketing. There may be variation however depending on the ownership of the farm. This is notwithstanding the fact that farming is an activity dominated by men, especially in Northern Ghana where resource ownership by women is limited. The perception is that farming is a tedious work that women do not have the energy to engage in.

4.2.2 Age distribution

From analysis, the average age of male irrigators is 40 years whiles that of female irrigators is 39 years. In the case of non-irrigators, the mean age is 48 years and 44 years respectively for males and females (Table 4.1). From the distribution, the highest percentage of irrigators fell within the age bracket of 26-35 (27%) followed by 36-45 (21.7%). This shows that irrigators are youthful in the study area.

Table 4.1 Age distribution of the sampled respondents

Age Category	Irrigators		Non-Irrigators	
	Frequency	%	Frequency	%
16-25	30	19.7	27	17.8
26-35	41	27.0	32	21.1
36-45	33	21.7	26	17.1
46-55	22	14.5	19	12.5
56-65	18	11.8	19	12.5
66-75	8	5.3	29	19.1
Total	152	100.0	152	100.0
Mean	39.61		45.68	

Source: Field Survey, 2016

The potential advantage of this finding is that apart from the sustainability of irrigated agriculture, the youth are normally very innovative and can bring their expertise to bear in terms of hard work and technology adoption. On the other hand, the highest percentage of non-irrigators fell within 26-35 (21.1%) and followed by those in the age bracket of 66-75 (19.1%). The fact that the mean age of irrigators is 39 years suggest that, the youth are enterprising and will be willing to adopt new technologies in farming.

4.2.3 Civil status

The results indicate that majority (83%) of male and female irrigators are married, followed by single respondents representing 17 percent males and 55 percent females (Table 4.3). Similarly, majority of non-irrigators are married representing 72 percent males and 59 percent females, followed widowed respondents representing 4 percent males and 32 percent of females. In addition, none of the irrigators are separated nor divorced as compared to non-irrigators where 2 percent of respondents were separated and 6 percent of respondents were divorced. The statistics in civil status suggests that, respondents who are married mostly engage in irrigated agriculture. Reasons may be that married respondents may engage in irrigated agriculture by virtue inheriting parcel of lands personally owed by respondents' spouse or inheriting parcel of land belonging to the spouse family. This notwithstanding, married women may have multiple roles that are likely to prevent them from engaging in irrigated agriculture.

4.2.4 Literacy level

Results revealed that, majority of respondents can neither read nor write in all categories. From the analysis, 71 percent of male and 78 percent of female irrigators can neither read nor write. Similarly, 70 percent of male and 84 percent of female non-irrigators can neither read nor write (Table 4.3). Further analysis also revealed that, the level of literacy is generally low in females than their males. Implications are that, female farmers' will not be able to equally access improved technologies when given the access as compared to their male counterparts. Ayoola *et al.* (2011) asserts that, literacy aids females' access to improved technologies.

4.2.5 Educational attainment

The results revealed that, formal education is low among the entire respondents. From the analysis, majority of respondents have no form of education representing 57 percent male and 78 percent female irrigators and 59 percent male and 84 percent female non-irrigators (Table 4.3). The statistics further explains why majority of respondents can neither read nor write. This also implies that low level of education is more pronounce in female respondents than in their male counterparts. The reason for the low level of education among respondents may be that, farming in Ghana is perceived to be a preserve for the less educated as those with higher education prefers moving into the urban centers for white-collar jobs. As industrial employers tend to prefer highly educated employers, the less educated opt for farming.

4.2.6 Household size

From the results (Table 4.2), the minimum household size for both irrigators and non-irrigators is 1.0 whiles the maximum household size for irrigators is 36.0 and 18.0 for non-irrigators. The pooled mean household size estimate was 6.0. Whiles irrigators had an average household size greater than the general mean, non-irrigators had household mean less than the pooled. The mean household size for the two categories are higher than the national average household size of 4.0 (GSS, 2014). A greater number of household size implies there available labour for farming and economic activities however; increasing family size means that, there is pressure on household resources. The reason for high household size in irrigated household may be as results of labour-intensive nature of irrigated agriculture in the study area. Due to the rudimentary nature of technology used in irrigated agriculture, labour is a very important especially for cultural practices like nursery, transplanting, weeding, fertilization, harvesting and processing. Farmers hence acquire labour through hiring or family labour. It is therefore not surprising that irrigators have the highest household size.

Table 4.2 Household size distribution

Household Size	Irrigators		Non-Irrigators	
	Frequency	%	Frequency	%
1.0-5.0	64	42.1	89	58.6
6.0-10.0	69	45.4	54	35.5
11.0-15.0	16	10.5	8	5.3
16.0-20.0	2	1.3	1	0.7
>20	1	0.7	0	0.0
Total	152	100	152	100.0
Mean	7.0		5.0	

Source: Field Survey, 2016

4.2.7 Household head

From the results, 70 percent of male irrigators were household heads whiles 71 percent of male non-irrigators were household heads. In the cases of female respondents, 11 percent of irrigators are household heads while 35 percent of non-irrigators are household heads. Reason for majority of male respondents being household head may be that, in the traditional Ghanaian setting, men are considered the breadwinner of the family, hence have the responsibility of engaging in economic prospects.

4.2.8 Farm experience

In the study area, majority of farmers who engage in irrigated agriculture also engage in rain-fed agriculture. Results show that, respondents have more experience in rain-fed agriculture than irrigated agriculture, which implies that farmers start cultivating rain-fed lands before deciding to engage in irrigated agriculture. This is because, traditional agriculture in Ghana is rain-fed which requires limited resources and skills however, irrigated agriculture requires more skills and resources. Farmers usually use income from rain-fed to invest in irrigated agriculture. From the results (Table 4.4), the average years' male irrigator is engaged in irrigated agriculture is 13 years whiles the number of years he is engaged in rain fed agriculture is 18 years. In the case of female respondents, the number of years female irrigator is engaged in irrigated agriculture is 12 years whiles the number of years she is engaged in rain fed agriculture is 15 years. For non-irrigators, the numbers of years involved in rain fed agriculture is 21 years and 15 years for male and females respectively.

4.2.9 Farm size

From the results (Table 4.4), the average farm size for male irrigators is 4.7 acres and 3.3 acres for female irrigators. For non-irrigators, the average farm size for male is 4 acres and 3 acres for females.

4.2.10 Farm income

Results show that (Table 4.4) the average monthly income of male irrigators is GHC 3, 616.21 and GHC 1,317.92 for female irrigators. For non-irrigators, the monthly income of male and female is GHC 1,329.96 and GHC 1, 008.69 respectively.

4.2.11 Extension visits

Results show that, 53 percent of male and 41 percent of female had contact with extension officers. The percentage share of respondents' decreases as the number of contact increases. For instance, while 46 percent of male farmers had contact with extension officers for 1-3 times, only 1 percent of the sampled farmers had contacts with extension service agents for 10-12 times. Similarly, while 34 percent of female farmers had contact with extension officers for 1-3 times, only 1 percent of sampled farmers had contact with extension services providers for 10-12 times. Generally, extension contact among respondents is low. The mean extension contact for both male and female farmers was once. This may have effect on the adoption and use of irrigation technology as it relates to up-to-date information on production and training for increased productivity.

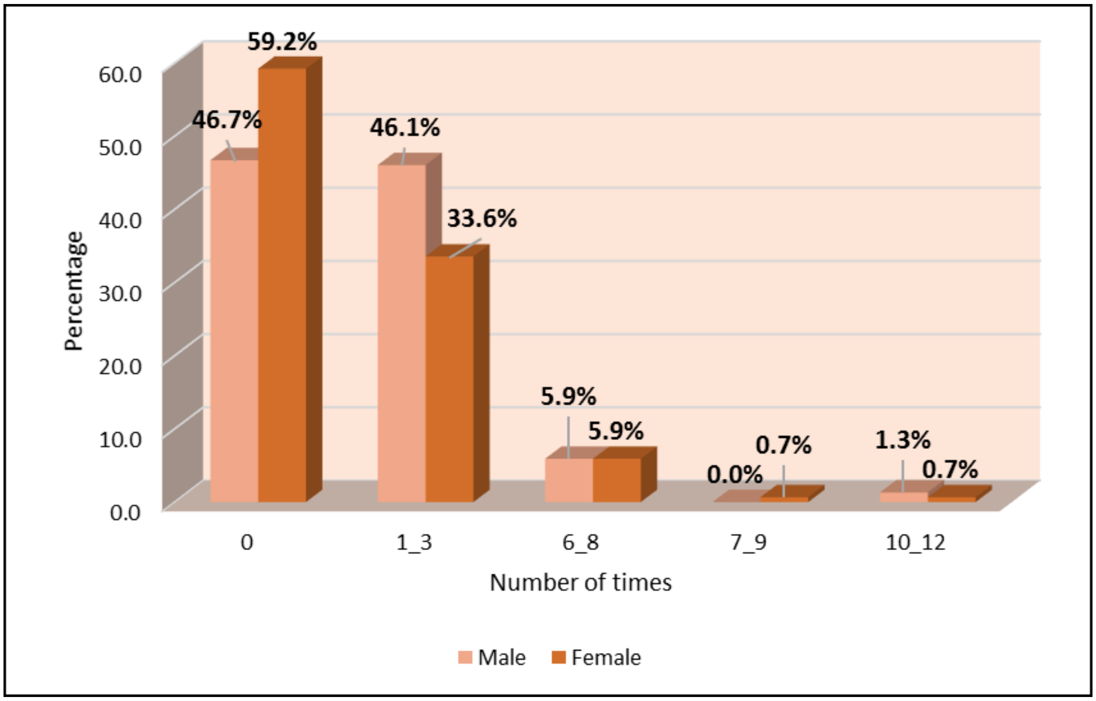

Figure 4.1 Number of times a farmer had contact with extension officer (s)

Source: Field Survey, 2016

4.2.12 Engagement in non-farm activity

Results show that, farmers who did not engage in any other economic activity apart from farming represented 69 percent while 31 percent were engaged in other economic activities. These other economic activities include petty trading, dawadawa making, shea butter processing, soap making, pito brewing, teaching, health service provider, social worker, fishing, gold mining and artisanry (e.g. sewing, mechanic, mason, electrician, driving, carpentry, blacksmith and basket weaving).

Table 4.3 Demographic characteristics of respondents

	Irrigators		Non-Irrigators	
	Males (n=76)	**Females (n=76)**	**Males (n=76)**	**Females (n=76)**
Marital Status				
Single	17	5	20	5
Married	83	83	72	59
Separated	0	0	1	1
Divorced	0	0	3	3
Widowed	0	12	4	32
Sub-total	**100**	**100**	**100**	**100**
Literacy				
Can read and write	26	18	29	12
Can read only	1	3	1	1
Can write only	1	1	0	3
Can neither read nor writes	71	78	70	84
Sub-total	**100**	**100**	**100**	**100**
Educational Attainment				
None	57	78	59	84
Non-formal	7	1	3	0
Primary	13	8	12	4
JHS/MSLC	16	11	11	11
SHS/VOCA	5	3	9	0
Tertiary	3	0	7	1

Sub-total	**100**	**100**	**100**	**100**
Household Headship				
Household heads	72	11	71	35
Not households	28	89	29	65
Sub-total	**100**	**100**	**100**	**100**

Source: Field Survey, 2016

Table 4.4 Socioeconomic variables of respondents

	Irrigation				**Rain-fed**			
	Mean	Min	Max	S.D	Mean	Min	Max	S.D
Age								
Males	39.5	20.0	70.0	13.6	47.5	19.0	91.5	20.9
Females	39.5	21.0	70.5	13.9	44.0	17.5	77.5	17.8
Income								
Males	2828.3	165.0	18710.0	3502.9	1022.3	110.0	5363.5	1033.5
Females	1325.7	140.0	5400.0	1171.6	715.5	75.0	3280.0	643.5
Experience Irrigation								
Males	13.5	2.0	46.5	9.8	1.4	1.0	27.5	393.925
Females	11.2	1.0	35.0	7.8	6.48	1.0	11.35	7.68
Experience Rain-fed								
Males	17.1	1.5	51.0	12.07	21.58	3.5	55	14.97
Females	13.9	0.5	42.5	10.715	15.19	1.0	48	13.32
Farm size								
Male	4.765	1.375	10.75	2.385	4.035	1.25	10.0	2.095
Female	3.345	0.5	11.25	2.075	3.15	0.625	8.25	1.74

Source: Field Survey, 2016

4.3 Perceived linkage among irrigation, ecosystem and livelihood

4.2.1 Linkage between ecosystem and livelihood

Ecosystem services contribute significantly to the livelihoods in the study area through direct access to various ecosystem goods and services (Table 4.5). The benefits respondents derive from the ecosystem services are discussed four broad categories. These include provision services, regulatory services, cultural services and supporting services. Provision services provides importance source of livelihood for respondents. The study reveals that, all (100%) of respondents are engaged farming activities as their primary source of livelihood. Both male and female respondents revealed that, they obtain food and income through the cultivation of crops and rearing of animals. Respondents also revealed that, river bodies also available provides fish and other aquatic animals used for both domestic consumption and selling. In addition, fresh water is an important household commodity especially for women who utilize it in domestic activities.

Table 4.5 Major economic trees and their importance to livelihoods

Economic Trees	Products Obtained	Mean Income GH¢	Rank highest Contributions To Domestics Use	
			Male	Female
Shea Tree	Fruits, firewood Oils, herbs	179	1st	1st
Dawadawa Tree	Spices, oil Fruit, herbs	117	2nd	2nd
Kapok Tree	Timber, Fiber, vegetables, seeds	361	4th	3rd
Baobab Tree	Fruits, vegetables, fibers, seed	57	3rd	4th

Source: Field Survey, 2016

Furthermore, respondents benefit from both forest products and non-timber forest products such as wood, honey, fruits, timber, bush animals, herbs and charcoal. The study revealed some important economic trees namely: shea tree (locally referred to as Tama), dawadawa tree (parkia biglobosa), kapok tree and the baobab tree. Respondents identified a variety of products obtained from these economic trees (Table 4.6). These products are used for both domestic and commercial purposes. The shea fruit serve as an important source of food during the cropping season i.e. the period between planting and harvesting of the first millet when household food is in short supply.

Again, the seed of the fruit is used in preparation of butter that is either sold or used in households as oil for cooking and also as cosmetic. The shea tree provide significant livelihood strategies for rural folks. This ranges from shea fruit picking, butter/oil preparation, selling which especially involve women. For instance, picking of nuts serve as an employment for some women who pick the nuts and sell to companies for industrial uses. This is evidenced in the results indicating that 42 percent of female irrigators and 28 percent of female non-irrigators use the products for both commercial and domestic uses. From analysis, the mean income obtained from shea products is GHC179. Kapok tree serves as an important source of income for the respondents. Further probe revealed that, the kapok serve as good timber for furniture, which explains the high value for it apart from its domestic uses. Hence, a mean income of GHC361 obtained from kapok products. Another important source of income is from the dawadawa tree. The results revealed that, all products from the tree could be sold and used in the household as well. For instance, the spices prepared can be sold by women and as well used as an important protein supplement in meals. The dawadawa spices serves as important ingredients in traditional northern meals. This is a result of it nutritional and medicinal properties. This is confirmed in the ranking (2nd) of the products in the table under category of respondents. The mean income obtained from dawadawa products is GHC117. Respondent revealed that, some plant serves as a source shade and shelter in the communities. For example, wood and clay are used by men to mold blocks for constructing houses whilst women use by-products of wild fruits (dawadawa) and fecal matter of animals to plaster (coat) the buildings. Again, some plant species serves as a source traditional herbs used to cure diseases and sickness in the study area.

Respondents added that, trees serve as a natural protector against strong winds during storms. In the dry season when temperatures are very, trees provide shades and filters the dusty winds, which prevents respiratory diseases whiles providing a good source of air for breathing. Respondents identified that, trees are responsible for good rains. It was also revealed that, some soil types serve as natural purifies of water and adds additional taste to water when drinking. The natural vegetation also help to prevent the washing of the soil on farmlands to prevent loss of soil nutrients. Respondents also revealed that, some parts of the communities especially forest grooves are reserved for traditional practices. Again, certain plants and animal species are used for special sacrifices and festivals.

Table 4.6 Linkages between ecosystem services and livelihoods

Livelihood Indicators	
Food	Provision of food through crops and animals.
Income	Sales of crops, animals and NFTPs
Employment	Provides necessary conditions for agriculture.
Health	Provision of medicinal plants and herbs
Cultural	Provision of crop and animal species for sacrifices, forest for sacred grooves

Source: Field Survey, 2016

4.2.2 Perceived importance of ecosystem services

Results indicate that, generally respondents attach high level of importance ranging 88-95 percent to provision services of ecosystem than other services. For instance, 88 percent of both male and female irrigators, 95 percent, and 86 percent for male and female non-irrigators perceived provision services to be very important to their livelihoods. This is because of the tangibles products and resources that they derive from the ecosystem. On the other respondents attached low level of importance to regulatory, cultural and supporting services of the ecosystems. Estimates from the percentage score (Figure 4.2) of the ecosystem services revealed that, provision services of the ecosystem are more important to respondents (both irrigators and non-irrigators) than other services of the ecosystem. Farmers percentage score further confirm this when the various products obtained from the ecosystem (Figure 4.3). It was revealed that all tangibles products like crops, animals, fuel wood and fish scored very high percentages as the respondents consider them very important to their livelihoods. These products include crops, animals, water, fuel wood and fish. This suggests that, products from the ecosystem that yield immediate or direct benefits are more valued by respondents in the study area. Boon & Ahenkan (2011) in their study found out that, food (35%), cocoa production (33%) and NFTPs (15%) were ranked as highest most important benefits derived from forest ecosystems. Per Carney *et al.* (2000) definition of livelihoods, an individual's priority is to meet the daily food needs of the households, which are provided by the provision services of the ecosystem. Additionally, these services are immediate and have direct impact on the survival of households as compared to the other services of the ecosystem hence the tendency to prioritize provision services over other services provided by the ecosystem. UNEP (2011) recounts that, agricultural ecosystem is managed by humans in a way that maximises provisioning ecosystem services such as food, fibre and fuel at the expense of other services. This implies that, actions of respondents in the study area may only be directed towards obtaining provision services of the ecosystem without considering the effect on other services of the ecosystem.

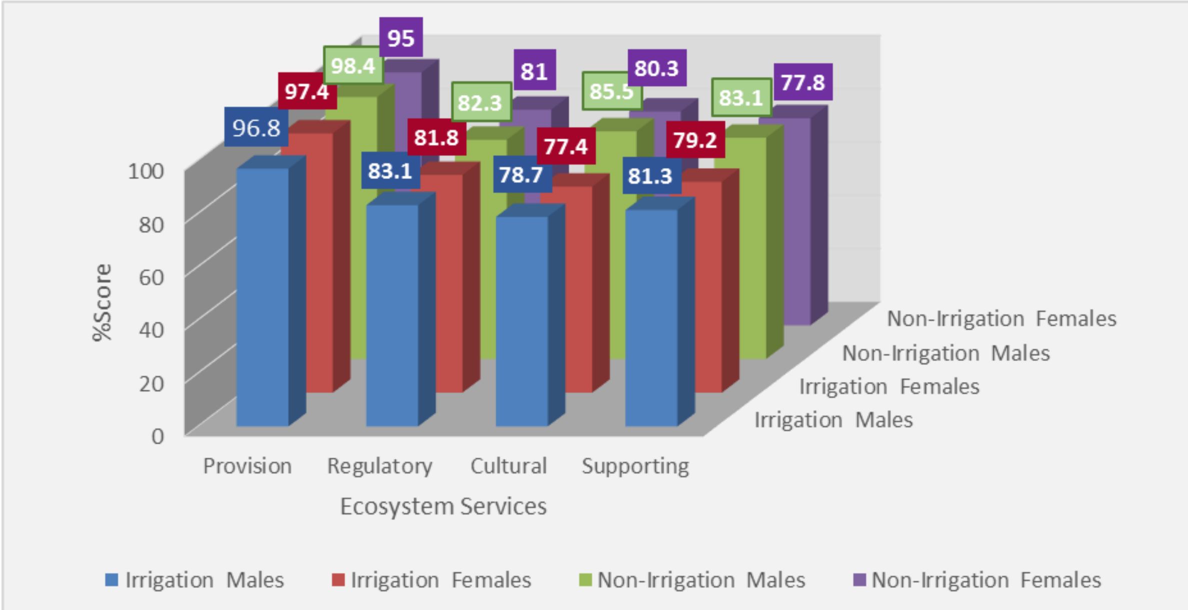

Figure 4.2 Percentage score for ecosystem services

Source: Field Survey, 2016

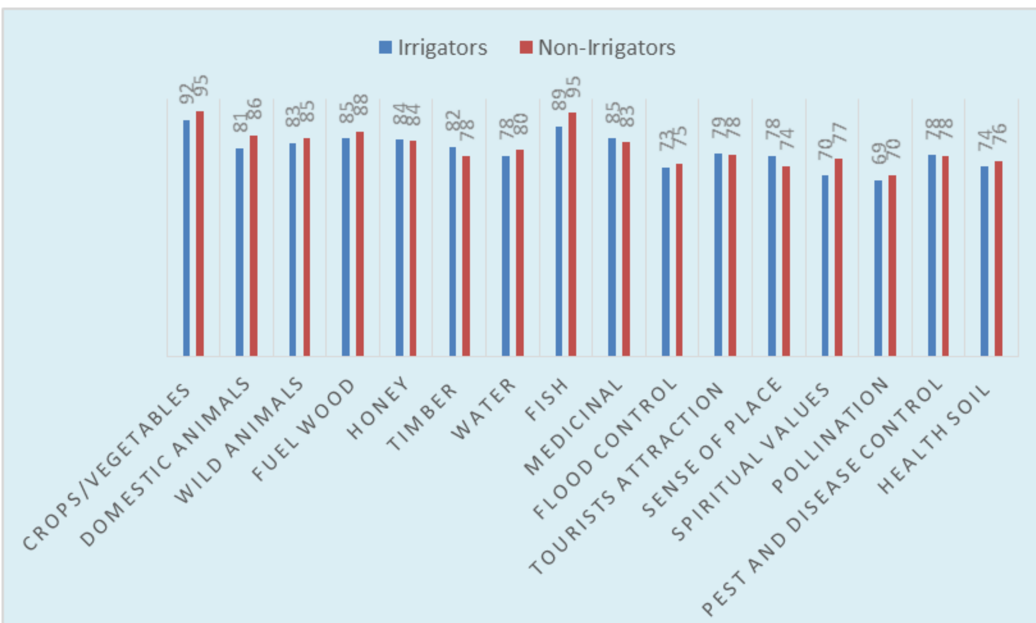

Figure 4.3 Percentage score of ecosystem products for irrigators and non-irrigators

Source: Field Survey, 2016

Also, it was revealed that non-irrigators appreciate ecosystem services than their irrigating counterparts. This is evidenced in their percentages score for ecosystem services. For instance, male non-irrigators attached relatively high level of importance to all the four categories of ecosystem services than their irrigating counterparts. Possible reasons may be that, since non-irrigators are more vulnerable to climate change, they appreciate the ecosystem services compared to their irrigating counterparts. This is consistent with the assertion that, ecosystems provide valuable benefits to the society especially the poorest and the most vulnerable people who strongly depend on them for their livelihoods and have limited ability to adapt the face of changing climate (UNEP, 2010).

4.2.3 Perceived linkage between irrigation and ecosystem

Respondent were also assessed on the knowledge about the linkage between irrigation and ecosystem (Figure 4.4). To assess this, respondents were asked whether there exists any relationship between irrigation and ecosystem. Results from the analysis indicate that, majority of both male and female irrigators revealed a positive relationship representing 54 percent and 47 percent for male and female respectively. They explained that, ecosystem provide necessary conditions such as land, water and air for irrigation farming to thrive whilst irrigation in return help the fertility of the soil through the use of fertilizer and other chemicals. Also 12 percent of female and 7 percent of female revealed a negative relationship. They also explained that, irrigation facilities introduce diseases such as malaria and also destroy the environment. Few respondents (3%) observed both positive and negative relationship.

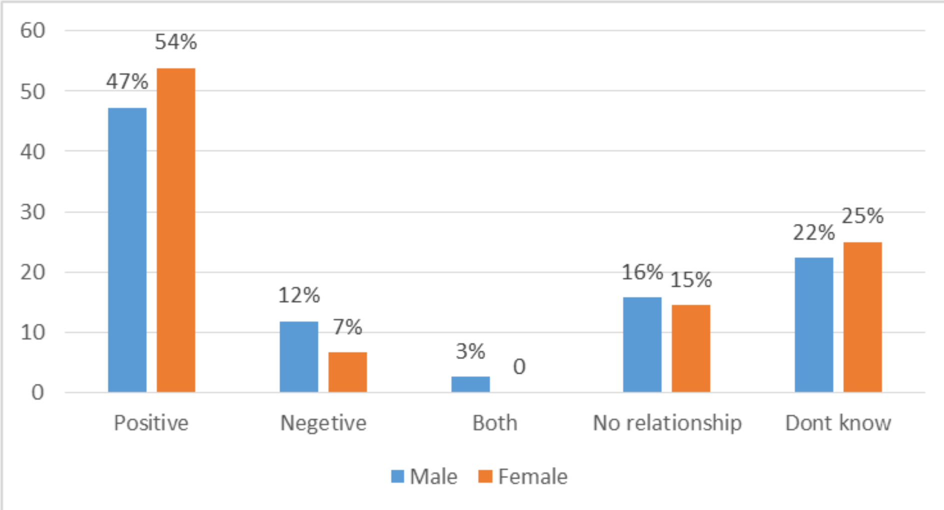

Figure 4.4 Knowledge of respondent about the relationship between irrigation and ecosystems

Source: Field Survey, 2016

Furthermore, majority of 67 percent of males and 65 percent of females identified some observable effects of irrigation on the ecosystem. Respondents identified hosts of effects, which are both negative and positive. The effects identified by respondents are represented in Table 4.7.

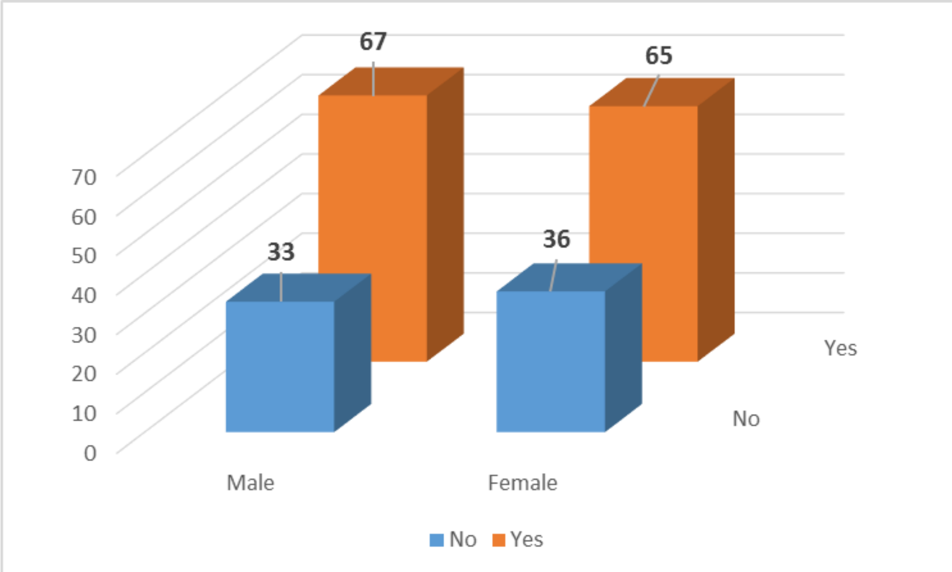

Figure 4.5 Knowledge of respondent of the observable effects of irrigation on ecosystem

Source: Field Survey, 2016

Table 4.7 Observable effects of irrigation on the ecosystem

Positives Effects	**Negatives Effects**
1. Support plant and crop growth	1. Destroys soil structure and living organism
2. Habitat for living organisms / supply of water for animals	2. Causes destruction in times of flooding especially for river irrigators
3. Enables the production of crop all year round	3. Dam constructions causes the destruction of environment
4. Feed for livestock	4. Loss of soil fertility, leaching of nutrients
	5. Land degradation and soil erosion
	6. Air pollution
	7. Spreading of disease such as malaria
	8. Flooding, water logging
	9. Breeding grounds for dangerous animals

Source: Field Survey, 2016

Again, the study assessed the perception of respondents about the changes in some selected ecosystem services over the past ten years (Figure 4.6). The ecosystem services include clean water, quantity of water, water available for domestic use, water available for livestock, water for fishing, water for recreation, food availability, water access, soil fertility, soil structure, water logging, flooding, erosion, siltation, fish availability, vegetative cover, fuel wood availability, availability of medicinal plants, biodiversity, incidence of pest and diseases, availability of economic trees, non-timber forest products (NTFPs).

Results revealed that, majority of the identified ecosystem functions have been decreasing over the years. In the views of males (both irrigators and non-irrigators) except for the supply of clean water, all other listed functions of the ecosystem are decreasing. They asserted that, the clean water is only increasing due the increasing construction of boreholes by both Governmental and Non-Governmental Organizations. This finding is consistent with the Millennium Ecosystem Assessment Report (2005). It reports that, about 60-70 percent of the world's ecosystem services are declining.

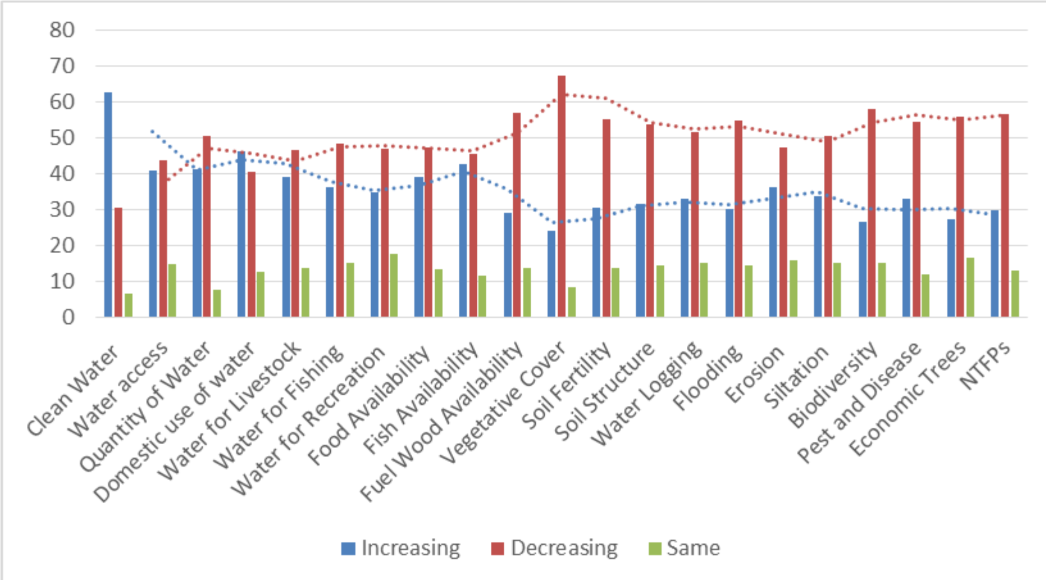

Figure 4.6 Changes in ecosystem for the past ten (10) years

Source: Field Survey, 2016

The perception of female respondents (irrigators and non-irrigators) is however, varied from that of their male counterparts. Female respondents (61% of irrigators and 68% of non-irrigators) observed that clean water for domestic use and water for agricultural purposes is increasing. Women also revealed that, they do not need to search water longer hours for their domestic activities due to the increase construction of borehole in their communities. Formerly, women have to walk long distance in search for water for cooking which delay their domestic chores and some generate conflict with their spouses. Except for female irrigators, all other respondents revealed the decreasing quantity of water over the past ten years. They explained that, although water is available for domestic use, the amount of water available to individual households is decreasing due to increasing population, hence reducing access to water.

Again, as compared to the past, respondents revealed that, negative effects of the ecosystem such as water logging, flooding, erosion, pest and disease infestation and siltation have been decreasing. Respondents attributed the decreasing trend to the adaptive and management strategies adopted over the years. Especially in the case of pest and diseases, more drugs are available to cure them. Majority of respondents also observed changing (decreasing) trends in vegetative cover, soil fertility, biodiversity and economic trees as well as non-forest timbers products. According to UNEP (2010), changing climate patterns have been attributed to deforestation, forest degradation, agricultural practices and change in land use.

To explain the causes of changing ecosystem functions, 85 percent of male 80 percent of females attributed the changes to human activities such as expansion of the communities, farming activities and economic activities leading to the exploitation of the ecosystem. Respondents identified some farming practices that have negative impact on the ecosystem (Figure 4.7). The results revealed that, bush burning is mostly prevalent activity identified in the study that is having the highest count of 44 percent. Respondents explained that, due to the prolong harmattan season, livestock owners especially those who own cattle burn the bush to enable the early growth of new grass for their livestock to feed on. In addition, farmers are used to burning crop residue in the farms after harvest in order to prepare the field for the next cropping season.

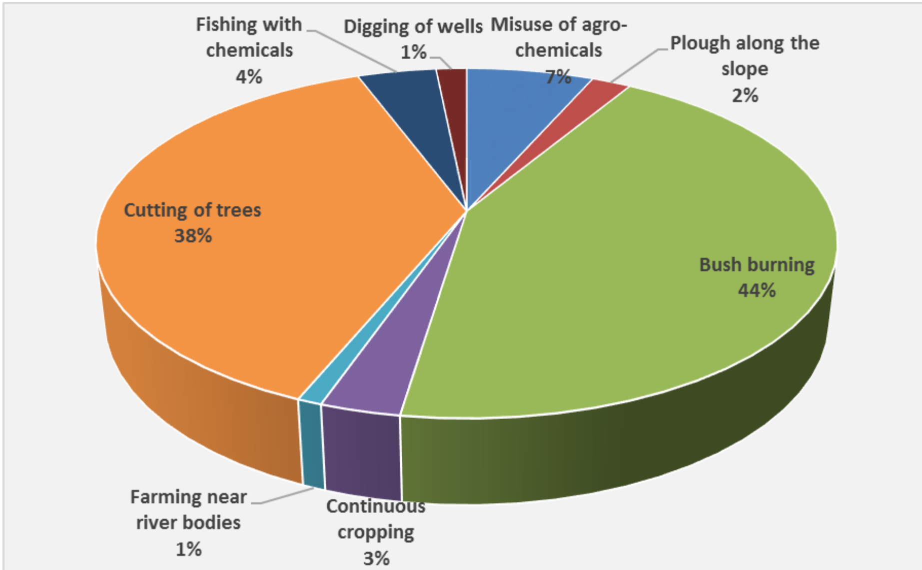

Figure 4.7 Farming activities that destroy the ecosystem

Source: Field Survey, 2016

Cutting down of trees around river bodies in order to increase farm size is the second most farming practices identified by respondents in the study. Cutting down of trees represents 38 percent. Estimates suggest that about 15 – 17 percent of global emissions are from deforestation and forest degradation (UNEP, 2010). This has resulted in increasing imbalance between the carbon emissions and absorption capacity of the earth. The table below details the farming activities identified and their perceived impact on the ecosystem.

Table 4.8 Farming activities and perceived impact on ecosystem

Farming Activities	Perceived Impact on Ecosystem
Misuse of agro-chemicals	Loss of soil nutrient, kills livestock, kill living organisms, destroys soil structure
Bush burning	Loss of vegetative cover, erosion, loss of soil nutrient, no grass for roofing houses, high temperature, loss of vegetation, loss of economic trees, pasture for animals grazing, kill living organism in the soil, destruction of wildlife, loss of biodiversity,
Continuous cropping	Loss of soil nutrients, loss of nutrients
Cutting of trees	Deforestation, exposes the soil, high temperature, reduce rainfall, drying of water bodies, dying of economic trees, no shade, cause drought
Fishing with chemicals	Destroy aquatic animals, water pollution
Digging of wells	Polluting of water bodies, breading of mosquitoes
Ploughing along the slope	Causes soil erosion
Farming near river bodies	Siltation, washing of chemicals into water bodies polluting drinking water.

Source: Field Survey, 2016

The decreasing ecosystem functions and the human activities directly impact rural livelihoods. Decreasing regulatory functions through cutting of trees, uncontrolled bush fires leading to loss of biodiversity vegetative cover and wild life which form important natural capital increases the vulnerability of households to the vagaries of climate which affect their livelihoods with direct effect on household food security. This will be worse for non-irrigation households that directly rely on the rain-fed agriculture as only source of livelihood. Hence decreasing ecosystem services directly impact agriculture and rural livelihoods. Respondents identified that, certain species of animals and plants that they have been identified with have gone extinct. These species hitherto have been used to perform cultural and traditional rites. Hence loss species implies loss of cultural heritage for them.

Social capital such as relations among families and communities have also been affected. Respondents explained that, families are now disintegrating recent times. In the main cropping seasons, farmers migrate to hinder lands in search for fertile land to cultivate. This is because, the nearby lands have lost their fertility. This has led to breaking of the traditional extended family system cherished in most parts of Northern Ghana. This is consistent with Akudugu *et al.* (2013) who observed that, climate change affect social safety nets that foster northern Ghana families and communities. Another area that, social relations are affected is relation between crop farmers and livestock farmers. Respondents revealed that in the dry seasons where vegetative cover and water is scarce, animals tend to graze on irrigated fields, destroying their cultivated crops. This degenerate into conflicts among them. Sometimes, farmers have additionally burden to fence irrigated crops or provide labour to monitor the fields which puts financial burden on them.

It was also found that decreasing soil fertility have resulted in low incomes and high cost of farming which affect the financial capital. Again, increased incidence of pest and disease resulting from pollution of water bodies with agrochemicals, breeding of vectors that transmit diseases like malaria leading to loss of lives affect human capital. A combination of these factors affect sustainable livelihood development through livelihood activities and strategies especially agricultural production systems which in turn affects rural livelihoods.

4.2.4 Linkage between irrigation and livelihoods

Irrigated agriculture serve as a significant part of rural livelihood especially in areas where there are limited opportunities for employment in other sectors of the local economy. From the study, it was revealed that, respondents engage in irrigated agriculture for different reasons. Results revealed that (Figure 4.8), 8 percent of males engage in irrigated agriculture for food only, 19 percent for income only, 45 percent for income and food and 28 percent for employment, shelter and acquire assets. However, for females farmers, 16 percent engage in irrigated agriculture for food only, 11 percent for income only, 54 percent for food and income and 19 percent for other reasons which include employment, shelter and assets acquisition. Irrigated agriculture in the study area is characterized with the production of cash crops mainly onion and cabbage hence it is cultivated for commercial purposes. Therefore, the only returns farmers get from this activity is income through the sales of produce since little quantities form part of their domestic consumption. This income in turn helps them to procure household needs. However, some farmers' especially female farmers concentrate in producing crops like allefu, okra, ayoyo, bra, cabbage that are directly consumed in the household however, surplus is sold. Other reasons for engaging in irrigated agriculture include employment and acquisition of assets.

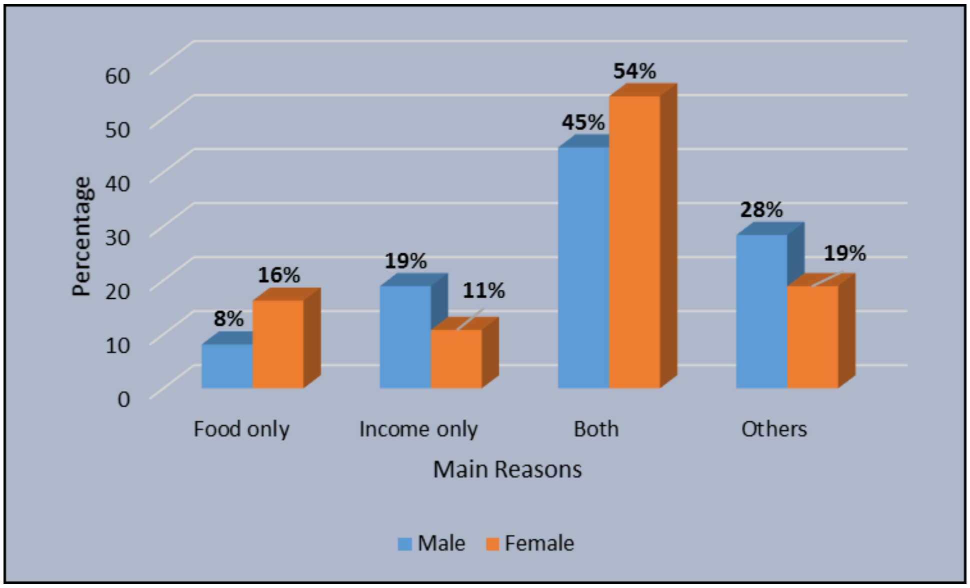

Figure 4.8 Major reason for participating in irrigated agriculture

Source: Field Survey, 2016

Results from the mean rank of livelihood indicators (Table 4.9) indicates that, the highest contribution of irrigation to livelihoods for male irrigators include food (ranked 1st), employment (ranked 2nd), and income (ranked 3rd). Similarly, female irrigators revealed employment (ranked 1st), food (ranked 2nd), and income (3rd). Respondents explained that, due to the prolonged dry spells coupled with unavailability of non-farm economic activities, irrigation serves as important source of employment as means to generate some income. This as well influence their choice of crop production especially in the case male irrigators. Respondents revealed that, although crops cultivated are not consumed in large quantities in the households they are sold in order to gain some income in order to purchase other foodstuffs consumed in the household to supplement depleting food stock. It was also observed in the case of female irrigators that, dietary diversity was ranked fourth among the livelihood indicators. Per the analysis and further probing, female irrigators who are usually allocated small land portion for irrigation by their spouse normally focus on mix cropping vegetables such as pepper, ayoyo and onion that are consumed in the household. This also enables them to sell some in the local markets in order to buy food ingredients and other domestic needs of the households. This is consistent with the assertion of Ojo *et al.* (2004) that, rural women engage in irrigated agriculture to meet households' needs and take care of children.

Table 4.9 Contribution of irrigation to livelihood

Livelihood Indicators	**Female**		**Male**	
	Mean	Rank	Mean	Rank
Employment	2.34	1st	2.39	2nd
Food	2.30	2nd	2.42	1st
Income	2.17	3rd	2.20	3rd
Dietary Diversity	2.04	4th	2.00	6th
Economic Dependency	2.03	5th	1.93	8th
Educational	1.93	6th	1.99	7th
Economic Freedom	1.92	7th	1.45	11th
Health	1.91	8th	2.03	5th
Status in the Community	1.86	9th	2.17	4th
Housing	1.67	10th	1.89	9th
Water facility	1.58	11th	1.84	10th

Source: Field Survey, 2016

Female irrigators revealed that as a result of additional income accrued from farming activities, they are able to meets their personal needs and immediate needs in the households without relying on their spouse hence economic independency ranked 5th by females. This is consistent with the findings of Alade *et al.* (2013) irrigated agriculture helped women to have income and increase food production and security. For male irrigators who focus on cash crops like onions, farming enables them increase their income to acquire more assets hence their general status in the community is improved and they are more respected. Respondents generally agree that, irrigation contributes to their income, which enables them to meets other livelihoods needs in the household.

4.3 Factors influencing participation in irrigated agriculture

The study examined factors influencing farmers' participation in irrigated agriculture through the estimation of adoption model. The probit estimates of the factors influencing gender adoption of irrigated agriculture discussed below. The socio-economic variables considered in the model include gender, age, marital status, household head, household size, market availability, extension contact, rain-fed income and farm size. Adoption estimates was presented separately for men, women and then a joint estimation with gender included as an independent variable. In the model, coefficients of two (2) and three (3) out of eight explanatory variables was found to be statistically significant for male and female respectively. On the other hand, when gender was included in the model, six (6) variables were statistically significant.

The coefficient for age was significant in the joint (gender) model but not significant in the separate male and female estimations. Age was found to be significant at 10 percent and have positive relationship with adoption. Thus, an increase in the age of a farmer, the likely the farmers' decision to participate in irrigated agriculture. Results from the marginal effects proved that age significantly increases farmers' probability to participate in irrigated agriculture. This may be due to the economic prospects of irrigation. The coefficient for aged squared was significant for male and joint model at 1 percent level of significance respectively but not significant for females. Age squared was significant and positively influence male farmers decision to participate in irrigated agriculture. The implication is that older farmers who are males had greater probability of going into irrigated agriculture than younger males. The negatively signed coefficient in the joint model however suggest that, younger farmers have higher probability of participating in irrigated agriculture than younger farmers i.e. as a farmer grows to a certain age the probability of participating reduces while younger farmers are likely to participate. This may be due to the labour-intensive nature of irrigated agriculture the study area and therefore older farmers have less vigor for farming. Irrigated sites in all the study areas do not have properly constructed canals. Additionally, farmers employ rudimentary technology in watering their crops. In this case, younger farmers may have energy required to perform these tasks than their older counterparts. Additionally, youth may be more enterprising and are willing to commercialize agriculture for economic gains as compared to older farmers who are more conservative. From the study the mean age for irrigators is 39 years whiles the mean age for non-irrigators is 45 years which supports this claim. This is consistent with findings of Ayoola *et al.* (2011).

The differences in the sign coefficient of aged squared may be attributed to locational disparities. In some communities in the study area, irrigated agriculture is perceived by the youth to be non-rewarding due to low prices for the produce coupled with high production cost and poor irrigation infrastructure. It is important to note that, crops cultivated on irrigated fields are cash crops in nature hence the only benefit for farmers is the returns on their investments. Therefore, farmers who are economically active, mostly the youth prefer to engage only in rain-fed agriculture and migrate to urban areas in search for "quick cash" i.e. to engage in more economically rewarding prospects such "galamsey" during the dry season. Hence the dominance of the older farmers who are less likely to migrate because they have already established their families in the community.

The coefficient of marital status was not significant in the males and females model but significant in the joint model. From the results, marital status was found to significantly influence farmer decisions to participate in irrigated agriculture. The marginal effects indicate that, as an individual is married into another family his/her probability to participate in irrigated agriculture increases by 15 percent. This is possible because, by association in the family, the individual is given the right to use family lands on irrigated sites. For women married into other families, their spouse give them portion of their lands for farming. In the cases where the woman inherits the land from her father, her husband assumes ownership of the land as the head of the household. In addition, married respondents may have access to irrigated lands as results of their husbands owing the lands or stand in to acquire portions of the irrigated lands for their spouse. The only group may not have access to these privileges are individuals who are divorced or separated.

Household head: The coefficient of was significant only in the separate estimation for females. Household head was significant at 1 percent level of significance but have an inverse relationship with adoption. This implies that, females in female-headed households likely to participate in irrigated agriculture than females in male-headed households. This possible because, females who head their own households take decisions on their own and decide the type of livelihood activity they should engage in. This is because, they are solely responsible for their own welfare. In the most Ghanaian homes, the decision to participate in any livelihood activity partially lies on the shoulders of household heads i.e. the head of the household would have to endorse an individual's economic activity. In the case of females in male-headed households, their husbands or heads would decide to own farms whiles the women play a supporting role in the farming activities hence the less likely they will own farms themselves. The marginal effect proved that, households' head who are females have the greater probability to engage in irrigated agriculture than their female counterparts in male-headed households.

Coefficient of market availability was significant in the female and joint estimation but not significant in males' estimation. Market availability was found to be significant at 1 percent level of significance and have a positive relationship with female farmers' and farmers in general decision to participate in irrigated agriculture. The positive coefficient shows that as the demand for the produce increases a farmer is likely to participate in irrigated agriculture. Availability of market has a significant probability of increasing females' decision to participate in irrigated agriculture by about 46 percent and farmers generally by about 33 percent when demand for the produce increases in the market. The positive effect of market availability variable did not come as a surprise because crops cultivated under irrigation are cash crops and are highly perishable like onions hence farmers are only motivated to produce when there are demands for them in the market. Additionally, marketing of produce is one of the traditional roles of women in the study area. In most cases, women will have to sell their produce in the market to earn some income before they are able to purchase both household and personal needs. Hence, market availability of produce significantly determine females' decision to participate in irrigated agriculture. Ofosu *et al.* 2014 opined that, predictable and reliable produce markets enhance the economic viability of irrigation farming.

The coefficient of extension was significant for males and also significant in the joint model but not significant for females. Extension services was significant 1 percent and positively influence male farmers' decision and generally, farmers' decision to participate in irrigated agriculture. The positive and significant marginal effect of extension variable means that as a farmer's contact with extension staff increases, his/her probability of going into irrigated agriculture also increases. This is plausible because, access to extension services implies access to improved technologies and good agronomic practices that increases the gains from the irrigations hence the higher the willingness to adopt. Agricultural extension provides up-to-date information to farmers on the production. Deressa *et al.* (2008) found out that, extension outreach had a positive significant effect on the adoption of new crop varieties. Ansah *et al.* (2015) and Amankwah *et al.* (2011) in their respective findings found out that, extension positively influences the adoption of technology.

Table 4.10 Maximum likelihood estimates of the farmers' determinants of irrigation participation.

Variable	Marginal Effects		
	Males	**Females**	**Joint**
Gender	-	-	0.022 (0.076)
Age	0.022 (0.019)	0.015 (0.017)	0.020* (0.012)
Age Squared	0.000* (0.000)	0.000 (0.000)	-0.000** (0.000)
Marital Status	0.121 (0.122)	0.088 (0.122)	0.158** (0.070)
Household Head	0.119 (0.118)	-0.284*** (0.114)	-0.099 (0.076)
Market Availability	0.186 (0.118)	0.459*** (0.082)	0.328*** (0.073)
Extension Contacts	0.219*** (0.086)	0.030 (0.093)	0.114* (0.062)
Rain-fed Income	0.000 (0.000)	0.000 (0.000)	-0.000 (0.000)
Farm Size	0.023 (0.020)	0.052** (0.028)	0.035** (0.016)

*Parenthesis ( )=standard errors, Number of Observation=152, ***significant at 1%, **significant at 5%, *significant at 10%*

Source: Field Survey, 2016

Farm size: Coefficient of farm size was significant for females and joint estimation but not significant males. The coefficient of farm size was significant at 5 percent level of significance. This implies that increase in the rain fed farm size increases the probability of females to participate in irrigated agriculture. This is plausible because irrigation participation is capital intensive and one of the major source of capital is income from sales of produce from rain fed agriculture. Hence, increase farm size will translate to increased revenue of which part could be invested in irrigated agriculture. It is important to note that in Northern Ghana women normally do not own farms. They belong to either the husbands or family heads. In cases where they are permitted to cultivate their own farms, they are allowed small parcel of their husbands' lands if married or allocated lands that are closer to the community or household (normally less fertile to cultivate) hence the sole aim of the production is to meet household food needs.

Increase in farm size have two implications for participating in irrigation: one of the implications is that, there is enough foodstuff in the household hence any additional income will be invested in irrigated agriculture (because women produce for household consumption) and two increases in farm size means increase in farm revenue which can be used to support irrigated agriculture. Similarly, the coefficient of farm size was significant at 5 percent level of significance in the joint model. This means that farm size increases farmers' decision to participate in irrigated agriculture. The positive and significant marginal effect of farm size variable means that, as a farmer rain-fed land for farming increased, his/her probability of going into irrigated agriculture increases. This is plausible because, increased size of farm literally means increased crop farm output and therefore increased farm revenue. Due to the capital intensive nature of irrigated agriculture, farmers need additional income that can help to invest in irrigated agriculture. Amankwah & Egyir (2013) also found that, farm size influence flooding irrigation technology among urban vegetable farmers' in Ghana.

4.4 Effect of irrigation on livelihood

The study further estimated the livelihood equation to determine the livelihoods effects of farmers' participation in irrigated agriculture. From the results, the adoption of irrigation had a significant and positive effect on the livelihood of farmers (average livelihood score). Other factors that were significant in determining average livelihood score were household size, location and education. However, while the coefficient of household size and education was negative, that of location was positive. Also, the lamda is very significant at 1 percent indicating that, selection bias was presented and there is the need to use average treatment effect to solve for the problem, hence the model is appropriate (Table 4.11). The positive sign of the adoption coefficient means that in general, irrigators had a greater average livelihood score than non-irrigators. Thus, the difference in the average livelihood of irrigators and non-irrigators is 0.089 percent (Table 4.11). This finding justifies the importance of irrigation in contributing to the livelihood of participants.

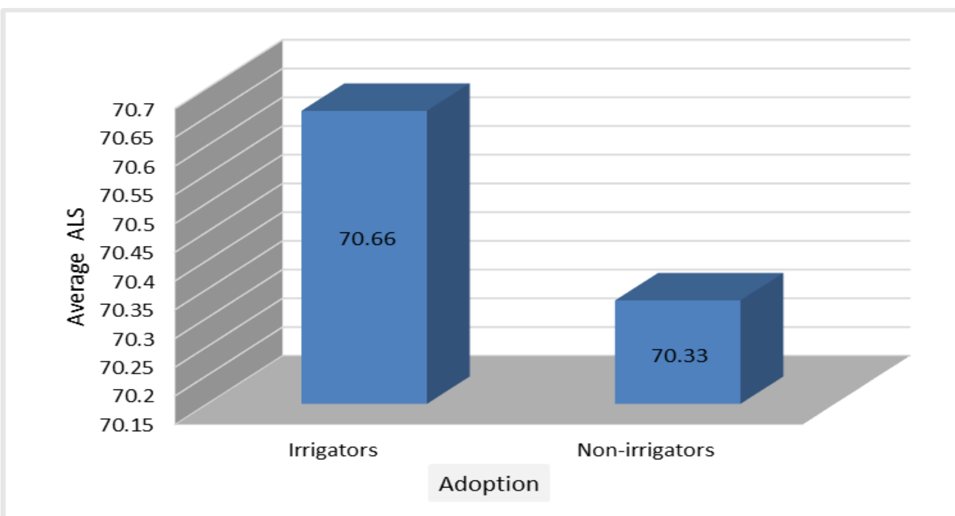

Figure 4.9 Participation in irrigation and average livelihood score.

Source: Field Survey, 2016

Household size was used as a proxy for family labour availability. Household size is statistically significant from zero and has a negative relation with average livelihood score. The negative coefficient means that the larger a farmers' household the smaller its average livelihood score. Although larger household size provides labour for irrigated agriculture, it is important to note that larger household size constraints household resources such as food and water. This means that, the per capita consumption of these households may be smaller. This confirm findings of Donkoh *et al.* (2014).

Location had a negative relationship with average livelihood score. The negative coefficient implies that, farmers sourcing their irrigation from dam have higher average livelihood score than their counterpart-using river as their source of water for irrigation. Thus, the difference in the average livelihood score between dam irrigators and rivers irrigators is 0.03 percent (Table 4.11). This may be attributed to the perennial flooding and destruction of farmlands, which affect households' food stock. As a reminder, communities along the white Volta annually experience perennial flooding of their farms during the peak of the raining season especially when the Bagre Dam from neighboring Burkina Faso is opened displacing lives and properties. This periodic disaster often lead to loss of lives and assets including destruction of farmlands of households that took them long years to build living most households vulnerable. This significantly affect livelihood in these communities.

Contrary to the research a prior expectation, however, was the effect of education on livelihood. Education was statistically significant from zero but had a negative relationship with average livelihood score. Considering the effect of education on human capital, one would expect that those with some level of education would have improved livelihood than those without. The opposite is this case; farmers who did not have any form of education have higher livelihood score than those who have some level of education. This may be because considering the nature of households in the study area; those who are educated are perceived to be 'well to do' hence have many family members depending on them for livelihood. This put pressure on individual resources thereby reducing the resource per capita.

Table 4.11 Maximum likelihood estimates of the determinants of irrigation livelihood.

Variable	**Coefficients**	**Standard Error**	**Z-Value**	**P>Z**
Constant	4.214	0.034	125.68	0.000
lnTotal_Income	0.006	0.004	1.4	0.161
lnHousehold Size	-0.016*	0.009	-1.72	0.086
Location	-0.034***	0.010	-3.47	0.001
Remittances	-0.011	0.014	-0.78	0.436
Education	-0.022**	0.011	-1.95	0.052
Adoption	0.089***	0.028	3.21	0.001
Lamda	-0.064***	0.017	-3.52	0.000

Source: Field Survey, 2016

4.5 The constraints, prospects and opportunities in irrigated agriculture

4.5.1. Constraints of irrigated agriculture

The fourth objective was to investigate the challenges and the prospects of participating in irrigated agriculture in the study area. Preliminary survey conducted on some respondents and key informants in the study area revealed some challenges. These challenges were later grouped for respondents to rank. The survey revealed seven (7) important constraints of both men and women engaging in irrigated agriculture. The constraints was presented to respondents for ranking. The Kendall's coefficient was used to measure degree of agreement in the rankings of respondents. The Kendall's coefficient was done such that, the smallest mean rank is the most important variable, whiles the least important variable has the greatest mean rank. The degree of agreement among the respondents is measured by W. The higher it is the better, because it shows the agreement among the respondents. From the results, the value for the Kendall's Coefficient of Concordance (W) was significant at 1 percent. This means that, there is an agreement among respondents in the ranking of the constraints in irrigated agriculture. The result of ranking is presented in Table 4.12.

The most important constraint identified by both male and female irrigators is the high cost of inputs such as seeds, weedicides, insecticides and fertilizers. Respondents revealed that, they are not able to procure all the necessary inputs needed during the season due to increasing price of the inputs in every production season. Farmers therefore do not follow the necessary agricultural practices leading to decrease in crop output. This is consistent with previous studies by Namara *et al*. (2011) who found out that, high cost of inputs in irrigation results in either outright losses or reduction in profit margin of farmers thereby serving as demotivation factor. Awulacchew *et al.* (2005) and Ojo *et al.* (2011) also found that, inputs like fertilizer are used in inadequate quantities due to high prices thereby affecting agricultural productivity (Ofosu *et al.*, 2014).

The fact that respondents identified inputs costs reveals the important role inputs play in the production of crops in the study area. Secondly, it reveals the willingness of farmers to adopt improved technologies in farming for optimum yields especially in the case of the study area where irrigated agriculture is for commercial purposes. Studies have demonstrated that, adoption of improved varieties of seeds and fertilizer increases crop output. Bruce *et al.* (2014), Wiredu *et al.* (2010); Uaiene *et al.* (2009) and Sserunkuuma (2005) found out that, adoption of improved varieties of rice seeds increases crop output. Johnson *et al.* (2003); Janvry & Sadoulet (2002); Evenson & Gollin (2000); Hazell & Ramasamy (1991) also indicated the successes of the green revolution in Asia was as a result of the use of inputs like fertilizer, irrigation and improved varieties of seeds.

Pest and disease attack was ranked second most important constraint by female irrigators but third most important by male irrigators. Respondents revealed that, occasional disease break out in their farms leads to loss of crops and in most cases destructions of the entire farm. Due to financial constraints, most farmers are not able to procure the recommended insecticides to combat some diseases. Some farmers engage in 'try-error' approach to control pest and diseases in farms. Farmers normally procure chemicals that they can afford which sometimes are not effective. Additionally, there is limited access to extension agents who will provide technical assistance on the appropriate insecticides or weedicides and the best management practices to control the diseases. Namara *et al.* (2011) in a similar study found out that pest and disease cause significant losses in yield of farmers. Dinye & Ayitio

(2013) also indicated that, farmers are exposed to pest and disease attack in the Tono irrigation dam facility.

Low access to credit facilities was ranked second most important constraint by male irrigators but third most important constraint by female irrigators. Respondents asserted that, due to the capital-intensive nature of their production, they require credit to augment their income in order to invest in their farms to obtain the expected yield. According to respondents, credit enables them procure all the needed inputs and services that is required in the farms. This is consistent with studies of Alade *et al.* (2013); Dinye & Ayitio (2013) and Namara *et al.* (2011). Credit forms important aspect of irrigated agriculture however credit support has been decreasing over the years partly due to decreasing budgetary allocation by governments (Ofosu *et al.*, 2014). Namara *et al.* (2011) also indicated that, under circumstances where credit is provided, the interest is too high for farmers. According to Dinye & Ayitio (2013), farmers due to high interest rates (18%) did not utilize credit facilities provided by IFAD/ADB. Other studies also identified gender disparities in access to credit in the study area. For instances SEND Ghana (2014) reports that out of every ten (10) women only one (1) have access to credit. FAO (2009) also indicated that, women irrigators in Northern Ghana lack access to credit facilities, as compared to other regions in the country.

The difference in the ranks between pest and disease attack and low access to credit by male and female may be that, in the opinion of males, access to credit enables them to procure the necessary agro insecticides to control the pest and diseases or seek the service of an extension agent. This is plausible because access to extension services implies access to practices and knowledge on preventive and curative methods to control these pests.

Male and female irrigators ranked labour availability or drudgery as the fourth most important constraint. It came to light that, in the study area, respondents still employ rudimentary technology in agriculture and there is no form of mechanization employed in their farming activities. All farm activities are carried out with the aid of traditional tools and equipment such as hoe and cutlass. Human labour is used from land preparation to harvesting. Again, another contributory factor is the underdeveloped state of the irrigation facility in the various sites. In the cases of river irrigators, farmers must pump water from the river into hand-made canals that directs the water to flood the fields. For dam irrigators, farmers must open main canals and allows water to flow into the fields canals that are manually constructed before the crops are irrigated using calabash. Coupled with this, is the scarcity of human labour for hiring due to migration of the youth to urban centers to engage especially in illegal mining during the dry season. Respondents added that, this phenomenon raises the cost of hiring labour since the few available are in high demand. This finding is like that of Alade *et al.* (2013). Thus, farmers who are not economically empowered must shoulder all farm practices by themselves or reduce farm sizes to be able to manage them by themselves. The situation is even worse in the case of female irrigators who revealed, they have to combine farm work with already existing traditional household responsibilities such as childcare and cooking.

One of the disincentive for engaging in irrigated agriculture is the low price of produce. In times of bomber harvest farmers are compelled to sell their produce at low prices to middlemen. Coupled with that, farmers will also have to compete with farmers from neighboring country Burkina Faso for prices whose produce are normally preferred by buyers due to quality. Farmers are hence compelled to sell at prices normally determined by the buyers because produce is highly perishable and they have no means of storage. Hence, low price of produce was ranked the fifth most important constraint by both male and female irrigators. According to Dinye & Ayitio (2013), there are no recognized or certified channels available to farmers, hence some farmers rely on the market centre or roadside buyers' whiles other are left to the mercy of the monopolistic and exploitative middlemen who purchase the produce on credit basis at extremely low prices.

Additionally, farmers must compete with Burkinabe irrigations farmers whose crops are of higher quality cultivating along the White Volta River basin. SEND Ghana (2014) adds that women producers especially are concentrated at the production end of the value chain with paucity of information on alternative marketing channels, long distances to market centres, low prices for food crops. Ofosu *et al.* (2014) noted that unfavorable market conditions such as artificial low pricing, market fluctuations and failure are harmful to irrigation development in sub-Saharan Africa. This is especially true in Ghana where irrigation farming is market oriented by the nature of the crops they cultivate and the fact that they consume a smaller proportion of what is produced.

Limited access to technologies was found to be the sixth most important constraint by both male and female irrigators. Respondents revealed that, they still employ traditional methods in farming which affect their output. According to their assertion, they lack access to modern technologies and skills employed in farming as experienced by other farmers in other parts off the districts. This may be attributed to the low extension outreach experienced in the district. About 52 percent of respondents do not have access to extension agents in the study area. Another problem revealed by the respondents in river irrigation sites is the high cost of energy used in lifting and distributing water to their farms i.e. the price of petrol and diesel used in powering the pumps. According to Namara *et al.* (2011), most irrigation facilities lack modern and efficient water lifting technologies or services that will result in optimum use. Ofosu *et al.* (2014) remarked that making farmer support services accessible and reliable has the potential of boosting economic prospects of irrigation facilities.

The seventh most important constraint identified by both men and women is poor water supply. Irrigation facilities are not fully developed and in some communities, there is no water distribution technology in the study area compared to other places. In all the sites, watering of farmland is done manually. In locations for dam irrigation, canals are not constructed to link all fields hence; farmers must constructs canals to link their fields to the main canals where plot owners either flood their plots or use calabash to water the crops. Similarly, river irrigators do not have any constructed canals except their improvised means to control water supply and management on their fields. For rivers irrigators, water pumps are used to lift water from the river to flood the plots. These affects water supply and management on the fields and farmers do not make optimum use of the water.

Table 4.12 Constraints in irrigated agriculture

Constraints	Males		Female	
	Mean Rank	Rank	Mean Rank	Rank
Labour availability or drudgery	3.92	4th	3.79	4th
Pest and disease attack	3.55	3rd	3.01	2nd
Low access to credit	3.20	2nd	3.32	3rd
High cost of inputs	2.80	1st	2.66	1st
Low price of farm produce	4.40	5th	4.63	5th
Limited access to technologies	4.91	6th	5.01	6th
Poor water supply	5.22	7th	5.58	7th
	Kendall's coefficient (W)= 0.171 Pr (value)=0.000		*Kendall's coefficient (W)= 0.257 Pr (value)=0.000*	

Source: Field Survey, 2016

4.5.2 Prospects for irrigated agriculture

The study employed the SWOT analysis to assess the prospects existing for the involvement of both males and females in irrigated agriculture. The table below (Table 4.13) illustrates the strengths, weakness, opportunities and threats identified by male and females participating in irrigated agriculture. The analysis revealed that, respondents have been engaged in irrigated agriculture for long and this has equipped them with some experiences. Also, respondents revealed they have easy access to water for irrigation. Respondents again revealed that, irrigation can serve as source of employment during the dry season when there are no alternative source of livelihoods.

Some weaknesses revealed by respondents include drudgery in farming, lack of credit for farming, lack of storage facilities etc. Farmers revealed that due to the use of rudimentary technology employed in farming, it makes their farming activities tedious and tiring. Especially in the case of female irrigators who combine farm work, domestic activities and child care.

In terms of opportunities, the respondents revealed that there exist large undeveloped areas around the dams that are not in use because canals are not extended to those areas. Expansion of irrigated facilities will enable them to expand farm size per head. Although respondents asserted that, prices are low there exist ready market for produce. For threats, factors that respondents revealed they are vulnerable to include pest and disease infestation, escalating cost of inputs coupled with low price of crop produce.

Table 4.13 Strengths, Weakness, Opportunities and Threats for irrigated agriculture

Strengths		Weaknesses	
Males	**Females**	**Males**	**Females**
• Have experience in irrigation farming • Available time for farming • Willingness to farm as business (entrepreneurial skills) • Easy access to water	• Have experience in irrigation farming • Available time for farming • Willingness to farm as business (entrepreneurial skills) • Easy access to water	• Drudgery in farming • Lack of farm credit • Low skills and farming techniques • Inadequate land irrigable land • Poor drainage system/poor water supply • Low access to improved technologies • Lack of storage facilities • Lack of farm machinery for mechanization • Animal destruction • High cost of farm machinery	• Drudgery in farming (old age and weakness) • Lack of farm credit • Low skills and farming techniques • Inadequate land irrigable land • Poor drainage system/poor water supply • Low access to improved technologies • Lack of storage facilities • Lack of farm machinery for mechanization • Animal destruction • High costs of irrigation machinery
Opportunities		**Threats**	
Vast land for expansion Available labour Available water for expanding irrigation • Available market for produce	• Vast land for expansion • Available labour • Available water for expanding irrigation • Available market for produce	• Pest and disease attack/infestation • High cost of inputs • Low price of farm produce (price volatility)	• Pest and disease attack/infestation • High cost of inputs • Low price of farm produce (price volatility)

Source: Field Survey, 2016

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This is the final chapter of the thesis. It includes a summary of key findings, the conclusions and recommendations based on the key findings. Irrigation continues to contribute significantly to rural livelihood, especially for those who depend entirely on it because of non-existing avenues for livelihood with Bawku West district not an exception. Benefits derived from irrigation infrastructure do not accrue equally with women at the disadvantage. Additionally, irrigation exists in a larger circle of ecosystem that interacts to yield multiple benefits. Understanding the interrelationships existing among ecosystems services, gender and irrigation investments for sustainable livelihoods development is critical in ensuring equity. It is against this backdrop that this study sought to understand the ecosystem services, gender and irrigation nexus. Specifically, the study looked at perceptions of farmers about the linkages among irrigation, ecosystems and livelihoods, factors influencing the involvement of men and women in irrigated agriculture, effects of irrigation farming on livelihoods and ecosystem and the prospects, opportunities and constraints that exist for men and women involvement in irrigated agriculture.

The study used a total of 304 respondents comprising 152 irrigators and 152 non-irrigators. Respondents were selected through a multistage sampling procedure. Cross-sectional data for the 2015 cropping season were collected for the study. The study employed different analytical methods. In measuring perception, percentage field scores were calculated. In estimating the factors influencing participation in irrigation and its effects on livelihood, the probit model was used. The average treatment effect model was used to estimate the effects of irrigation on livelihoods of farmers. This enabled the researcher to determine the pure effect of irrigation on livelihoods of respondents. SWOT analysis was also employed to assess the prospects of irrigation in the study area.

5.2 Summary of key findings

Ecosystem services serve as important source of livelihood to farmers in the study area, especially in terms of food, employment, income and health. For instance, availability of economic trees serve as a source of employment for both males and females. Whiles male farmers are most engaged in the cutting off trees for timber, females are engaged in processing and marketing of ecosystem products. Averagely, revenue accrued from this activity is estimated at GH¢179. Respondents generally agreed that, there exists both positive and negative links between ecosystem and irrigation. For instance, while ecosystem provides water, land and air for irrigation systems to thrive, irrigation systems support biodiversity. Farming activities identified to negatively affect the ecosystem include bush burning, tree cutting, and misuse of agro-chemicals among others. It was established that irrigation contributed significantly to employment, food, income and dietary diversity. This shows there is potential for irrigation to positively impact income and food security. The research established that, among the ecosystem services, respondent (irrigators and non-irrigators) perceived provision services to be the most important to their livelihoods development. This is attributed to the tangible products that respondents derive from these services.

Engagement in irrigated agriculture is characterized by the cultivation of cash crops such as onion and cabbage mainly by smallholder farmers with no formal education; an average land holding of 4.7 acres for males and 3.3 acres for females with an average of 13 years of farming experience. Generally, irrigators are also engaged in rain-fed agriculture and have more experience (18 years) in farming. Irrigated agriculture in the study area involved the use of indigenous technology from land preparation to harvesting. Although both males and females engage in irrigated agriculture, there are labour divisions in production activities. Men normally engage in activities such as land preparation, weeding, spraying, fertilization, harvesting and storage whiles females dominate activities like planting, watering, transportation, processing and marketing. From the adoption model, the factors that significantly influence the probability of engaging in irrigated agriculture were found to be marital status of the farmer, availability of market for the produce, access to extension services and farmers with larger rain-fed farms. Furthermore, age of farmer and access to extension services increases male farmers' probability of engaging in irrigated agriculture whiles females having access to market for produce, larger rain-fed farms and having females as their household heads were more likely to engage in irrigated agriculture. Participation in irrigation had a positive effect on the livelihood of farmers. This means that farmers engaged in irrigated agriculture (irrigators) had higher livelihood score than farmers not engaged in irrigated agriculture (non-irrigators). Livelihood was higher also for the following categories of farmers; (1) farmers with relatively smaller households; (2) farmers using dam for irrigation; and (3) farmers with relatively less formal education.

It was established from the study that major the constraints in irrigated agriculture include drudgery, pest and disease attack, low access to credit, high cost of inputs, low price of farm produce, limited access to technologies and poor water supply. Some mitigating measures adopted by farmers include reducing the farm size, borrowing money from friends, selling of household food stock and livestock, hiring of labour for farm activities, use of insecticides and ash to control pests and diseases and reduce the quantity of inputs used.

It was established that, there exists potential for increasing the gains from irrigated agriculture in the study area. Farmers identified availability of land and water for expansion, availability of labour and market for the produce coupled with the willingness to commercialize irrigated agriculture with the needed support. Potentials threats to realising this objective include pest and disease infestations and high input costs and low output prices.

5.3 Conclusions

From the study, it can be concluded that irrigation has the potential of contributing significantly to the livelihood of farmers in the Upper East region of Ghana. Specifically, the following conclusions can be drawn from the study:

1. Although farmers appear to have a general understanding of the critical relationship among irrigation, ecosystem and livelihoods, there is still limited understanding about the specific mechanisms through which the relationship affects their livelihoods.
2. Farmers generally perceive their activities to be negatively affecting the health of the ecosystems.

3. The ecosystems provide multiple benefits to both men and women. Benefits to men include income and social recognition whiles benefits to women include household food and nutrition security.
4. Due to multiple roles of women, the consequences of ecosystems deterioration such as water and food scarcity are likely to affect the livelihoods of women most.
5. The factors that significantly influence males' participation in irrigated agriculture are age and extension contact. For women, being a member of a female headed household, market availability and farm size are the factors that significantly determine their participation in irrigated agriculture.
6. Additionally, marital status influence both male and female participation in irrigated agriculture.
7. Irrigation has positive effects on farmers' livelihood. However, high dependency ratio and natural disasters are likely to offset these benefits.
8. Factors that constrain farmers in production are high cost of inputs, low access to credit, pest and disease attack, drudgery, low farm produce, limited access to technologies and poor water supply.
9. There exist prospects for upscaling irrigated agriculture in the study area for improved livelihoods.

5.4 Recommendations

In the light of the conclusions drawn, the following recommendations are made to enhance the future of irrigated agriculture:

1. Educate farmers on the specific functions and the importance of the various ecosystem services.
2. Farmers should be trained on eco-friendly management practices, especially in irrigated ecosystem for sustainable production practices.
3. Policy makers should:
   i. Develop gender specific policies and programmes to educate and sensitize men and women on their distinct roles and decision making processes for enhanced benefits for all from the ecosystems.
   ii. Formulate policies and programmes that will encourage the youth to actively participate in irrigated agriculture. This may include input subsidies, knowledge support and secured end markets.
   iii. Formulate policies and programmes that specifically aim at removing barriers to effective participation in decision making, markets access as well as control and use of productive resources for women and youth.
4. Farm families with large household sizes must be supported through appropriate social protection programmes whiles empowering them to take advantage of the high household labour for increased agricultural production. Also, farmers must be trained on natural disaster management techniques to offset the negative effect of natural disasters.

5. Farmers must be supported with improved technologies in irrigated agriculture, particularly water distribution and input use. This is based on the fact that farmers still employ traditional methods in farming that are environmentally unfriendly. Adoption of improved methods of farming will address the twin objective of providing food and protecting the ecosystem thereby ensuring sustainability.
6. Considering the important role of extension service provisioning in the study area, there is the need for the District Department of Agriculture to develop effective means of delivering gender sensitive technical support services to farmers in the study area so as to promote the adoption of new and improved technologies and ensure knowledge transfers.
7. There is also the need to form an umbrella body that will regulate the activities of farmers in the study area. The objective of this umbrella body among many other things should be to facilitate access to credit, agricultural inputs and mechanization services as well as marketing services to remove the barriers to unfair pricing.

REFERENCES

Adesanya, A. O., Anake, T. A., & Udoh, M. O. (2008). Improved continuous method for direct solution of general second order ordinary differential equation. *Journal of the Nigerian Association of Mathematical Physics*, *13*, 59-62.

Adomako, T., & Ampadu, B. (2015). The Impact of Agricultural Practices on Environmental Sustainability in Ghana: A Review. *Journal of Sustainable Development*, *8*(8), 70.

Ahenkan, A., & Boon, E. (2011). Improving nutrition and health through non-timber forest products in Ghana. *Journal of Health, Population, and Nutrition*, *29*(2) 141.

Akudugu, M. A. (2011). Rural banks' financial capital and livelihoods development of women farmers in Ghana. *Journal of Enterprising Communities: People and Places in the Global Economy*, *5*(4), 248-264.

Akudugu, M. A., Dittoh, S., & Mahama, S. (2012). The implication of climate change on food security and rural livelihoods: Experiences from Northern Ghana. *Journal of Environmental and Earth Science, 2*(3), 21-29.

Alade, O. A., Ademola, A. O., & Eniola, P. O. (2013). Roles of irrigated agriculture in improving rural women welfare in Oyo State, Nigeria. *International Journal of Applied Research and Technology*, *2*(3), 9-15.

Albinson, B., & C. J. Perry. (2002). *Fundamentals of smallholder irrigation: the structured system concept* (Vol. 58). IWMI.

Amankwah, A., & Egyir, I. (2013, August). Modeling the choice of irrigation technologies of urban vegetable farmers in Accra, Ghana. In *Agricultural & Applied Economics Association's 2013 AAEA & CAES Joint Annual Meeting, Washington, DC*.

Amarantunga, D., Baldry, D., Sarshar, M., & Newton, R. (2002). Quantitative and qualitative research in built environment: application of “mixed” research approach. *Work Study*, *51*(1), 17-31.

Ansah, I. G. K., Eib, D., & Amoako, R. (2015). Socioeconomic determinants of livestock production technology adoption in Northern Ghana. *Asian Journal of Agricultural Extension and Sociology 5*(3), 166-182.

Assessment, M. E. (2005). Millennium ecosystem assessment findings. *Millennium Ecosystem Assessment.*

Ayoola, J. B., Dangbegnon, C., Daudu, C. K., Mando, A., Kudi, T. M., Amapu, I. Y., & Ezui, K. S. (2011). Socioeconomic factors influencing rice production among male and female farmers in Northern Guinea Savanna Nigeria: lessons for promoting gender equity in action research. *Agriculture and Biology Journal of North America*, *2*(6), 1010-1014.

Beal, G. M., & Rogers, E. M. (1960). Practices in a central Iowa community, Ames Iowa agricultural and home economics experiment station, *Special Report*, 26.

Beaman, L., & Dillion, A. (2012). Do household definitions matter in survey design? Results from a randomised survey experiment in Mali. *Journal of Development Economics*, *98*(1), 124-135.

Becerril, J., & Abdulai, A. (2010). The impact of improved maize varieties on poverty in Mexico: a propensity score-matching approach. *World Development*, *38*(7), 1024-1035.

Biggs, E. M., Duncan, J. M., Atkinson, P. M., & Dash, J. (2013). Plenty of water, not enough strategy: how inadequate accessibility, poor governance and a volatile government can tip the balance against ensuring water security: the case of Nepal. *Environmental Science & Policy*, *33*, 388-394.

Bond. I., Grieg-Gran. M., Wertz-Kanounnikoff. S., Hazlewood, P., & Wunder, S. (2009). Incentives to sustain forest ecosystem services: *A Review and Lessons for REDD*. (No. 16). IIED.

Brannen (1992) *In* Hudu, Z. (2009). Socio-economic analysis of livelihoods strategies of rural women beneficiaries of microcredit in the Tolon/Kumbungu district of the Northern region of Ghana. *University of Ghana, Legon*. (MPhil Dissertation).

Brannen, J. (1992). Combining qualitative and quantitative approaches: An overview (pp. 3–37). *Mixing methods: Qualitative and quantitative research. Aldershot: Avebury*.

Bruce, A. K. K. (2015). Improved rice variety adoption and its effects on farmers 'output in Ghana (Doctoral dissertation).

Burns, S.N., & Grove, S.K. (2003). Understanding nursing research. Philadelphia: W. B. Saunders Company, 3rd edition.

Carney, D. (1998). Implementing the sustainable rural livelihoods approach. *Sustainable rural livelihoods: What contribution can we make*, 3-23.

CGIAR Research Program on Water, Land and Ecosystems (WLE). (2014). Gender strategy. (IWMI).

CGIAR Research Program on Water, Land and Ecosystems (WLE). (2015). Groundwater and ecosystem services: a framework for managing smallholder groundwater dependent agrarian socio-ecologies - applying an ecosystem services and resilience approach. (IWMI).

Chambers, R., & G.R. Conway. (1991). 'Sustainable rural livelihoods: practical concepts for the 21st century'. University of Sussex, *IDS Discussion Paper* No. 296.

Clarvis, M. H., Allan, A., & Hannah, D. M. (2014). Water, resilience and the law: From general concepts and governance design principles to actionable mechanisms. *Environmental Science & Policy*, 43, 98-110.

Corvalan, C., Hales, S., & McMichael, A. J. (2005). Ecosystems and human well-being: health synthesis. *World Health Organization*.

Couros, A. (2003). Innovation, change theory and the acceptance of new technologies: A literature review. Unpublished literature review). Retrieved from http://www.educationaltechnology.ca/couros/publication_files/unpublishedpapers/change_ theory. Pdf

Crossman, N. D., Connor, J. D., Bryan, B. A., Summers, D. M., & Ginnivan, J. (2010). Reconfiguring an irrigation landscape to improve provision of ecosystem services. *Ecological Economics*, *69*(5), 1031-1042.

Cullis, J., & Van Koppen, B. (2007). Applying the Gini coefficient to measure inequality of water use in the Olifants River Water Management Area, South Africa (Vol. 113). IWMI.

De Fraiture, C., Molden, D., & Wichelns, D. (2010). Investing in water for food, ecosystems, and livelihoods: An overview of the comprehensive assessment of water management in agriculture. *Agricultural Water Management*, *97*(4), 495-501.

De Schutter, O. (2013). Gender equality and food security: Women as empowerment as a tool against hunger.

Denzin, N. & Lincoln, Y. (1998). Collecting and interpreting qualitative materials.

Denzin, N. K. (1989). The Research Act: The Theoretical Introduction to Sociological Methods. New Jersey: Prientice.

Deressa, T., Hassan, R. M., Alemu, A., Yesuf, M., & Ringler, C. (2008). Analyzing the determinants of farmers' choice of adaptation methods and perception of climate change in the Nile Basin of Ethiopia. *IFPRI Discussion Paper*.

Dessalegn, M., & Merrey, D. J. (2014). Is 'Social Cooperation' for traditional irrigation, while 'Technology' is frontiers in ecology and the environment, *7*(1), 4-11.

DFID. (2001). Sustainable livelihoods guidance sheets. London: *DFID*.

Dinye, R. D., & Ayitio, J. (2013). Irrigated agricultural production and poverty reduction in Northern Ghana: A case study of the Tono Irrigation Scheme in the Kassena Nankana District. *International Journal of Water Resources and Environmental Engineering* *5*(2), 119-133.

Dittoh, S. Bhattarai, M., & Akuriba, M. A. (2013). Micro irrigation-based vegetable farming for income, employment and food security in West Africa.

Dittoh, S., Snyder, K. A., & Lefore, N. (2015). Gender policies and implementation in agriculture, natural resources and poverty reduction: case study of Ghana's Upper East Region. *WLE Research for Development (R4D) Learning Series, 3*.

Donkoh, S. A., & Awuni, J. A. (2011). Adoption of farm management practices in lowland rice production in Northern Ghana. *Journal of Agriculture and Biological Sciences Vol*, *2*(6), 183-192.

Donkoh, S. A., Alhassan, H., & Nkegbe, P. K. (2014). Food expenditure and household welfare in Ghana. *African Journal of Food Sciences,* Vol. 8(3), pp. 164-174.

Dore, J., Blake, D., & Bhattarai, M. (2007). Ecosystems, livelihoods and governance in large-scale Southeast Asian irrigation. *The future of large rice-based irrigation systems in Southeast Asia*, 70.

Edwards, (1964) *In* Donkoh, S. A., & Awuni, J. A. (2011). Adoption of farm management practices in lowland rice production in Northern Ghana. *Journal of Agriculture and Biological Sciences Vol*, *2*(6), 183-192.

Ekong, E. E. (2003). An introduction to rural sociology. *Uyo: Dove Educational Publishers*, 198-207.

Ellis, F. (2000). Rural livelihoods and diversity in developing countries. Oxford: Oxford university press.

FAO (2005) *In* Kyei-Baffour, N., & Ofori, E. (2006). Irrigation development and management in Ghana: Prospects and challenges. *Journal of Science and Technology (Ghana)*, *26*(2), 148-159.

Food and Agriculture Organisation (2002). Report to "The New Partnership for Africa's Development" land and water resources issues and agricultural development. 22nd Regional Conference for Africa.

Food and Agriculture Organisation (2008). Feeding the World. Sustainable Management of Natural Resources. Fact sheets, FAO, City New York.

Food and Agriculture Organisation (2010). Gender and Food security, synthesis report of regional documents:

Food and Agriculture Organisation (2011). The state of the world's land and water resources for food and agriculture. Managing systems at risk. Summary report. Rome.

Fortmann, L. (2009). Gender in agriculture sourcebook. *Experimental Agriculture*, *45*(4), 515.

Galbraith, H., Amerasinghe, P., & Huber-Lee, A. (2005). The effects of agricultural irrigation on wetland ecosystems in developing countries: A literature review. IWMI.

Gordon, D. (2006). The concept and measurement of poverty. *Poverty and Social Exclusion in Britain. The Millennium Survey, Policy Press, Bristol*, 29-69.

Greene, W. H. (2003). Econometrics analysis. (5th Edition), New Jersey-U.S.A: Prentice Hall.

GSS (2014). Ghana Living Standards Survey Round 6 (GLSS 6). Poverty profile in Ghana (2005-2013). Ghana Statistical Service.

GUIDE, R. (2003). Mainstreaming Gender in Water Management.

Hagos, F., Makombe, G., Namara, R. E., & Awulachew, S. B. (2009). *Importance of irrigated agriculture to the Ethiopian economy: Capturing the direct net benefits of irrigation* (Vol. 128). IWMI.

Hall, B. H., & Khan, B. (2003). Adoption of new technology (No. w9730). National bureau of economic research.

Hanjra, M. A., Blackwell, J., Carr, G., Zhang, F., & Jackson, T. M. (2012). Wastewater irrigation and environmental health: Implications for water governance and public policy. *International Journal of Hygiene and Environmental Health*, *215*(3), 255-269.

Heckman, J. J. (1979). Sample selection as a specification error. *Econometrics,* Vol. 47, pp. 153-161.

Holloway, I., & Wheeler, S. (2002). Qualitative research in nursing. Oxford: Blackwell, 2nd edition.

Huang, Q., Rozelle, S., Lohmar, B., Huang, J., & Wang, J. (2006). Irrigation, agricultural performance and poverty reduction in China. *Food Policy*, *31*(1), 30-52.

Hudu, Z. (2009). Socio-economic analysis of livelihoods strategies of rural women beneficiaries of microcredit in the Tolon/Kumbungu district of the Northern region of Ghana. *University of Ghana, Legon*. (MPhil Dissertation).

Hussain, I. (2004). Assessing impacts of irrigation on poverty: Approaches, Methods, Case Studies and Lessons 1.

Hussain, I. (2005). Pro-poor intervention strategies in irrigated agriculture in Asia. IWMI.

Hussain, I., & Biltonen E. (Eds.). (2001). Proceedings of national workshops on pro-poor intervention strategies in irrigated agriculture in Asia. IWMI.

Hussain, I., & Hanjra, M. A. (2003). Does irrigation water matter for rural poverty alleviation? Evidence from South and South-East Asia. *Water policy*, *5*(5), 429-442.

Hussain, I., Marikar, F., & Jehangir, W. (2000). Productivity and performance of irrigated wheat farms across canal commands in the Lower Indus Basin. IWMI.

Inocencio, A., Kikuchi, M., Tonosaki, M., Maruyama, A., Merrey, D., Sally, H., & de Jong, I. (2007). Costs and performance of irrigation projects: A comparison of sub-Saharan Africa and other developing regions. IWMI.

International Water Management Institute (IWMI). (2014). Promoting productive gendered spaces for adapting to climatic stress: two case studies from rural Bangladesh. IWMI.

Jick, T. D. (1979). Mixing qualitative and quantitative methods: Triangulation in action. Administrative Science Quarterly. 24: 602 – 611.

Joffre, O., & de Silva, S. (2015). Community water access, availability and management in the Tonle Sap region, Cambodia Worldfish.

Johansson, R. C., Tsur, Y., Roe, T. L., Doukkali, R., & Dinar, A. (2002). Pricing irrigation water: a review of theory and practice. *Water Policy*, *4*(2), 173-199.

Koutsoyiannis, A. (2003). Modern Microeconomics. (3rd Edition), London: Macmillan.

Krantz L. (2001). The sustainable livelihood approach to poverty reduction. Division for Policy and Socio-Economic Analysis: *Swedish International Development Cooperation Agency*.

Lam, W. F. (1996). Improving the performance of small-scale irrigation systems: The effects of technological investments and governance structure on irrigation performance in Nepal. *World Development*, *24*(8), 1301-1315.

Mabe, F. N., Sienso, G., & Donkoh, S. A. (2014). Determinants of choice of climate change adaptation strategies in northern Ghana. *Research in Applied Economics*, *6*(4), 75-94.

Maddala G. S. (1983) Limited dependent and qualitative variables in econometrics. Cambridge University Press, New York, 257-291.

Mangisoni, J. H. (2008). Impact of treadle pump irrigation technology on smallholder poverty and food security in Malawi: a case study of Blantyre and Mchinji districts. *International Journal of Agricultural Sustainability*, *6*(4), 248-266.

Marchetta, F. (2011). On the move livelihood strategies in Northern Ghana. Post-Doctorante CNRS, Clermont Universite, Universited'Auvergne, CNRS, UMR, 6587.

Mehta, L., & Srinivasan, B. (2000). Balancing pains and gains. A Perspective Paper on Gender and Large Dams. *Contributing paper for WCD Thematic Review*, *1*.

Meizen-Dick, R., van Koppen, B., Behrman, J., Karelina, Z., Akamandisa, V., Hope, L., & Wielgosz, B. (2012). Putting gender on the map: methods for mapping gendered farm management systems in sub-Saharan Africa.

Mikkelson, B. (1995). Methods for Development Work and Research, New Delhi.

Millennium Ecosystem Assessment (2005). Millennium ecosystem assessment synthesis report. Island Press.

Minichiello, V., Aroni, R., Timewell, E., & Alexander, L. (1995). In-depth interviewing principles, techniques, analysis. Melbourne: Longman.

Molden, D., & de Fraiture, C. (2004). Investing in water for food, ecosystems and livelihoods. Blue Paper. Comprehensive Assessment of Water Management in Agriculture. IWMI.

Morse, S., Acholo, M., & McNamara, N. (2009). Sustainable livelihood approach: A critical analysis of theory and practice. University of Reading.

MOFA. (2013). Agriculture in Ghana: Facts and Figures, 2012. Statistics, Research and Information Directorate (SRID), Ministry of Food and Agriculture, Accra, Ghana.

Munang, R., Thiaw, I., & Rivington, M. (2010). The role of ecosystems in developing a sustainable 'green economy'. *UNEP Policy Series:* Ecosystem Management.

Muntaka, J. M. (2012). Factors influencing women participation in Women-In-Agriculture (WIA) program of kaduna state agricultural development project. Doctoral Dissertation.

Namara, R. E., Awuni, J. A., Barry, B., Giordano, M., Hope, L., Owusu, E. S., & Forkuor, G. (2011). Smallholder shallow groundwater irrigation development in the upper east region of Ghana. IWMI.

Namara, R. E., Awuni, J. A., Barry, B., Giordano, M., Hope, L., Owusu, E. S., & Forkuor, G. (2011). Smallholder shallow groundwater irrigation development in the upper east region of Ghana (Vol. 143). IWMI.

Namara, R. E., Upadhyay, B., & Nagar, R. K. (2005). Adoption and impacts of micro irrigation technologies: Empirical results from selected localities of Maharashtra and Gujarat states of India (Vol. 93). IWMI.

Ofosu, E. A., P. Van, Nick van de Giesen, & S. N. Odai. Success factors for sustainable irrigation development in Sub-Saharan Africa. *African Journal of Agricultural Research* 9, no. 51 (2014): 3720-3728.

Ogunlela, Y. I. & Mukhtar, A. A. (2009). Gender issues in agriculture and rural development in Nigeria: The role of women. *Humanity & Social Sciences Journal*, *4*(1), 19-30.

Ojo, O. D., Connaughton, M., Kintomo, A. A., Olajide-Taiwo, L. O., & Afolayan, S. O. (2011). Assessment of irrigation systems for dry season vegetable production in urban and peri-urban zones of Ibadan and Lagos, Southwestern Nigeria. *African Journal of Agricultural Research*, *6*(2), 236-243.

Oruonye, E. D. (2011). Reducing Rural poverty and Development Livelihood Opportunity Through Irrigation Farming in Taraba State, Nigeria. *International Journal of Plant Animal and Environmental Science*, *1*(1), 144-150.

Otsuka, K., & Kalirajan, K. P. (2006). Rice green revolution in Asia and its transferability to Africa: An introduction. *The Developing Economies*, *44*(2), 107-122.

Ovwigho, B. O., & Ifie, P. A. (2014). Effects of the Women in Agriculture (WIA) program on welfare of rural women in Uvwie block of the Agricultural Development Program (ADP), Delta State, Nigeria.

Oweis, T., & Hachum, A. (2006). Water harvesting and supplemental irrigation for improved water productivity of dry farming systems in West Asia and North Africa. *Agricultural Water Management*, *80*(1), 57-73.

Parahoo, K. (1997). Nursing research: principles, process and issues. Basingstoke: Macmillan.

Pehu, E., Lambrou, Y., & Hartl, M. (2009). Gender in agriculture sourcebook. The World Bank, FAO, IFAD.

Polit, D. F., Beck, C. T., & Hungler, B. P. (2001). Essentials of nursing research: Methods, appraisal, and utilization. Philadelphia: Lippincott, 5th edition.

Rockström, J., Folke, C., Gordon, L., Hatibu, N., Jewitt, G., De Vries, F. P., & Schulze, R. (2004). A watershed approach to upgrade rainfed agriculture in water scarce regions through Water System Innovations: an integrated research initiative on water for food and rural livelihoods in balance with ecosystem functions. *Physics and Chemistry of the Earth, Parts A/B/C*, *29*(15), 1109-1118.

Rogers Everett, M. (1995). Diffusion of innovations. *New York*, 12.

Rogers, E. M. (1983). Diffusion of innovation. Third Edition. A Division Macmillan publishing Co., Inc. New York.

Sampath, R. K. (1992). Issues in irrigation pricing in developing countries. *World Development*, *20*(7), 967-977.

Scoones, I. (1998). 'Sustainable Rural Livelihoods: a framework for analysis'. IDS Working Paper 72. University of Sussex.

Sebastian, K. (Ed.). (2014). Atlas of African agriculture research and development: Revealing agriculture's place in Africa. *Intl Food Policy Res Inst*.

Secretariat of the Convention on Biological Diversity (CBD). (2009). Sustainable forest management, biodiversity and livelihoods: a good practice guide. Montreal.

Sen, A. K. (1987). Commodities and Capabilities: Professor Dr. P. Hennipman Lectures in Economics, 1982 *Delivered at the University of Amsterdam*. Oxford University Press.

Senanayake, N., Mukherji, A., & Giordano, M. (2015). Re-visiting what we know about Irrigation Management Transfer: A review of the evidence. *Agricultural Water Management*, *149*, 175-186.

SEND. (2014). Women and smallholder agriculture in Ghana. Policy Brief No. 4.

Sheheli, S. (2012). Improving livelihood of rural women through income generating activities in Bangladesh. Doctoral dissertation.

Siebert, S., & Döll, P. (2007). Irrigation water use–a global perspective. *Global Change: enough water for all*, 104-107.

Siebert, S., Henrich, V., Frenken, K., & Burke, J. (2013). Update of the digital global map of irrigation areas to version 5.

Sophat, S., Chandara, P., & Vibol, S. (2012). Importance of Forest Ecosystem Services for the Livelihoods of a Rural Community in O'Som Commune, Pursat Province, Cambodia. *Researchgate. net*, *1*, 5-22.

Sugden, F., de Silva, S., Clement, F., Maskey-Amatya, N., Ramesh, V., Philip, A., & Bharati, L. (2014). A framework to understand gender and structural vulnerability to climate change in the Ganges River Basin: lessons from Bangladesh, India and Nepal. *IWMI Working Paper*, (159).

Tarde, G. (1903). The laws of imitation, trans. *EC Parsons.* New York: Henry, Holt.

Team, S. O. F. A., & Doss, C. (2011). The role of women in agriculture. *Rome: Agriculture Development Economics Division, Food and Agriculture Organization, ESA Working Paper*, (11-02).

Thiaw, I., Kumar, P., Yashiro, M., & Molinero, C. (2011). Food and ecological security: identifying synergy and trade-offs. *UNEP Policy Series: Ecosystem Management*, *4*, 1-12.

Todaro, M., & Smith, S. (2003). Development economics. *Pearson education*.

Udoh, A. J., Idio, A., Umoh, E., & Robson, U. (2008). Socioeconomic factors influencing adoption of Yam Monist Technology in South eastern Nigeria: A probit analysis. *India Research Journal of Extension and Education*, Vol. 8(2-3), pp. 1-5.

UNDP (2000). United Nation Development Program. The commitments to poverty reduction in overcoming human poverty. UNDP poverty report.

UNDP (2002). United Nation Development Program. Local governance for poverty reduction in Africa. Concept paper presented at the 5th African governance forum. Retrieved from www.undp.com

van Koppen, B. (2002). A gender performance indicator for irrigation: Concepts, tools, and applications. (Vol. 59). IWMI.

Vanderslice, S. (2000). Listening to Everett Rogers: diffusion of innovations and WAC. *Journal of Language and Learning Across the Disciplines*, *4*(1), 22-29.

Wang, X., Otto, I. M., & Yu, L. (2013). How physical and social factors affect village-level irrigation: An institutional analysis of water governance in northern China. *Agricultural Water Management*, *119*, 10-18.

Ward, F. A., & Pulido-Velazquez, M. (2008). Water conservation in irrigation can increase water use. *Proceedings of the National Academy of Sciences*, *105*(47), 18215-18220. Washington DC.

Webber, M., Barnett, J., Finlayson, B., & Wang, M. (2008). Pricing China's irrigation water. *Global Environmental Change*, *18*(4), 617-625.

Wezel, A., Bellon, S., Doré, T., Francis, C., Vallod, D., & David, C. (2009). Agroecology as a science, a movement and a practice. A review. *Agronomy for sustainable development*, *29*(4), 503-515.

World Bank Group (2012). *World Development Indicators*. Washington DC: World Bank.

Yates, S. J. (2004). Doing social science research. London: Sage Publications.

LISTS OF APPENDICES

Appendix A: Questionnaire

WATER, LAND AND ECOSYSTEM (WLE)/UNIVERSITY FOR DEVELOPMENT STUDIES (UDS), TAMALE, GHANA

DEPARTMENT OF AGRICULTURAL AND RESOURCE ECONOMICS (ARE)

SURVEY QUESTIONNAIRE

'OPIC

Disclaimer and Consent:

Dear Research Participant(s),

he aim of this survey is to assess the ecosystem, gender and irrigation nexus in the Nabdam and awku West Districts of Ghana using a livelihood approach. It is a study in partial fulfillment for ie award of Master of Philosophy (M.Phil.) Degree in Agricultural Economics at the University or Development Studies (UDS), Tamale. Thus the information obtained through this interview is or academic purposes only and will be accorded the highest degree of confidentiality. Your onsent is therefore sought to provide frank responses to the questions contained in this guide. hank you for your cooperation and understanding.

QUESTIONNAIRE INFORMATION

Name Of Enumerator:	**Contact Details:**
Date Of Interview:	**District:**
Name Of Community:	**Questionnaire Number:**
Name Of Respondent:	**Contact Details:**

SECTION A.

DEMOGRAPHIC CHARACTERISTICS OF RESPONDENTS

1. Household basic characteristics

1.1 Gender of respondent	(1) Male [ ] (2) Female [ ]
1.2 Are you the household head?	(1) Yes [ ] (2) No [ ]
1.3 If no, state your relationship with the household head	(1) Spouse [ ] (3) Child/House-help [ ] (2) Parent/Parent-in-law [ ] (4) Brother/sister [ ] (4) Brother/sister-in-law [ ] (6) Any other, specify……………………….. [ ]
1.4 Main occupation	………………………………………………………
What is your monthly income from your main occupation?	GH……………………………………………
1.5 Occupation of spouse	………………………………………………………
1.6 Sex of household head	(1) Male [ ] (2) Female [ ]
1.7 Age of respondent	…………………………………
1.8 Marital status of respondent	(1) Single [ ] (4) Divorced [ ] (2) Married [ ] (5)Widowed [ ] (3) Separated [ ]
1.11 Literacy	(1) Can read and write (4) Can neither read nor write (2) Can read only (3) Can write only
1.13 Educational attainment	(1) None (4) JHS/MSLC Years……. (2) Non-formal education (5) SHS/Vocational Years… (3) Primary Years……….. (6) Tertiary Years………..
1.14 Are you a native (indigene)?	(1) Yes [ ] (2) No [ ]

2. Please indicate the composition of your household [*use table below*]

Household Category	Total Number of Household Members	
Age	Male	Female
0-14		
15-24		
25-54		

55-64		
65 above		
Level of Education		
None		
Primary		
JHS		
SHS		
Tertiary		

Note: Household size includes all people, who usually eat from the same pot and sleep nder the same roof. Include also members who are absent for less than two months!

3. Which of the following livelihood activities contribute significantly to household income? (Please rank the activities based on its contribution to household income; 1 indicates highest contribution and 8 indicates the least contribution)

Livelihood activities	Tick as many as applicable	Rank
a. Crop production (rain-fed)		
b. Crop production (irrigation)		
c. Livestock rearing		
d. Crop marketing		
e. Livestock marketing		
f. Petty trading		
g. Agro-processing		
h. Waged labour		
i. Aquaculture/ Fishing		
j. Craftsmanship		
k. Other (specify)………………		

SECTION B

INVOLVELMENT IN RAIN-FED AND IRRIGATED AGRICULTURE

What is your method of crop production? (1) Rain-fed only [ ] (2) Irrigated only [ ] (3)Both [ ]

5. If irrigation, what is your source of water for irrigation? (1) Dam [ ] (2) Dug-out [ ] (3) Rivers [ ]
6. Do you have any reason for your choice of crop production? (1) Yes [ ] (2) No [ ]
7. If yes, please provide your reason......……………………………………………………………………
8. Do you have access to irrigable land? (1) Yes [ ] (2) No [ ]

9. If yes, what is the source of land? (1)Personal [ ] (2) Family [ ] (3) Hired [ ] (4) Community land [ ] (5) Share cropping [ ] (6) Contract farming [ ]
10. Do you have access to farm land (rain fed)? (1) Yes [ ] (2) No [ ]
11. If yes, what is the source of land? (1)Personal [ ] (2) Family [ ] (3) Hired [ ] (4) Community land [ ] (5) Share cropping [ ] (6) Contract farming [ ]
12. Do you have easy access to irrigable water? (1) Yes [ ] (2) No [ ]
13. What is the distance from source of irrigable water to farm land? ………………………………miles
14. What is the distance from home to your farm……………………miles
15. For how long have been engaged in farming? (1) Irrigated………..years
(2) Rain-fed…………years
16. What type of crop do you cultivate? ………………………………………………………………………..
17. Do you have easy access to market for your produce? (1) Yes [ ] (2) No [ ]
18. What is the distance from your farm to the market center?.................................miles.
19. Do you need to access credit before engaging in irrigated agriculture? (1) Yes [ ] (2) No [ ]
20. Do you currently have access to farm credit? (1) Yes [ ] (2) No [ ]
21. If yes, source of credit? (1)Banks [ ] (2) Credit unions [ ] (3) Co-operative [ ] (4) Susu [ ] (5) Family and friends [ ] (6) Other (s), please specify……………………………
22. If yes, please state the amount received for last season. GH¢…………………………….
23. Do you receive extension visits? (1) Yes [ ] (2) No [ ].
24. If yes, indicate the number of contacts in a year………times(s)
25. Do you belong to any association or farmer based group? (1) Yes [ ] (2) No [ ]
26. If yes, what is the name………………………………………………………………………………….
27. Are you engaged in any non-farm income generating activity(s)? (1) Yes [ ] (2) No [ ]
28. If yes, please provide the non-farm income generating activities with amount obtained last season below

Type of Non-farm Activity	Amount

NB: Non-farm income generating activities include; salary, petty trading, farm labour (by-day), fishing etc.

29. Do you receive any external financial support e.g. remittances grants, gifts, pensions? (1) Yes [ ] (2) No [

30. If yes, specify your source of support. (1) Relatives [ ] (2) Government [ ] (3) Friends [ ]
31. How much did you receive in all for last season? GH¢………………………………….
32. In your household, indicate who is predominantly responsible for the performance of the following farming activities and if involvement in each of these activities affect your decision to irrigate :

Activity	Method of Production		Influence on decision to irrigate 1. Has influence 2. Has no influence
	Rain-fed agriculture 1. Men 2. Women	Irrigated agriculture 1. Men 2. Women	
1.Land preparation			
2.Seed planting/sowing			
3.Watering			
4.Weeding			
5.Fertilizer application			
6.Spraying of chemicals			
7.Harvesting			
8.Transportation			
9.Processing			
10.Storage			
11.Marketing			
12.Others(list below)			

SECTION C

PERCEPTION OF FARMERS ON THE LINKAGES BETWEEN IRRIGATION, ECOSYSTEM AND LIVELIHOODS

3. What you understand by the environment?...
4. What benefits do you derive from the environment? List the ones you know including those you cannot see

……….

……….

35. How important are these services the environment provides to you and your community?

Please tick [√] appropriately in the table below

Environmental services	Very important	Important	Somewhat important	Least important	Not Important
Provisioning services					
Regulatory services					
Cultural services					
Supporting services					

NB: Provisioning services (*food, fresh water, fuel wood, fiber, biochemical, and genetic resources*), **Regulatory services** (*flood, disease control, climate regulation, water regulation, water purification, and pollination*), **Cultural services** (*spiritual and religious, recreational and ecotourism, aesthetic, inspirational, education, sense of place, and cultural heritage*), **Supporting services** (*nutrient recycling, soil formation, and primary production*)

6. How important are the following benefits provided by the ecosystem in your community?

Please tick [√] appropriately in the table below

Ecosystem services/Functions	Very important	Important	Somewhat Important	least important	Not important
Crops/vegetable					
Animals (domestic)					
Animals(wild)					
Firewood					
Honey					
Tourist attraction					
Sense of place					
Timber					
Water					
Flood control					
Fish					
Medicinal					
Spiritual values					
Pollination					
Pest and disease control					
Healthy soil					

37. Which of the trees in your environment provide benefits to you and your community. Please provide the type of benefits and their use.

Trees	Products obtained	Types of benefits 1. Household consumption 2. Selling 3. Both	If (1), please state the amount accrued last season (GHc)	Rank highest contribution to domestic use
Shea tree				
Dawadawa tree				
Kapok tree				
Baobab tree				

3. What do you think is the relationship between irrigation farming and the environment? (1) Positive [ ] (2) Negative [ ] (3) Both [ ] (4) No relationship [ ] (5) Don't know [ ]

9. Explain your answer in 38 above

……………………………………………………………………………...
………………………………………………………………………………………
………………………………………………………………………………………
……………………………………

0. Do you think irrigation farming have any observable effects on the environment? (1) Yes [ ] (2) No [ ]

1. What are these observable effects?

………………………………………………………………………………………
………………………………………………………………………………………
………………………………………………………………………………………
……………………………………………………………

2. What is your perception about changes in the under listed environmental resources over the past ten years and the contributions of rain-fed and irrigated agriculture to these changes?

Environmental resources	Observed changes (10yrs): 1-increasing 2-decreasing 3-same		Contribution of rain-fed and irrigated farming to observed changes: 1-positive 2-negetive 3-don't know	
			Irrigated	Rain-fed
Clean water				
Water quantity				
Water availability for domestic use				
Water availability for livestock watering				
Water availability for fishing				
Water availability for recreational purposes				
Food availability				
Water accessibility				

Soil fertility				
Soil structure				
Water logging				
Flooding				
Erosion				
Availability of particles in water				
Fish availability				
Vegetative cover				
Fuel wood availability				
Availability of medical plants				
Biodiversity (different animals and plants)				
Incidence of pest and diseases				
Availability of economic trees (Shea, Dawadawa, baobab)				
Non Forest timber products e.g. wild fruits, honey, bush meat)				

3. Please indicate the effects of irrigation on the under listed livelihood outcomes, rank the extent of effect and state why you think so.

Indicators	Effect: 1. Positive 2. Negative 3. No effect 4. Don't know	Rank 1. High 2. Average 3. Low 4. N/A	Reason for rank
Income			
Employment			
Food availability			
Dietary diversity			
Health needs			
Educational needs			
Housing condition			
Water facility			
Economic dependence			
Economic freedom			
Status in community/family			

44. Do think there are some human activities that affect the environment? (1) Yes [ ] (2) No [ ]
45. If yes to 44, what are some of these activities? Please list some of them and which direct effect it has on the environment?

Human Activities	Perceived direct effect on environment

SECTION D

LIVELIHOOD STATUS OF FARMERS

6. Please provide information on distribution of production last season

Plot No	Size of land (acre)	Area cultivated(acre)	Own land/Share cropping/ Rented/Gift (O-1, S-2, R-3, G-4)	Distance of farm from home (kg/mile)	Irrigated /Rain-fed (I-1, R-2)	Mixed cropping/ Mono (1-mixed, 2-Mono)	List crops
1							
2							
3							
4							
5							

7. Please indicate your level of engagement in farming in relation to other activities you undertake in a typical day.

Activities	Number of hours
Engagement in agricultural activities	
Household activities	
Non-farm income generating activities	
Social activities	
Personal activities	
Others (specify)	

48. How farmers' livelihood conditions have been affected												
A. Food availability situation in farmer's household throughout the year												
Instructions: tick[√] and score the appropriate condition for each month												
Grading	Sufficient =3, Insufficient=2, Extreme shortage=1											
Month	Jan	Feb	Mar	April	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Score												
l Score												

Housing condition of farmer			
uctions: tick[√] the appropriate condition for each housing condition			
		Score	Total Score
ership of house	Personal house= 3 Family house= 2 Rented =1		
entage of rooms ed	All rooms =3 Half of the rooms =2 Below half=1		
entage of rooms are cement ked	All rooms = 3 Half of the rooms= 2 Below half=1		
eral impression	Excellent =4 very good =3 good= 2 bad= 1		

Iealth situation			
th status		Score	Total Score
re of health s in household	Good = 3 Short illnesses=2 Frequent illnesses=1		
ss to health treatment		Score	Total Score
ict hospital/ munity Health centres	Always=3 Sometimes=2 Not at all=1		
Pharmacy	Always =3 Sometimes=2 Not at all=1		
Herbal treatment	Always =3 Sometimes=2 Not at all=1		
Ability to access treatment			
Affording health treatment	Have active health insurance card =3 Inactive health insurance card but can afford =2 Inactive health insurance card and cannot afford=1		

51. **Water facilities**			
(i) Water source		Score	Total score
Source of water	Borehole/pipe= 4 Mechanized well=3 Uncovered well=2 River/pond=1		
(ii) Water quality		score	Total score
Drinking water	Good= 3 Clean but smells or hard =2 Unclean=1		

(iii) Availability of water												
Grading	Adequate =3 Inadequate=2 Scarcity =1											
th	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
e												
l Score												

reedom in cash expenditure						
uctions: tick[√] and score the appropriate condition for each month						
gs for nditure	Level of decision in cash expenditure				Score	Total score
	Farmer=4	farmer and spouse=3	Spouse=2	extended family=1		
y expenditure						
stment on land						
dren education						
th						
sehold assets						

Sanitation		**Score**	**Total score**
ession of a toilet	Owned toilet=3 community toilet=2 None=1		
dition of toilet	Hygienic =3 Better= 2 Unhygienic =1		

Participation in social activities		**score**	**Total score**
cipation level	-freedom to participate in any gathering=2 -limited freedom to participate=1		

55. **Health of ecosystem services**				**Score**	**Total score**
Environmental services	Sustained =3	Deteriorating =2	Worsened =1		
Fish availability					

Vegetation for animals						
Availability of medicinal plants						
Availability of fuel wood						
Fruits availability						
Water availability for recreational purposes						
Flood control						
ion control						
lable particle in r						
and diseases control						

SECTION F

CONSTRAINTS AND PROSPECTS

6. What are the five most important constraints for rain-fed and irrigated agriculture (Don't prompt)?

Constraint for rain-fed agriculture	Response	Constraints for irrigated agriculture	Response
Labour availability or drudgery		Labour availability or drudgery	
Pest and disease attack		Pest and disease attack	
Low access to credit		Low access to credit	
High input cost		High input cost	
Lack of storage facilities		Lack of storage facilities	
Land tenure insecurity		Land tenure insecurity	
Lack of access to ready market		Lack of access to ready market	
Low cost of farm produce		Low cost of farm produce	
Limited access to inputs and technologies		Limited access to inputs and technologies	
Poor water supply		Poor water supply	
High cost of renting farm machinery		High cost of renting farm machinery	
Low price of farm produce		Low price of farm produce	
Livestock /dry season interface			

57. What have you done to address each of the constraints mentioned above?

Constraint for rain-fed agriculture	Constraints for irrigated agriculture
*	

8. Identify your strengths, weaknesses, opportunities, and threats of participating in irrigation in your community.

Strength	Weakness	Opportunity	Threats

Thank You for Your Participation!!!

Appendix B: Detailed demographic characteristics of farmers

	Irrigators						**Non-Irrigators**					
	River		Dams		**Pooled**		River		Dams		Pooled	
	1	F	M	F	**M**	**F**	M	F	M	F	**M**	**F**
Marit												
Singl	3	11	26	0	**17**	**5**	27	3	13	7	**20**	**5**
Marr	2	79	74	87	**83**	**83**	68	63	77	55	**72**	**59**
Separ	)	0	0	0	**0**	**0**	0	0	2	3	**1**	**1**
Divor	)	0	0	0	**0**	**0**	0	2	5	3	**3**	**3**
Wido	)	11	0	13	**0**	**12**	5	32	3	32	**4**	**32**
Sub-t	)0	100	100	100	**100**	**100**	100	100	100	100	**100**	**100**
N=38					**N=76**		**N=38**				**N=76**	
Litera												
Can r write	9	18	24	18	**26**	**18**	21	3	37	21	**29**	**12**

Can read only	0	3	3	3	**1**	**3**	0	3	3	0	**1**	**1**
Can write only	0	3	3	0	**1**	**1**	0	5	0	0	**0**	**3**
Can r[illegible] read [illegible] write[illegible]	[illegible]1	76	70	79	**71**	**78**	79	89	60	79	**70**	**84**
Sub-t[illegible]	[illegible]0	100		100	**100**	**100**	100	100		100	**100**	**100**
N=38			100		**N=76**		**N=38**		100		**N=76**	
Educ[illegible]ment												
None	[illegible]7	74	66	82	**57**	**78**	66	86	53	82	**59**	**84**
Non-f[illegible]	[illegible]1	3	3	0	**7**	**1**	0	0	5	0	**3**	**0**
Prima[illegible]	[illegible]8	5	8	11	**13**	**8**	13	5	11	3	**12**	**4**
JHS/[illegible]	[illegible]8	13	13	8	**16**	**11**	8	8	13	13	**11**	**11**
SHS/[illegible]	[illegible]	5	5	0	**5**	**3**	8	0	11	0	**9**	**0**
Terti[illegible]	[illegible]	0	5	0	**3**	**0**	5	0	8	3	**7**	**1**
Sub-t[illegible]	[illegible]0	100	100	100	**100**	**100**	100	100	100	100	**100**	**100**
N=38					**N=76**		**N=38**				N=76	
Household Headship												

Household heads	76	11	68	11	72	11	66	24	76	45	71	35
Not house	4	89	32	89	28	89	34	76	24	55	29	65
Sub-t	)0	100	100	100	**100**	**100**	**100**	100	100	100	**100**	**100**
	38				**N=76**		**N=38**				**N=76**	

Appendix C: Detailed socioeconomic characteristics of farmers

Variable	**Irrigation**							**Rain-fed**							
	lean	Min		Maxi		S. D		Mean		Mini		Maxi		S.D	
Age															
	D	R	D	R	D	R	D	R	D	R	D	R	D	R	D
Ma	40	20	20	70	70	13.13	14.1	48	47	17	21	93	90	22.97	19.01
Fen	42	18	24	72	69	14.88	13.1	43	45	18	17	75	80	17.79	17.83
Inc															
Ma	1892.84	130	200	31176	6244	5469.4	1536.38	809.8	1234.78	100	120	3500	7227	783.51	1283.5
Fen	1262.73	200	80	5000	5800	1050.9	1291.80	639.47	791.81	50	100	3200	3360	589.38	697.69
Exp ... ation															
Ma	13.07	3	1	50	43	9.89	9.86	1.73	1.07	0	0	30	25	783.5	4.35
Fen	10.84	1	1	40	30	9.30	6.37	0.76	12.2	0	0	20	2.7	3.36	12
Exp ... fed															
Ma	16	1	2	52	50	12.34	11.8	22.86	20.3	4	3	50	60	15.20	14.74
Fen	13.9	1	0	45	40	11.46	9.97	18.18	12.2	2	0	56	40	15.12	11.52
Far															
Ma	4.79	1.5	1.25	12	9.5	2.42	2.35	3.37	4.7	1	1.5	8	12	1.59	2.6
Fen	3.46	0.5	0.5	9.5	13	1.88	2.27	3.02	3.28	0.75	0.5	7.5	9	1.67	1.81

Appendix D: Maximum likelihood estimates for males (Stata output)

```
. mfx

Marginal effects after probit
      y  = Pr(Adoption) (predict)
         =  .47075076
```

variable	dy/dx	Std. Err.	z	P>|z|	[95%	C.I.]	X
Age_res	.0218533	.01919	1.14	0.255	-.015762	.059468	43.6513
Age_sqd	-.0003453	.0002	-1.70	0.088	-.000742	.000052	2231.38
Marita~t*	.1210205	.12226	0.99	0.322	-.118602	.360643	.776316
House~ad*	.1187767	.1184	1.00	0.316	-.113273	.350827	.717105
Market~y*	.1857642	.11845	1.57	0.117	-.046402	.417931	.828947
extens~s*	.2194596	.08575	2.56	0.010	.051401	.387518	.539474
InRain~d	-.0000244	.00004	-0.63	0.531	-.000101	.000052	1275.44
frmsze	.0234903	.01971	1.19	0.233	-.015148	.062128	4.40546

(*) dy/dx is for discrete change of dummy variable from 0 to 1

Appendix E: Maximum likelihood estimates for females (Stata output)

```
. mfx

Marginal effects after probit
      y  = Pr(Adoption) (predict)
         =  .48266601
```

variable	dy/dx	Std. Err.	z	P>|z|	[95% C.I.	]	X
Age_res	.0150064	.0169	0.89	0.374	-.018109	.048122	41.6447
Age_sqd	-.0002133	.00019	-1.14	0.254	-.00058	.000153	1992.37
Marita~t*	.0875916	.12196	0.72	0.473	-.151447	.32663	.710526
House~ad*	-.2843042	.11408	-2.49	0.013	-.5079	-.060708	.223684
Market~y*	.4592314	.08249	5.57	0.000	.297549	.620914	.835526
extens~s*	.0298297	.09263	0.32	0.747	-.151731	.211391	.407895
InRain~d	-.0000637	.00007	-0.88	0.380	-.000206	.000079	662.026
frmsze	.0520895	.02752	1.89	0.058	-.001852	.106031	3.25132

(*) dy/dx is for discrete change of dummy variable from 0 to 1

Appendix F: Maximum likelihood estimates for gender (Stata output)

```
. mfx

Marginal effects after probit
      y  = Pr(Adoption) (predict)
         =  .48291956
```

variable	dy/dx	Std. Err.	z	P>|z|	[95% C.I.	]	X
Gender~s*	.0219476	.07588	0.29	0.772	-.126765	.17066	.5
Age_res	.019709	.01167	1.69	0.091	-.003173	.04259	42.648
Age_sqd	-.0002716	.00013	-2.16	0.030	-.000518	-.000026	2111.87
Marita~t*	.1580911	.07041	2.25	0.025	.020087	.296095	.743421
House~ad*	-.0998996	.0761	-1.31	0.189	-.249063	.049263	.470395
Market~y*	.3288681	.07257	4.53	0.000	.186639	.471097	.832237
extens~s*	.1140029	.06158	1.85	0.064	-.006694	.2347	.473684
Rainfe~e	-.0000414	.00003	-1.23	0.219	-.000107	.000025	968.734
Farm_s~e	.0348235	.01564	2.23	0.026	.004162	.065485	3.82839

(*) dy/dx is for discrete change of dummy variable from 0 to 1

Appendix G: Linear regression with endogenous treatment (Stata output)

```
Linear regression with endogenous treatment     Number of obs     =        304
Estimator: two-step                             Wald chi2(6)      =      31.95
                                                Prob > chi2       =     0.0000
```

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
lnALS						
lnTotal_Income	.0057298	.0040867	1.40	0.161	-.0022801	.0137396
lnHousehold_size	-.0160596	.009355	-1.72	0.086	-.034395	.0022759
Location	-.0343452	.0098989	-3.47	0.001	-.0537466	-.0149438
Remittances	-.0112167	.014402	-0.78	0.436	-.0394441	.0170106
Education	-.0222496	.0114382	-1.95	0.052	-.0446681	.0001689
Adoption	.0893624	.0278448	3.21	0.001	.0347876	.1439372
_cons	4.214276	.0335308	125.68	0.000	4.148557	4.279996
Adoption						
Gender_res	.0550719	.1904402	0.29	0.772	-.318184	.4283279
Age_res	.0494484	.0293107	1.69	0.092	-.0079995	.1068963
Age_sqd	-.0006814	.0003153	-2.16	0.031	-.0012994	-.0000635
MaritalStat	.4028834	.1843299	2.19	0.029	.0416035	.7641633
Household_head	-.2513865	.192612	-1.31	0.192	-.6288991	.126126
Market_Availabilty	.9000954	.2359995	3.81	0.000	.4375449	1.362646
extension_visits	.2869206	.1560105	1.84	0.066	-.0188543	.5926955
Rainfed_Income	-.0001038	.0000843	-1.23	0.218	-.0002691	.0000615
Farm_size	.0873697	.0392414	2.23	0.026	.0104579	.1642815
_cons	-2.040328	.609341	-3.35	0.001	-3.234615	-.8460418
hazard						
lambda	-.0621564	.0176658	-3.52	0.000	-.0967806	-.0275321
rho	-0.64434					
sigma	.09646579					