UNIVERSITY OF CAPE COAST

PERCEPTION OF FARMERS ON FACTORS AFFECTING ADOPTION OF IRRIGATED RICE PRODUCTION TECHNOLOGIES IN BONTANGA, NORTHERN REGION, GHANA

BY

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DECLARATION

Candidates Declaration

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

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

Name: Seini, Abubakari

Supervisor's Declaration

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 of Cape Coast.

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ABSTRACT

Rice production is important to the economy and improvement of livelihoods of smallholder farmers. Despite the efforts of government and development partners, yields of rice remain low. However, there were no studies to determine levels of adoption of irrigated rice technologies by farmers at the bontanga irrigation area. The study used a survey design to randomly select 197 farmers who were interviewed using questionnaire. Relationships between independent variables were established, whilst ordinal logistic regression was used to determine best predictors of adoption levels. Credit, mechanisation, and input supply constrained adoption of rice production technologies. Farmers who perceived technologies to be relevant, positively adopted them. Radio, group meetings, friends, family members, and farmers, were the important sources of information on rice technologies. There were very high technologies adoption levels with fertilizer technologies registering the least adoption levels. TPB, RCT, and DIT were relevant in explaining farmers adoption decisions. Age, household size, experience, having assets, farmers group support, status in group, and conducive weather were the best predictors of technologies adoption levels. The study recommends the facilitation of access to inputs, use of ordinal logistic model in studies of multiple technologies, and use of multiple theories in explaining technology packages adoption.

KEY WORDS: innovation adoption, multiple technologies, adoption theories, adoption levels, ordinal logistic regression, correlation.

KEY WORDS

Innovation adoption

Multiple technologies

Adoption theories

adoption levels

Ordinal logistic regression

Correlation

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DEDICATION

To My Father, Takobihi-Naa Seini Alhassan

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LIST OF ACRONYMS

CA:	Conservation agriculture
CODAPEC:	Cocoa disease and pest control
COMMIT:	Communication and Malaria initiative
DIT:	Diffusion of innovation theory
FAMPIM:	Farmer Participatory Irrigation Management
FAO:	Food and agricultural organisation
FAOSTATS:	Food and Agricultural Organisation Statistics
FARA:	The Forum for Agricultural research in Africa
GSS:	Ghana statistical service
IBP:	International breeding programme
IDA:	Irrigation development authority
IITA:	International Institute of Tropical Agriculture
IMF:	International Monetary Fund
IPM:	Integrated pest management
IRRI:	International rice research institute
JICA:	Japan international cooperation
LDC:	Least developed countries
MoFA:	Ministry of agriculture
MTADP:	Medium term agricultural development plan
NCRM:	National centre for research methods
NEPAD:	New partnership for Africa's development
NGO:	Non-Governmental Organisation
NPK:	Nitrogen, Phosphorus, and potassium
ODI:	Overseas Development Institute
PNDC:	Provisional National Defence Council
RCT:	Rational choice theory
SADA:	Savanah agricultural development authority
SAP:	Structural adjustment programme
SME:	Small and medium enterprises

SPSS:	Statistical package for social sciences
T/V:	Training and Visit
TAM:	Technology acceptance model
TOE:	Technology-organisation-environment
TPB:	theory of planned behaviour
USAID:	United States Agency or International Development
USDA:	United States Department of Agriculture

CHAPTER ONE

INTRODUCTION

Background to the Study

World rice production

The available data in 2013 indicate that rice production in the world hit over 700 million tonnes, with developing countries accounting for 95 percent of the total production. However, China and India contribute nearly half of the total rice output in the world. The Asian countries namely Pakistan, Bangladesh, Vietnam, Thailand, Myanmar, Philippines, and Japan together with China and India accounted for 92% of the total rice production in the World (FAO, 2020), (IBP, 2013). According to FAOSTATS (2020) and USDA (2020), Europe and Africa contribute less than 1% and 3.7% respectively to total global rice production. Rice production in the world has fluctuated significantly from 2000 to 2011. The production, in 2000 increased from 599,355 to 722,760 thousand tonnes in 2011, while the lowest production of 571,387 thousand tonnes was recorded in 2002, reflecting unstable productions from the individual countries of the continent (Table 1).

Rice production in development countries and Africa

Rice production in developing countries experienced marginal increased growth rates in 2000 and 2010. For instance, increases in growth rates of 1.8% to 5.2%, between 1990 and 1999 increased marginally from 1.1% and 1.2% between 2000 and 2010 (Table 1).

Table 1- Rice production and consumption in the World, Asia, Europe, Africa, and Ghana

Region	World		Asia		Europe		Africa		Ghana	
Year	Prod	Cons	Prod	Cons	Prod	Cons	Prod	Cons	Prod	Cons
2000	599355	392899	545546	352421	3181	3634	17477	16083	249	335
2001	599828	396010	546141	354238	3150	3588	16658	17114	275	494
2002	571387	398750	517319	355669	3210	3860	17602	17973	280	524
2003	587069	400568	532846	356888	3258	3805	18497	18476	239	495
2004	607990	406403	547753	359700	3468	4029	19035	19081	242	509
2005	634445	413773	574111	367062	3352	3873	20289	19385	287	526
2006	641207	421155	580848	374550	3405	3990	22016	20528	250	585
2007	656970	426769	598878	379255	3599	4039	21010	21495	185	600
2008	688527	445873	624499	396978	3478	4212	24485	21935	302	646
2009	685094	449659	619206	397525	4228	4409	23565	23118	391	692
2010	701128	392899	633746	352421	4319	3634	25878	16083	492	335
2011	722760	455914	653240	354238	4376	3588	26532	17114	464	494
2012	736597	461788	666113	416476	4396	3968	29034	27784	481	950
2013	742505	471532	672528	419581	4010	4104	28750	28454	570	965
2014	742454	471780	669243	-	3965	-	30751	-	604	965
2015	745905	466512	673315	-	4224	-	30850	-	642	980
2016	751885	476740	677674	-	4239	-	33324	-	688	1050
2017	769829	481419	696964	-	4143	-	31812	-	722	1100
2018	782000	485304	705393	-	4023	-	33174	-	769	1150

Source: FAOSTATS and USDA, 2020. Note: prod = production, cons = consumption

The marginal growth rates are attributed to interplay of factors such as reduced areas cropped and harvested, poor use of improved varieties and production technologies, and inadequate crop intensification. The African continent achieved the highest annual growth rate of 3.5% and 2.7% for the 1990-99 and 2000-10 periods (FAO, 2020; USDA, 2020; IBP, 2013).

Rice consumption

Analysis of Table 1 indicate that rice production worldwide is related to consumption patterns across nations. In the year 2000, global rice consumption was estimated at 65% of production. This increased to 69.8% in 2002 but reduced to 63% in 2011. In Africa, 92% of total production is consumed.

Globally, rice production has always outstripped consumption. Similarly, Asia has consistently recorded surplus production over consumption for periods 2000 to 2018. Between these years, Europe recorded deficits in the years 2010 to 2013. In contrast to these scenarios, production had exceeded consumption except for 2005 and 2008 to 2013 for the African continent.

Ghana contributes less than 2% to the Africa aggregate production and has consistently experienced short falls in rice production and consumption between the years 2000 and 2018 except 2010 when production surpassed consumption by 32% (Table 1).

Ghana is an agrarian and developing country and consumes a lot of rice. The problem of deficit production, therefore, requires attention. While production in the Asian countries continue to rise, consumption seems to be dwindling.

In the case of Ghana, while production is decreasing, consumption is consistently increasing. Whilst the natural conditions of Ghana are generally adequate for agricultural production, Ghana continues to face food security problems because domestic production, especially rice consistently lag far behind demand (Wolter, 2008; Kranjac-Berisavljevic, Blench, & Chapman, 2003; IRRI, 2013).

The reduction in rice production in Ghana is attributed to low yields per hectare. While achievable rice yields are estimated at 6.5t/ha (FAO, 2020), Ghana still lags with yields of 2.7 and 2.4t/ha for the years 2010 and 2011 respectively. This trend therefore renders the country a net rice importer (MOFA, 2011). Rice has become an important staple food for many Ghanaian households, especially the middle class resulting in rice estimated bill of US$400 for Ghana (Ministry of Food and Agriculture (MoFA), 2009; MoFA/JICA, 2014). Rice production further serves as a source of employment for 295,000 households.

Government interventions to improve rice production

Successive Governments of Ghana have implemented various interventions to improve production as a response to the production gap and problems in production over the years (Kranjac-Berisavljevic' et al., 2003; FAO, 2013; MOFA, 2009; FARA, 2009). The interventions spawned the introduction and implementation of irrigation projects. Many Asian countries such as North Korea, South Korea, Taiwan, China, and Japan have also supported paddy rice production in remote areas of Ghana under Ghana-Bilateral relations. ODI (2013) described the bilateral approach as complex and made it difficult to trace the history of the introduction of rice varieties and technologies due partly to the diversity of projects. Large scale mechanised commercial rice production had been introduced through the bilateral relations in the 1970s to 1980s. Subsidies were further introduced for the purchase of tractors, combine harvesters and fertilizers (Kranjac-Berisavljevic' et al., 2003).

Irrigation intervention

A further intervention was the Government of Ghana initiation and construction several irrigation projects to boost rice and vegetable production and yields. Five of such prominent irrigation projects in Ghana are found in the Northern and Upper regions of Ghana namely: Vea irrigation project (1965-1980), Libga irrigation project (1970-1980), Golinga irrigation Project (1971-1974), Tono irrigation project (1975-1985), and Bontanga irrigation Project (1978-1980) (MOFA, 2013).

The irrigation projects were successfully implemented by the Government under the management of Irrigation Development Authority (IDA). Initially IDA stationed a project manager, agronomists, and extension staff to oversee and manage the project. These were complemented with mechanisation services including tractors, rice combine harvesters, and power tillers for field levelling at the project area.

The Bontanga irrigation project was setup in 1978 to provide an opportunity for small scale farmers to produce rice intensively and to satisfy domestic consumption needs and reduce rice imports in Ghana (Kranjac-Berisavljevic' et al., 2003 and MOFA, 2009). Table 2 depicts the irrigated rice technologies introduced to farmers at the Bontanga irrigation area as follows and expanded as in Table 2:

1. Land preparation involving ploughing, harrowing, and levelling.
2. Seed nursing and transplanting of seedlings to flooded field

Table 2- Components of introduced technologies under study

Technologies	Subgroup	Components
Land preparation	Pre-planting	Transplanting
		Ploughing
		Harrowing
		Levelling
		Flooding
		Seedling nursing
		Transplanting immediately after field preparation
Fertilizer	Compound fertilizer	4bags/ac immediately after planting
	Nitrogen fertilizer	2bags/ac3-4 weeks after planting
Improved seed	Use of improved variety	Use of improved seed variety
IPM	Weed control	Intermittent flooding of field
		Intermittent drainage of field
	Disease control	Fungicide application before transplanting
		Insecticide application at milky stage

Source: Field survey, Seini (2013)

3. improved early maturing and high yielding rice varieties such as GR18 (Afife), GR19 (Bumbas), Thailand, 'Andii' and, IITA 222. These varieties were early maturing capable of increased yields if
4. fertilizer application at 2bags (100kg) nitrogen and 4bags (200kg) compound fertilizer (NPK) per acre respectively
5. Integrated pest management (IPM) involving transplanting, intermittent flooding and draining of planted fields, insecticide and application of fungicide and insecticides at booting/milky stage.

6. Farmer Participatory Irrigation Management System (FAMPIM) that included: group formation, training on information dissemination, and water management (scheduling).

After several years of project implementation, Ghana Government is still faced with persistent perennial rice importation bills due to unmet production-consumption gap. The adoption of the introduced innovations therefore becomes questionable.

Statement of the Problem

Farmers at the Bontanga irrigation area were introduced to rice production and management technologies to improve yield of rice (Table 2). However, according to MoFA (2011) and FAO (2013) the yield of many irrigation systems in Ghana has not improved, with an estimated rice yield of 2.4t/ha and 2.7t/ha, while achievable yields are estimated at 6.5-8t/ha. Nguu (2013) reported that rice yield figures for Bontanga irrigation project fluctuated between 2.5 and 4.3t/ha between 1997 and 2010 with an average yield of 3.6t/ha. With introduction of irrigated rice technologies, farmers are expected to achieve yields of 8t/ha.

The low rice yields at the Bontanga irrigation project area after the technology's intervention raised questions of whether farmers adopted the package of technologies introduced. However, no study has been conducted since the inception of the project. The success of dissemination of agricultural technology is measured by the adoption and their effectiveness in enhancing food production and human livelihoods. Norman and Kebe (2007) reported that the adoption of improved rice production technologies guarantees increases and sustainable rice production.

Ouwersloot and Rietveld (2000) argued that dissemination of technologies does not neccesarily imply application due to issues of compatibility of technology to adopters. Rogers (2003) posited that technological package, which consists of one or more distinguishable elements of technology are perceived to be interelated and influence adoption. Therefore, it is often important to examine the usefulness of technology as a package. Farmers stand the chance of total yield effects from individual technologies in addition to the synergistic effects of the package if technologies are adopted simultaneously. However, effects of using the technological mix is seldom studied in adoption research (Bartolini, Latruffe, & Viaggi, 2011; Rogers, 2003; Mafuru et al., 1999). Most adoption studies have explained adoption decisions in the binary form (adoption or no adoption) (Rafael, 2011; Mamudu, Emelia, & Samuel, 2012) though agricultural technologies are introduced in packages (Rogers, 2003; Abbott & Yarbrough, 1999). These approaches suggest a single technology. Adoption studies on introduction of multiple or package of technologies using such methodological approach of adoption/diffusion are inadequate (Abbot & Yarbrough, 1999; and Rogers 2003). Consequently, the study adopted the multiple technology approach using the ordered logistic regression methodology to assess the adoption levels of irrigated rice technologies at Bontanga rice irrigation project area to fill the methodological gap. This would provide anwers to the adoption levels of the technologies package introduced and explain the low rice yields at Bontanga irrigation area.

Research Questions and Hypothesis

Research questions

1. What are farmer perceptions of socio-economic characteristics, rice technologies characteristics and institutional support for irrigated rice technologies adoption?

2. What are the levels of farmers' adoption of irrigated rice technologies?

3. How do factors affecting adoption correlate with adoption levels of irrigated rice technologies

4. What socio-demographic characteristics, technologies characteristics, and institutional support best predict adoption levels of irrigated rice technologies?

Hypotheses

1. H(0): farmer characteristics (gender, age, household size, marital status, experience, and education) do not predict farmer technology adoption levels

   H(1): farmer characteristics (gender, age, household size, marital status, experience, and education) positively predict farmer adoption levels

2. H(0): Technology attributes (cost, complexity, riskiness) do not predict farmer technology adoption levels

   H(1): Technology attributes (cost, complexity, riskiness) negatively predicts farmer technology adoption levels

3. H(0): Technology attributes (compatibility, meet needs, disease, and pest resistances) do not predict farmer technology adoption levels

H(1): Technology attributes (compatibility, meet needs, disease, and pest resistances) positively predicts farmer adoption levels

4. H(0): Resource factors (available land, available capital, available labour and have assets) do not predict farmer technology adoption levels

   H(1): Resource factors (available land, available capital, available labour, and have assets) positively predict farmer technology adoption levels

5. H(0): Social factors (status in community, ethnicity, member in group, position in group, and land tenure) do not predict farmer technology adoption levels

   H(1): Social factors (status in community, member in group, position in group, and land tenure) positively predict farmer technology adoption levels

6. H(0): Social factor, ethnicity, do not predict farmer technology adoption levels

   H(1): Social factor, ethnicity, negatively predict farmer technology adoption levels

7. H(0): Institutional support (NGO, MoFA, farmer group, bank/credit, agrochemical companies, radio, and market) do not predict farmer technology adoption levels

H(1): Institutional support (NGO, MoFA, farmer group, bank/credit, agrochemical companies, radio, and market) positively predict farmer technology adoption levels

8. H(0): Environmental factors (conducive weather and good soils) do not predict farmer technology adoption levels

   H(1): Environmental factors (conducive weather and good soils) positively predict farmer technology adoption levels

Objectives of the Study

General objectives

The main objective of the study is to examine perception of farmers on factors affecting adoption level of irrigated rice production technologies in Bontanga in the Northern Region of Ghana.

Specific Objectives

The specific objectives are to:

1. Describe farmer perceptions on effects of socio-demographic characteristics of farmers, rice technology characteristics and institutional support for adoption of irrigated rice technologies at Bontanga irrigation area.
2. Determine the levels of adoption of irrigated rice technology package introduced to farmers at the Bontanga irrigation area.
3. Establish correlates of irrigated rice technologies adoption.

4. Predict adoption levels of irrigated rice technologies from farmer perceptions of farmer, technologies, and socio-demographic characteristics and institutional support.

Justification

Rice is important in the Ghanaian economy in that it can ensure food security and improve the livelihood of rural farmers. The study identifies factors associated with adoption of irrigated rice technologies. Project implementers could use the factors to improve farmers' decision to adopt technologies and eliminate constraints of adopting irrigated technologies. The study focuses on the adoption of multiple technologies introduced to farmers at the Bontanga irrigation project area. The outcome of the project would contribute to knowledge of adoption studies regarding irrigated rice technologies in Ghana. Development workers and policy makers can use information to shape innovation development, dissemination, and adoption of agricultural technologies. The results would reveal factors that are perceived important for adoption which would be useful for policy makers in developing technology to improve livelihood of rural people. If appropriate technologies are developed and disseminated through identified communication channels, technology adoption by farmers could improve. Improved adoption has the potential of ameliorating farming practices which consequently could facilitate and improve rice production and productivity of farmers.

Definition of Terms

The key terms as used in the study are defined in this section. Technology and innovation are used interchangeably in the study. A technology means an idea, activity, object (physical or mental) that is introduced and has the capacity to improve rice production. The technologies are land preparation, transplanting, fertilizer, improved seed, and IPM described in (Table 2). Adoption levels refer to proportion of technologies adopted by the farmer, out of the total package of technologies. Adoption levels are described as very high, high, medium, and low.

1. Very high adoption level connotes the use of more than 76% of the components of the technologies by a farmer.
2. High adoption level refers to the use of 51-75% of the technology's components in the package.
3. Medium adoption level refers to use of 26-50% of the technologies in the package.
4. Low adoption level refers to use of 25% or less of the technologies in the package.

Organisation of Thesis

The thesis is organised into eight chapters. The first chapter focuses on background to the study that described trends in rice production in the World, Africa, and Ghana. The statement of the problem provided the gap while objectives of the study followed. The benefits of the study to respective stakeholders are outlined in the justification of the study and followed by definitions of terms and organisation of thesis.

The second chapter is devoted to review of literature, related literature from sources such as books, journals, and conference papers on variables of the study. The chapter ends with conceptual framework adopted for the study.

The third chapter presents methodology employed in the study. Items included are study area, research design, population, sampling and sample size, instrumentation, data collection and analysis.

The fourth chapter presents results and discusses the socio-economic characteristics of farmers, rice technologies characteristics and institutional support for adoption of irrigated rice technologies at the Bontanga irrigation project area.

The fifth chapter focuses on the results and discussions of adoption of irrigated rice technologies introduced to the farmers at the Bontanga irrigation area. The sixth chapter presents results and discusses correlates of adoption of irrigated rice technologies. Results and discussions on ordinal logistic regression analysis to determine the best predictors of levels of irrigated rice technologies adoption at the Bontanga irrigation area are presented in the seventh chapter. Finally, the eighth chapter contains summary, conclusions, and recommendations on key findings of the study.

CHAPTER TWO

LITERATURE REVIEW

Introduction

The chapter presents the review of related literature on adoption of rice, the theoretical concepts, and empirical variables of the study. Specifically, the chapter looked at the theory of planned behaviour (TPB), rational choice theory (RCT) and diffusion of innovation theory (DIT). Concepts reviewed include agricultural technology, technologies adoption and diffusion. The empirical review focused on measurement of adoption of technologies, and methods such as the ordinal logistic regression model and history of rice development in Ghana, irrigated rice production technologies in Ghana and factors influencing agricultural technologies adoption. The chapter ends with the conceptual framework that guided the study of adoption of irrigated rice technologies among farmers in the Bontanga irrigation project area.

History of rice development in Ghana

Rice has been cultivated in Ghana by traditional small-scale farmers through history using *Oryza glaberrima* under the bush/fallow and/or shifting cultivation systems as staple food. Large scale mechanised commercial rice production was introduced in the 1970s to 1980s. The programmed rice produce was targeted at urban markets with emphasis on commercial farms (Kranjac-Berisavljevic' et al., 2003). Rice yields have been a major problem for successive Governments in Ghana. Several policies and programmes have been initiated to improve rice yields and production in Ghana over the years including subsidised tractor and fertilizers prices and the construction of irrigation dams for rice production.

In the 1970s, rice production saw state intervention with the supply of subsidies in the form of tractor and fertilizers to boost rice production. The Government of Ghana introduced rice schemes as a major tool in improving food security and incomes. Many Asians from North and South Korea, Taiwan and China supported paddy rice production in isolated projects in remote areas of Ghana. According to ODI (2013), this approach was complex and made it difficult to trace the history of the introduction of rice varieties and technologies due partly to the diversity of projects. During this period, several irrigation projects were initiated and constructed to boost rice and vegetable production and yields. Five prominent irrigation projects in the Northern and Upper Regions of Ghana, developed to improve rice production include (MoFA, 2013): Vea irrigation project; 1965-1980, Libga irrigation project: 1970-1980, Golinga irrigation project; 1971-1974, Tono irrigation project; 1975-1985, and Bontanga irrigation project; 1978-1980.

In 1983, political developments in Ghana resulted in a major change in the economic policy of the country. The government of the day accepted International Monetary Fund (IMF) and World Bank conditions and adopted the Structural Adjustment Programme (SAP). Ghana had to disengage from these types of interventions in between 1970-1980, under pressure from the IMF and World Bank in the 1980s and 1990s. All subsidies on agricultural inputs were removed, and many infrastructural components of rice projects such as processing mills were sold to the private sector. The SAP intervention generally downplayed the rice sector in favour of horticultural and tree crop producers but not rice producers (ODI, 2013; JICA, 2006; Kranjac-Berisavljevic et al., 2003; and Kranjac-Berisavljevic, 2000).

Irrigated rice production technology in Ghana

Irrigation development in Ghana has followed the global trends, with a peak in 1970 having started in the 1960s. The scale of overall development has however, remained incredibly low. Irrigated land (19,000 ha), represents a mere 1% of approximately 1.9 million ha of potential land for development, and only about 0.36% of a total 5.3 million ha of agricultural land (JICA, 2006; MOFA, 2007). Less than 1 percent of arable land is under irrigation and the poor management of existing systems further limits their effectiveness. Formal public irrigation schemes are operating at approximately a third of their design capacity with low yield and low cropping intensity because of poor operation and maintenance of irrigation facilities, the latter being partly due to inadequate cost recovery. Formal irrigation development has been very much supply-driven, and over-reliance on the formal system is limiting the area under irrigation (MoFA, 2007).

The introduction of irrigation technology resulted in the construction of 22 irrigation facilities across the country including Bontanga irrigation project (Kranjac-Berisavljevic' et al., 2003, JICA, 2006). The World Bank's review of Ghana's irrigated agriculture of 1986 however, indicated that Ghana's irrigated agriculture was not adequately achieving results reflecting the investments committed to irrigated agriculture. World Bank therefore recommended that Ghana Government should focus on functional recovery of existing facilities and promotion of the operation and maintenance of facilities by farmers themselves.

Underpinning the recommendation was the curtailment of government's role as directed/influenced by the Bank's Structural Adjustment Programme. Ghana government formulated the Medium-Term Agricultural Development Plan (MTADP) which spawned the policy of focusing on the functional recovery of existing irrigation facilities and on improvements to their productivity. This involved rehabilitation, improvement of irrigation facilities, and promoting the operation and maintenance of irrigation facilities through small-scale irrigated agriculture with the participation of farmers against the policy of promoting new irrigation development projects.

This was to address facility site problems such as unskilled water management and farming technologies, the decline of facility functions due to a lack of thorough maintenance, and the decline of agricultural productivity. "Participatory Irrigation Management" project was introduced as a result, to be run by the Farmers' organisations. The realisation, however, was that there was no framework for the successful advancement of irrigated agriculture hence the introduction of the "Project for Improving the Farmer Participatory Irrigation Management System" (FAMPIM) in 2004 (JICA, 2006).

The underlying reason for the introduction and maintenance of irrigation schemes in Ghana is not far-fetched. Irrigated ecology records the highest rice yields because the levels of technology (improved land preparation, improved varieties, fertilizer application and weed control through water management) utilisation are higher than in both rain fed lowland and upland ecologies (MoFA, 2009; and JICA, 2006). Yields of plots of rice under irrigated, upland, and lowland ecologies treated with fertilizer, improved seed and herbicide were reported to be 4.7, 3.0 and 2.0 tons/ha.

Without these inputs the plots recorded yields of 1.2, 0.6 and 1.0 tons/ha respectively (Ragasa, et al., 2013) indicating the superiority of irrigated ecologies among the three rice ecologies in Ghana.

Globally, irrigated farmland accounts for about 17% of the world's farmland, but it supports about 40 % of the world's food production. Irrigated agriculture performs a large role in food security. Productivity from irrigated agriculture is quite high in comparison with rain-fed agriculture (JICA, 2006). Interventions through irrigation projects is in tandem with the assertion that agricultural interventions in areas of chronic emergencies should promote higher productivity (New Partnership for Africa's Development (NEPAD), 2003) Among other strategies, NEPAD recommended three intervention types: small-scale irrigation development including small scale informal irrigation, upgrading and rehabilitation of existing large-scale irrigation systems, and development of new, large-scale schemes.

Ghana has been promoting irrigation development policy since the 1960s through to the 1980s (JICA, 2006) due to annual rainfall variations between 800 and 2400 mm, generally decreasing from south to north and from west to east. This creates unfavourable conditions for sustainable rice production ecologies especially in the North which can be ameliorated through the establishment and maintenance of irrigation facilities for these locations, complemented by the introduction of irrigated technologies to improve agricultural productivity.

Review of Concepts of Study

Agricultural technology and innovation

Several views of what constitute agricultural technology have been expressed in the literature. Jain, Arora, and Raju (2009) defined agricultural technologies to include all kinds of improved techniques and practices which affect the growth and agricultural output. In this study, agricultural technologies included high-yielding varieties of seeds, chemical fertilizers, pesticides, weedicides, and use of machinery. In a similar context, Baumüller (2012) posited that agricultural technologies include physical objects such as seeds and fertilizer, and farming methods. Agricultural technology may be new to a farmer. Such technology is termed as innovation. Innovation is described as ideas, practices, products, services, processes, technologies, policies, equipment, structures, and administrative systems that the adopting unit perceives as new (Rogers, 2003; Ming-Horng & Chieh-Yu, 2011). An innovation is best understood as anything new that is successfully incorporated into social or economic processes (Monge, Hartwich, & Halgin, 2008) Innovation is measured by the passage of time since its first use or discovery. The perception of newness of the idea for the individual determines the reaction and explains different rate of use. Mustonen-Ollila (2014) had earlier described that newness to connote innovation and further described improved methods as innovation only when it is also widely spread in use and perhaps modified to some extent, and/or adapted to better fit the circumstances of the individual.

Technological innovations usually have two components namely the hardware which embodies the tool, product, and the software consisting of knowledge required to use the hardware component (Rogers, 1983; Rogers, 2003).

Adoption and diffusion of innovation

Adoption and diffusion of technologies are distinct but related concepts. The two concepts describe the decision to use (adoption) or to use an innovation by an individual (adoption) and the adoption of an innovation, within a geographical location of a technology among adopting units over time, connotes diffusion. Rogers (2003) differentiated between adoption and diffusion and defined diffusion as aggregate adoption to describe the process of technology communicated through certain channels over time among members of a social system. Four different elements are thus delineated in the concept of diffusion namely: technology, communication channels, time period and social system. This concept of diffusion plays an important role in spreading messages and/or information about the innovation (Rogers, 1983; Rogers, 2003). Risks and uncertainties associated with the innovation (Sunding & Zilberman, 2000; and Rogers, 2003) are reduced through this diffusion communication process. Diffusion as a concept consequently reflects on analysis both at the individual and macro levels (Carr Jr., 2013.; Sunding & Zilberman, 2000; Rogers, 2003). Consequently, individual adoption behaviour may be depicted by more than one variable at the micro level. Adoption behaviour may be described by a discrete choice; using or not using an innovation, or a continuous variable indicating the extent or level a divisible or cluster of innovation is used (Sunding & Zilberman, 2000).

Innovation communication process causes a delay in use of technology between innovation introduction and adoption due to farmer experimentation and learning (Feder et al., 1982). Researchers consequently have shown interest in the concept of adoption and have developed descriptions of what constitute adoption. Technology adoption has been described as a behavioural choice or an innovation decision at a time and space. For instance, innovation adoption has been described as the decision to make full use of the innovation as the best course of action available. The description embodies the mental process an individual undergoes because of the communication process, to eventual innovation adoption (Rogers, 2003). Rogers (2003) mentioned that the individual is usually the unit of analysis, though in recent years, studies have been conducted where organisations have been the unit of analysis.

The characteristic of unit of analysis is attributed to research methods such as using survey to study innovation adoption. Many studies have focused on individual level decisions of adoption. Feder et al. (1982) describe individual farmer level adoption in long-run equilibrium, as the degree of use of a new technology when the farmer has full information about the innovation and its potential benefits.

Adoption of technological innovations in agriculture has attracted considerable attention among development and social scientists because majority of the population of least developed countries (LDCs) derive their livelihood from adoption of improved agricultural production technologies. New technology offers opportunity to substantially increase production and income. However, the introduction of many new technologies has met with only partial success in the rate of innovation adoption.

The rate of adoption of agricultural innovations is however, subject to technology characteristics, socio-economic characteristics of farmers, as well as agricultural policies (Morris, Tripp, & Dankyi, 1999) Rogers (2003) identifies two characteristics of innovations; from the perspective of the farmer, that best explain different adoption rates namely the perceived relative advantage of using the technology vis-à-vis the preceding technology and perceived compatibility with existing values, needs, experiences and culture. Innovations are more likely to be adopted if they are less complex, more compatible and lend themselves to trials and whose outcomes are observable to others. Immediate and uniform adoption of innovations in agriculture is quite rare due to differential adoption behaviour across socio-economic groups and over time. Several factors further constrain rapid and uniform adoption of innovation namely but not exclusively lack of credit, limited access to information, risk aversion, inadequate farm size, inadequate tenure arrangements as well as insufficient human capital, absence of equipment to relieve labour shortages and timely farm operations, chaotic complementary input supply (seeds, chemicals, and water) and inappropriate transportation infrastructure. Sunding and Zilberman (2000) and Rogers (2003) further argue that innovations are usually accompanied by risk/uncertainties with respect to their appropriateness to the farm and their performance culminating in a significant interval between the time an innovation is developed and available in the market, and the time it is widely used or adopted by producers.

Theoretical Framework

The study is guided by three main theories namely rational choice theory, theory of planned behaviour, diffusion of innovation theory.

Theory of planned behaviour

The theory of planned behaviour (TPB) (Figure 1) was put forward by Icek Ajzen in 1998, to predict and explain human behaviour in specific situations. It was proposed to complement the theory of reasoned action (Ajzen, 2006). TPB postulates that attitudes alone are not sufficient to predict human behavour.

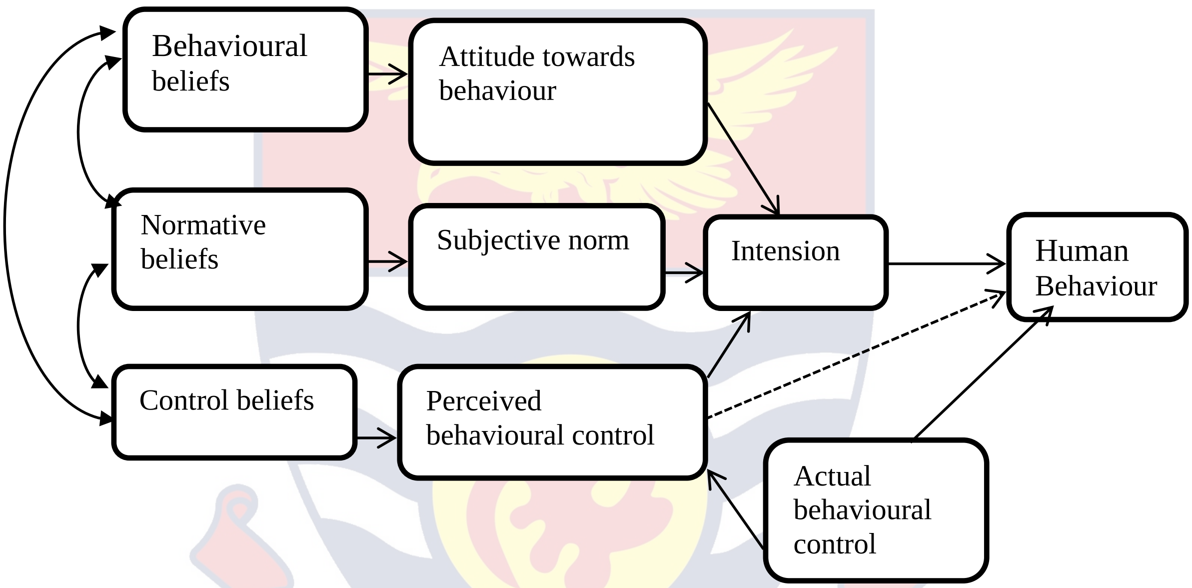

Figure 1: A schematic representation of TPB adopted for the study of irrigated rice technologies adoption in Bontanga irrigation area

Source: (Ajzen, 2006).

Social pressures and the perceived difficulty in implementing the decision or action are equally important considerations in predicting human behaviour. WHO (2008) reported that TPB was effective in evaluating social norms and beliefs in the ability of one to use bednets in Tanzania under the Communication and Malaria Initiative (COMMIT). Similarly, Wayne (2016) reports that the TPB had been applied successfully in predicting and explaining health behaviour and intentions in areas as smoking, drinking, health services utilisation as well as breast feeding. In the study of adopting organic agriculture, Caroline (2006) used TPB to investigate the psychological barriers to organic agriculture adoption using the ordered probit procedure. The results indicated that the model containing the TPB constructs better predicts the intentions to adopt organic agriculture. The theory assumes that behavioural beliefs are influenced by normative and control beliefs which would lead to attitudes towards behaviour. Normative beliefs describe social pressure which is a subjective norm. Control beliefs are about behavioural control which will influence perceived behaviour control. These would result in intention towards adoption behaviour. Actual behaviour can coincide with perceived behaviour control to influence intentions and subsequently human behaviour. The implications of TPB is that, human behaviour such as farmers adoption behaviours is thus influenced by one or more of the factors/determinants namely attitudes, subjective norms, and or perceptions of behavioural control i.e. the presence or otherwise of constrains and motivating factors. Once intentions are made about the intervention(s), human behaviour (adoption) takes place in the direction of the intentions. Stronger intentions for behaviour most likely suggest better performance of behaviour (Doris & Hugh, 2010).

Rational choice theory

Rational choice theory has been applied to understand human choice behaviour. RCT as implied by Kennedy and Sifiso (2013) is an approach in explaining human choices by making certain assumptions about factors that motivate individual actions. The RCT is premised on the fact that every action is fundamentally rational and that all individuals calculate probable costs, benefits and risks of any given action prior to the final decision of whether or not to undertake the choice/behaviour. In the context of the current research, it can be said that researchers are concerned with developing innovations and issuing them to potential clientele (farmers) based on the belief of the superiority of the current innovation to preceding innovations. Farmers on the other hand are interested in the utility to be derived from the adoption of the innovation to address needs and aspirations. Farmers are therefore assumed to be making subjective and/or objective evaluation of technologies in terms of costs, benefits and risks associated with the technologies. These would provide motivation to adopting the technologies or otherwise. The perceived higher net benefits of technology choice options would influence the farmer to adopt the technologies. Farmers make observations and exchange information among themselves to gain knowledge on technologies to minimise technology risks which affect adoption decisions and choices. The theory has gained application in various disciplines (Green, 2002). RCT has been applied to understand human choice behaviour (Kennedy & Sifiso, 2013) and explained that human choices are being made based on certain assumptions about factors that motivate action. RCT has also been used to conceptualise mobile banking choice options in South Africa (Kennedy & Sifiso 2013)

Diffusion of innovation theory

Diffusion of innovations theory is a theory seeks to explain how, why, and rate innovations/technology spread. It has been described as a form of communications in which innovations are communicated through certain channels to members of a social system over time (Rogers, 2003). Diffusion of innovation theory is premised on the assumption that characteristics of technologies, and communication channel used to communicate innovation, characteristics of individual adopters, social networks, needs or perceptions (beliefs) of individual members of the social system over time influence adoption decisions of individual adopters. In reviewing literature on appropriate models for tourism perspectives, Mirjam (2015) concluded that DIT was the most appropriate model for studies on factors influencing businesses to adopt sustainable tourism practices. The influence of technology characteristics on technologies adoption is premised on farmers objective and subjective assessment of the technologies. Technologies that are or perceived to be compatible with farmers culture and practices and have advantage over preceding technologies, receive farmers' favourable adoption attitudes. On the other hand, complex and costly technologies exert negative technology adoption influence. In the context of DIT, communication is the essential factor that sets forth the process/mechanism of technology dissemination.

The use of appropriate communication reduces risks, uncertainties and normalise information disequilibrium inherent in the introduced innovation and exert a positive influence on technology adoption decisions. Farmer social networks play an influencing role in technologies dissemination and adoption decisions through knowledge and information sharing. Interactions with change agents and social networks through appropriate interaction channels would further influence technology adoption behaviours. The interactions within the social system serve as guides for farmers to go through an adoption decision process (Hall & Khan, 2002; Rogers, 1983, 2003). Hart, Ojiabo, Bartholomew, and Emecheta (2015) used technolgy acceptance model (TAM), theory of planned behaviour (TPB) and technology-organisation-environment

(TOE) to study e-commerce adoption by SMEs and reported that the combination of different theoretical models helps explain better and provide better insight into how firms adopt e-commerce.

The constructs in RCT, TPB, and DIT are complementary to one another rather than being mutually exclusive. It is important to note that in these theories, the individual is the unit of adoption behaviour subject to objective and subjective evaluation of the innovation complemented by farmer characteristics and social communication networks.

Empirical Review

This section presents literature regarding thematic areas covered by the study: innovation adoption and related components and the variables of the study as reported in literature. A common weakness in adoption studies is the tendency to consider innovation adoption in dichotomous terms (adoption/non adoption) even though the actual decisions made by farmers are defined over a continuous range (e.g., quantity of fertilizers used). Another aspect where progress can be made is the simultaneous nature of many of the decisions on adoption when, a package of new practices is promoted. Such a situation requires appropriate analytical tools (Feder et al., 1982) based on the type of adoption measurement adopted. Attention to adoption measurement is therefore an important aspect for this study.

Measurement of adoption of technology complex

For several decades of diffusion studies, the assumption was that innovation was an invariant quality and did not change as it diffused. Rogers (2003) however, indicates that was not entirely the case but rather potential adopters either rejected the innovation, discontinued earlier adoptions or modified the innovation as influenced by socio-economic, financial, risks and uncertainties associated with innovations as well as farmers' perceptions and attitudes towards the innovations.

The modification phenomenon spawned the concept of reinvention: the degree to which an innovation is changed or modified by a user in the process of its adoption and implementation. Reinvention is usually measured as the degree to which an individual's use of the new idea departs from the mainline version of the innovation originally promoted or introduced. In light of this scenario, an innovation may either be adopted as introduced or modified to suit potential adopters' needs and/or context (reinvention) (Abbott & Yarbrough, 1999; and Rogers, 2003).

Farmers' adoption decision has been measured as a binary or dichotomous function; adopted or not adopted (0 or 1) for single innovations as used in (Chiputwa, Langintuo, and Wall, 2011; Adesina & Baidu-Forson, 1999; Langintuo and Mekuria, 2008, Baffoe-Asare, Danquah, & Annor-Frimpong, 2013). In this context, Doss (2006) indicates that, who an adopter is or what constitutes adoption becomes a complicated question without an obvious correct answer. The adoption of a single technology without due consideration to other technologies can be measured by the proportion of cropped area applied with that technology (Feder et al., 1982).

For multiple or cluster of innovations or multiple seed varieties, adoption decision is measured as the proportion of innovations adopted or otherwise. The adopting units are thus categorised into groups as none, low, medium, high or very high adopters or levels (Jain, Arora, & Raju, 2009;

Doss, 2006). The process is referred to as adoption index; an aggregation or collapsing of different dimensions of agricultural technologies (Doss, 2006; and Jain et al., 2009).

The nature of adoption measurement determines the selection and use of the analytical procedure. Various researchers thus define adoption to suit objectives of the study. In some instances, adoption is considered as discrete (0 or 1); in other words, the adopting unit either adopts or rejects the innovation (Abbott & Yarbrough, 1999; Feder et al., 1982). Treating adoption responses in such simple dichotomous fashion is only applicable to single technology adoption studies. For multiple technologies, adoption is considered as a continuum, occurring in proportions of technologies adopted. The outcome variable (adoption), measured in proportions or percent can thus be categorised into levels of adoption along the continuum according to their differing levels and/or intensities of use of the technologies as the researcher may prefer (Abbott et al., 1999; and Feder et al., 1982).

Adoption responses can then be assessed by categorising respondents into levels of adoption units based on the number or proportion of technologies components adopted. Adopting units are then categorised into none, low, medium, high and/or very high adoption levels according to researchers' objectives. Even then, researchers differ in the levels of measurement with some treating the measurement as nominal while others consider adoption levels as ordinal scales. However, the ordinal scale represents crude measurement of an underlying interval/ratio scale; levels, proportions and intensities of use measurement. The different modes of measurements impose equally different empirical analytical tools such as Ordered Logit analytical models (Das & Rahman, 2011).

Analytical procedures

Different statistical methods have been used in the literature to analyse agricultural technology adoption. These methods include general linear regression, binary logistic model, ordinal logistic model (Das & Rahman, 2011), and multinomial logistic model. Modified forms of regression models such as linear, logistic, tobit, probit and ordinal regression methods as well as correlation and chi-square, are useful for analysing the relationship between multiple explanatory variables (Chiputwa, Langintuo, & Wall, 2011). When the dependent variable is bi-variate categorical (0 or 1), the probit or logit models are used to determine variables that statistically explain adoption decisions (Chiputwa et al., 2011; Adesina & Baidu-Forson, 1985; Langintou & Mekuria, 2008). These methods permit researchers to estimate the magnitude or probability of the effect of the explanatory variables on the dichotomous categorical outcome variable (Agresti & Finlay, 1997; Field, 2005; Gravetter & Forzano, 2009). For instance, the tobit models have been used in adoption studies as in (Ojiako, 2011; Adesina & Zinnah, 1993; Baffoe-Asare et al., 2013; Mensah, 2008; Setsoafia, Sarpong, & Kwadzo, 2013; Fernandz-Cornejo, Daberkow, & McBride, 2001) to describe and explain respondents' adoption decisions. The logit model has also been used by adoption researchers (Wandji et al., 2012) to identify and explain technology adoption decisions.

Chiputwa et al., (2011) used the censored tobit procedure to assess the factors influencing adoption and use of conservation agriculture in the

Mashonal of Zimbabwe while Wandji et al. (2012) applied the logit procedure in analysing the perceptions and adoption of New Aquaculture technologies in the western high lands of Cameroon. Similarly, Baffoe-Asare et al. (2013) studied the socio-economic factors influencing adoption of Codapec and cocoa High-tech technologies among small holder farmers in the Central Region of Ghana. Following, the ordered categorical measurement applied for this study, ordinal logistic regression analytical procedure has been adopted (Doss, 2006).

Regression analysis specifies the level and direction of influence of an explanatory variable and the physical potentials of the technological innovations on farmers' decision to adopt improved technologies and intensity of use of those technologies (Saka, Okoruwa, Lawal, & Ajijola, 2005; Agresti & Finlay, 1997). The logit model has been used by several adoption researchers to identify factors influencing farmers' adoption decisions as to whether to adopt agricultural technologies (Saka et al., 2005)

Ordinal logistic regression model

The ordinal logistic model is one of many models subsumed under the rubric of generalized linear models for ordinal dependent variables. The model assumes that there is a latent continuous outcome variable and that the observed ordinal outcome arises from discretizing the underlying continuum into a determined ordered groups/threshold which estimate these cut-off values. Ordinal logistic regression is a very useful and powerful method for adoption classification (Yay & Akinci, 2009; Das & Rahman, 2011).

Compared to the other regression methods used in the literature, the ordinal logistic regression method is the most suitable and practical technique for analysing the effects of multiple explanatory variables on the ordinal outcome that cannot be assumed to be a continuous measure with normal distribution (Yay & Akinci, 2009; Agresti & Finlay, 1997; and National Centre for Research Methods (NCRM), 2016). Ordinal regression model/procedure is suitable for the outcome variable that is categorical, ordered and not an interval/ratio scale measurement. It has the advantage of preserving the ordinality of the outcome variable (Agresti & Finlay, 1997; Field, 2005 and Yay & Akinci, 2009). The ordinal regression model is adopted to analyse multiple irrigated rice farmers' technologies adoption behaviour. For multiple technologies adoption studies, it is inappropriate to treat adoption on a binary scale as valuable information would be lost and also producing overwhelming number of results, for each technology under the study (Agresti & Finlay, 1997; Field, 2005). The same logistic model can be written in different ways. The version that shows what function of the probabilities results in a linear combination of multiple parameters is:

$$\ln\left[\frac{\text{prob(event)}}{(1-\text{prob(event)})}\right] = \beta 0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 \text{ .... } + \beta_k X_k \quad \text{............} \quad \textbf{(1)}$$

The quantity to the left of the equal sign is called a Logit: the cumulative log of the odds that an event occurs. The odds that an event occurs, is the ratio of the probability that the event occurs and the probability that the event does not occur. The coefficients (β_i) in the logistic regression model indicate how much the Logit changes based on the values of the predictor variables (x_i). In ordinal logistic regression, the event of interest is observing cumulative odds for a particular score or less (Shapiro, 2005). However, it is important to assess the model fitness before establishing the contributions of the predictor variables.

Model assessment

It is important to determine how well the model generally fits the data by observing the difference or change in the -2log likelihood chi-square statistics of the base and final models. An observed significance level would suggest a good model. The implication then is that the null hypothesis that the base model is as good as the final is not plausible. The Pearson and Deviance chi-squares are also important in assessing the goodness of fit of the model. These are good or reliable statistics when there are no cells with zeros (0) or when there are fewer cells with non-zero frequencies. The chi-square statistics need to be non-significant for the model to be reliable otherwise the model does not fit well.

The ordinal logistic regression model assumes equal or the same regression coefficients for all the outcome categories. A non-significance level of the chi-square statistic suggests that coefficients are the same: there is no evidence to reject the proportional odds (parallelism) hypothesis (Field, 2005; Shapiro, 2005).

The pseudo R-square (R^2) statistics (Cox & Snell, Nagelkerke and McFadden), are the coefficient of determination, used to determine the strength of association. These are interpreted as the proportion of the variation in the dependent variable that is explained by variation in the independent variables. Pseudo R^2 ranges from 0 to 1: the closer to 1 it is, the better the independent variable has explained the variation in the dependant variable (Field, 2005; Shapiro, 2005).

Factors Influencing Innovation Adoption

This section presents reviews on the influence of these factors on farmer innovation adoption decisions. Literature has cited several factors as moderators of farmers' innovation adoption (Rogers, 2003; Abbott & Yarbrough, 1999; Adesina & Baidu-Forson, 1985; Wejnert, 2002; Mengistu, 2012; Wejnert, 2002; Baffoe-Asare et al., 2013). Several specific variables have been identified and discussed as determinants of or factors influencing the adoption-decision process (Feder, Just and Zilberman 1982; Feder and O'Mara, 1981; Mamudu, Emelia, and Samuel, 2012; Boedalo, Gennaiolo, and Shleifer, 2010; Ekoja, 2004; Sakurai, 2002). Generally, commonly cited factors in the studies included water source, acreage of lowland area, distance from village centre to lowland, access to village, land ownership, experience, age, sex, education/schooling, family size, occupation, operational land holding, farm size (herd size), income from piggery, social participation, extension contact, farming experience, farm education exposure, scientific orientation, knowledge, training received, and financial help received. These factors are classified into three thematic groups namely demographic charateristics such as age, gender, experience, education, household characteristics etc, socio-economic chracteristics including societal entity such as participation, familiarity with the innovation, status characteristics, position in social as well as tenural arrangements and environmental context include geographical settings, societal culture, political conditions, soil and climatic conditions.

Further Feder et al., (1985), in reviewing adoption of agricultural innovations in developing countries, cited constraints to the rapid innovation adoption to include lack of credit, limited access to information, aversion to risk, inadequate farm size, inadequate incentives associated with farm tenure arrangements, insufficient human capital, absence of equipment to relieve labour shortages, chaotic supply of complementary inputs (seed, chemicals, water etc.), and inappropriate transportation infrastructure. These variables are time invariant or predetermined at the time of the investment (Sakurai, 2002). The study classifies determiners of innovation adoption as farmer, technologies, capital, social and environmental related characteristics (Table 3).

Farmer Related Factors

Gender

Gender connotes the sex of the respondents and farmers' responses were sought on whether they adopt irrigated rice technologies because of their sex. In their studies (Akpan et al., 2012; Vidogbena et al., 2012; Sakurai, 2002) posited that male farmers are more likely to adopt agricultural technologies than female farmers. Akpan et al. (2012) further posits that the coefficient of gender is significant and positively related to fertilizer use intensity indicating that male farmers are more likely to increase fertilizer use intensity compared to their female folks. This assertion conflicts with (Baete, 2012) who asserts that gender does not influence farmers' decision to adopt rice technologies in the village of Fiu of the Malaita province. Further, Djokoto & Blackie (2014), using the probit model found gender to be positive and significantly related to mechanised harvesting technology adoption. The results show that men were more likely to adopt mechanised harvesting technology on the Kpong irrigation project in Ghana than their counterpart women.

Age

Evidence from literature on the influence of age of the farmer in explaining technology adoption is controversial. The age of the farmer has the tendency to either increase or decrease the probability of technology adoption; older farmers may have gathered much more experience that allows them to adopt improved technologies (Kalineza, Mdoe, & Mlozi, 1999), while younger ones may be risk-averse and more flexible in their adoption behaviour hence are less prone to adopting improved technologies (Kalineza et al., 1999; Mamudu, Emelia, & Samuel, 2012). The age of farmers is however, incorporated as it is believed that with age, farmers accumulate more personal human capital, hence, show a greater likelihood of investing in innovations (Mamudu et al., 2012). Sakurai (2002), in a paper presented at the Workshop on the Green Revolution in Asia and its transferability to Africa, posits that younger male farmers are more likely to adopt modern varieties. In a study of fertilizer use intensity among small holder crop farmers in Abak Agricultural Zone in Akwa Ibom State of Nigeria, Akpan et al., (2012) report that age and education of small holder arable crop farmers are positive determinants of fertilizer use intensity. Age, however, is not consistent as an influencing factor in the literature of adoption studies. Results showed that it was less likely for an older farmer to adopt conservation agriculture (CA) than a relatively younger one (Nyanga, 2012). In their assessment of the influence of neighbourhood effects on the adoption of improved agricultural technologies in developing agriculture Langintuo and Mekuria, (2008) reiterated that older farmers are less willing to adopt improved maize varieties. In a similar fashion Saka, Okoruwa, Lawal, and Ajijola, (2005) found a significant negative impact of age on farmers' adoption of improved rice seed technology. In contrast, Baete (2012) indicated that age is not an influencing factor of farmers' decision to adopt rice technologies though farmers above 65 years adopted the rice technologies. Similarly, in the Kpong Irrigation Project in Ghana, age was reported to have a non-significant negative influence on mechanised harvesting technology adoption (Djokoto & Blackie, 2014).

Household size

This refers to the number of people in the house and is postulated to be two pronked in its effect on the farm family: one of it serves as a source of household farm labour and also a presure source of feeding the farm family hence a motivtaion to increase production through rice irrigated production technology adoption. In their conference paper on factors influencing adoption of soil conservation technologies (Kalineza et al., 1999) indicates that the number of adults who can work in the farm is an indication of the availability of labour for soil conservation technology. Though their results showed positive relationships, the influence of adults was insignificant. Corroborating wth this findings (Djokoto & Blackie, 2014) posit that household size was a negative sinificant determinant of mechanised harvesting technology. Contrary to this assertion, Akpan et al., (2012) report that increase in farmer's family size decrease the fertilizer use intensity in the study area. In their study, Langintuo and Mekuria (2008) report that one of the most important determinants of cultivated farm sizes in Mozambique was unavailability of family labour-force. Furthermore, Feder et al., (1985) emphasised this phenomenon in indicating that new technologies may increase the seasonal demand of labour so that adoption is less attractive for those with limited family labour or those operating in areas with less access to labour markets. This hypothesis is to positively influence rice irrigated technologies.

Number of women in the household

Women usually complement the efforts of men in farming especially in rice production; adult men in the localities are known to be polygamous and stand to benefit from their labour support. Ojiako (2011), in his study, indicates that the number of adult women in the household had positive significant relationship with adoption and use intensity of soybean technology. The number of women in the house would be a proxy for household labour availability.

Maritals status

Marital status is assessed in relation to the benefit of increased labour availability for irrigated rice technologies adoption as well as increased responsibilities on the farmer for household sustainabilities. Both scenarios should spur the farmer in favour of technologies adoption. Using the probit technique, (Denkyirah et al., 2016) reported that marital status had a significant influence on access to credit in the Tolon Ditrict of Ghana. This however, contradicts the findings of Ayoola (2012) which indicates that marital status did not influence yam miniset technology adoption in the Kogi and Benue States of Nigeria.

Education

Farmers with high education are typically assumed to be better able to access, process and use information and search for appropriate technologies to alleviate their production constraints. This is due to the view that, education gives farmers the ability to perceive, interpret and respond to new information much faster than their colleagues who are without/low education (Mensah, 2008; Kalineza et al., 1999). In Ghana, low literacy rates, especially in the northern part where the majority of farmers are illiterate and the average number of years of schooling of the household head is correspondingly low; adversely affect technology adoption and utilisation (Ministry of Food and agriculture (MOFA), 2009). Using the multivariate regression analysis, Akpan, et al. (2012) indicate that education of small holder arable crop farmers is a positive determinant of fertilizer use intensity, implying that fertilizer use intensity increases with the age and education of farmers. Results from Mensah's (2008) study also showed that the level of education has a significant positive relationship with the adoption of Roundup Ready soybeans. Saka et al. (2005), in their investigation, also found a significant positive ($p = 0.05$) influence of education on the adoption of improved rice varieties. In assessing harvesting technology adoption on the Kpong Irrigation Project, farmers' level of education was reported to be a positive and significant determinant of mechanised harvesting technology adoption (Djokoto & Blackie, 2014). On the contrary, Baete (2012) found that education did not influence rice technology adoption. The expected sign on the coefficient on education is hypothesised to be positive.

Experience of the farmer

Experience is the number of years the farmer has been involved in irrigated rice farming activities. This is expected to increase human capital (Mensah, 2008) of the specific farmer and his/her knowledge and capacity to effect changes that enure to his/her benefit. Experience can allow the operator to gain better management skills to handle new technology as opposed to a novice. Experience of the farmer has been found to have a significant positive effect on adoption of agricultural technologies (Baffoe-Asare et al., 2013; Mensah, 2008). The most important farmers' personal characteristic influencing rice technologies adoption in Fiu is farmers' experience with an earlier Japanese funded community rice project (Baete, 2012). Non-adopters of the same project also indicated that their experience with earlier rice projects influenced their decision not to adopt the rice technologies. This indicates that experience can either influence adoptions positively or negatively depending on the disposition of the individual farmers or adopting unit. However, Djokoto & Blackie (2014) reported experience to be positive but a non-significant determinant of mechanised harvesting technology.

Technology Related Factors

Characteristics of innovations

There have been notions that suggest that technological innovations are invariant, hence uniform adoption and adoption rates. This assertion is an oversimplification of the innovation adoption phenomenon. Different innovations have different attributes which help explain their different rates of adoption (Rogers, 2003).

Adoption is described as a decision to make full use of an innovation or technology as the best course of action available as influenced by the attributes of the innovation (Rogers, 2003). He stressed that the process of assessing the attributes of the innovation requires a great mental effort by the farmers before they could decide, on whether to accept/reject the innovation. The farmer is though not certain about the profitability of the technology. In a study of SMEs innovation adoption, Ming-Horng and Chieh-Yu (2011) found that complexity, compatibility, and benefits of green innovations will affect the adoption behaviour. SMEs will be more likely to adopt a green innovation when they perceive that the green innovation is simple and easy to learn and use, compatible to their existing business operations, and helpful for improving environmental and economic performance. Some selected technology attributes are discussed in relation to irrigated rice technologies adoption in the ensuing sections.

Relative advantage

Relative advantage is the degree to which an innovation is perceived as better than the idea it supersedes. Though it may be measured in economic terms, social prestige, convenience and satisfaction (cost benefit relationships) are also important factors. One of the most important factors influencing the farmers' adoption decisions is the yield of the improved seed crop over the traditional variety (Langintuo & Mekuria, 2008). In a similar study of the factors affecting rice adoption in the Solomon Islands, Baete (2012) found that only relative advantage (perceived improvement in food security, high yielding and early maturing, perceived improvement in income, palatability and convenience (in cooking) to be the influencing factors of farmers' adoption decisions.

Prior to the adoption of new technology by an individual farmer, he/she will follow an adoption process like awareness, interest, evaluation, trial and adoption. For an innovation to be acceptable to the farmers, it must be economically profitable, socially acceptable, and technologically observable (Rogers, 2003). Thus, the technologies must supersede the preceding technology in benefits or advantage.

Higher crop yield exhibited over conventional varieties has featured as one of the relative advantages of improved varieties. Crop yield according to Langintuo and Mekuria, (2008) is one of the most important factors determining farmers' decision to adopt improved varieties of crops as the farmers subjectively appraise the seed technology. Crop yield in assessing adoption is interpreted as a revenue function and in combination with inputs price (seed, fertilizer, labour, pests, and disease resistance) may be random variables and their uncertainty may affect technologies choices (Feder et al., 1982). The attributes of disease and pest resistance of a crop variety improve the quality of the crop. In their study of adoption of improved rice varieties of small-holder farmers, Saka et al., (2005) posit that the intensity of use (adoption rate) is significantly influenced positively by the yield rating of the improved rice variety. Similarly, in studying farmers' perceptions about improved sorghum and mangroove rice varieties in Burkina Faso and Guinea on its adoption, Adesina and Baidu-Forson (1985) found that yield performance of improved sorghum variety significantly influenced adoption positively at the 5% level.

Complexity

Complexity is the degree to which an innovation is perceived as difficult to understand and use. Some innovations are relatively easy to understand by most members of the social system while others are more complicated to understand and this influences adoption decision. The more complex an innovation is, the more negatively it influences adoption decision of the adopting unit (Rogers, 2003).

Compatibility

Technology compatibility connotes the harmonious interplay between technology and the farmers' knowledge base, practices, and culture. The more compatible an innovation, the more likely farmers would adopt the innovation and the higher the rate of adoption (Rogers, 2003). Comparably, Baete (2012) found that farmers failed to adopt indicating that the irrigated rice technology was not compatible with their system of farming.

Cost of technologies

Total expenditure incured on adopting irrigated rice production technologies made up of the cost due to the various components of the technologies: labour, improved seed, transplanting, land preparation, equipment etc represent the cost of the technology. Mensah (2008) found that there was highly significant (1%) negative impact of the total cost of the cultivation of Roundup Ready soybeans varieties on the adoption of Roundup Ready soybeans.

Resources Related Factors

Access to credit

Constrained access to credit figures prominently among the often cited reasons why technology fails to diffuse (Feder et al., 1982). Feder et al. (1982) further posits that constraints to the rapid adoption of innovations involves factors such as lack of credit, limited access to information, aversion to risk, inadequate farm size, inadequate incentives associated with farm tenure arrangements, insufficient human capital, absence of equipment to relieve labour shortages, chaotic supply of complementary inputs (seed, chemicals, water etc.), and inappropriate transportation infrastructure. Differential access to credit or capital is often cited (Nyanga, 2012; Michael, Robert, & Dankyi, 1999) as a factor in differential rates of technology adoption. This seems to be particularly true in indivisible or lumpy technologies such as machinery (Feder et al., 1982).

At the same time, a number of studies have found that lack of credit does significantly limit adoption of high yielding varieties. The lack of sufficient accumulated savings by smallholder farmers may prevent them from having the necessary capital for investing in new technologies. According to Langintuo and Mekuria (2008), cash is required to purchase seed and complementary inputs. They further aserts that moving a farmer with no access to credit to a position of access to credit has the potential of increasing the adoption rate and intensity of use of improved maize varieties by 24%.

However, insignificant negative impact of access to credit was reported by Saka et al. (2005) in their investigation of factors influencing small-holder farmers' adoption of improved rice varieties. Feder et al. (1982) however, posit that the effect of credit is not that simply concluded. In their work; adoption of agricultural innovations in developing countries, they indicate that in technology mixes, the adoption of each component ties up cash resources with the effect that policies that enhance the adoption of one component may retard the adoption of the other when dealing with dynamic adoption models.

Static models of single innovations indicate that increased credit/cash positively affects adoption hence adoption will increase over time. However, for cases of packages of innovations, the pattern of adoption is not clear-cut and is a function of the degree of complementarity of the innovations. In this light, Akpan et al. (2012), using the double-hurdle estimation technique, on a single technology (fertilizer) found access to credit to have a significant negative influence on fertilizer techonology adoption.

Access to labour

This reflects extent of labour availability and whether farmers can pay for the expenses of available labour. Ojiako (2011) reported in his study of the socio-economic stratification on adoption and use intensity of soybean technology that labour expenses had a significant positive effect on adoption behaviour of the rich class. Access to labour is relevant for labour intensive technologies as rice seed nursing, transplanting, and harvesting. Affholder, Jourdain, Quang, Tuong, and Morize (2009) in a study on constraints to farmers' adoption of direct-seeding mulch-based cropping systems: a farm scale modelling approach applied to the mountainous slopes of Vietnam, reported that together with cash, labour availability limited the adoption of direct-seeding mulch-based agricultural systems. Labour requirement limited the adoption of the technologies through extra labour required for establishing the mulch layer. Access to labour is expected to have a positive influence on irrigated rice technologies adoption behaviour.

Land availability

In the case of Uganda, with entrenched overlapping and relatively unsecure property land rights, Deininger & Ayalew (2008) indicate that availability of land alone may not spur agricultural technology adoption. Furthermore, even in countries with secure property rights but poorly developed financial markets, land availability may not reduce the credit constraint and thus may not necessarily influence adoption. In order to address the liquidity and supply constraints faced by poor farmers with regard to technology adoption, a number of African countries have implemented various forms of 'smart subsidies' that target specific farmers (Minde et al. 2008)

One of the most highlighted constraints to agricultural technology adoption is the inadequate availability of cultivable land (De Janvry, Dustan, and Sadoulet, 2011; Carletto, et al., 2007; Pingali et al., 2008). It is argued that availability of land helps reduce the liquidity constraints faced by households and reduces risk aversion. On the other hand, ownership of large tracts of land, can facilitate experimentation with new agricultural technologies, and determine the pace of adoption as large landowners are more likely to be the early adopters (de Janvry et al., 2011). On the other hand, the limited availability of land may spur the use of organic fertilizers in a poor resource setting (Kasirye, 2013; Pingali et al., 2008).

Social Factors

Leadership effects

This section discusses the influences of leadership characteristics namely household head, community leader, farmers group/organisation leadership on irrigated rice technologies adoption decisions.

Household head

Household head connotes being the leader of a household or family which specifies who is the main decision maker of the household or has the responsibility of taking major decisions concerning the household and household farm operations. The decision domain includes social and business (agriculture and related) decisions. The leader takes decisions as to whether or not innovations should be incorporated into the farming practices of the household and thus influences the adoption decisions of the household.

Community leader/status in community

Being a leader of a community confers social status on a person in the community or village. Community leaders are main decision makers of the village and under appropriate community entry practices are one of the first people to be informed about a new technology coming into the village for the first time. Their decision to welcome the introduction and subsequent use of the technology influences other members' use of the technology. Their access to first hand information and being the first to receive information from the source of introducers is expected to influence their adoption of the technology. In their work in Burkina Faso on farmers perceptions and adoption of new agricultural techologies, (Adesina & Baidu-Forson, 1985) report that being a village head was negatively related to technology adoption though insignificantly so. Not only are the technical knowledge levels and skills of the leaders important factors influencing technologies adoption but also the trust members of a group, cooperative or society have about the leadership (Baete, 2012).

Group leader

Group or cooperative leadership is used to achieve same or similar farmers' learning or influence as was envisaged for contact farmers under the T/V system of extension. Their influence on technology adoption is a function of their technical knowledge, skills and attitudes towards the technology and members of the group or cooperative. For instance, the irrigated rice farmers of the Malaita province of the Solomon Islands discontinued the use of the rice technologies because the Leadership of the Farmers cooperatives/groups lacked the requisite technical knowledge and skills in the areas of fertilizer management, pest and disease management as well as small machinery maintenance (Baete, 2012).

Membership of farmers' organisation

Membership to an agricultural organisation by a farmer has served as a source of information and knowledge about agricultural technologies. Farmers within a group learn from each other how to grow and market new crop varieties (Nyanga, 2012). The evidence suggests that network effects are important for individual decisions, and in the context of agricultural innovations, farmers share information and learn from each other (Nyanga, 2012; Langintuo and Mekuria, 2008). In a study of the influence of neighbourhood effects on the adoption of improved agricultural technologies in developing agriculture, (Langintuo & Mekuria, 2008) observed that adoption rates will be enhanced if farmers belong to farmers' organisation. The probability of getting a farmer to adopt an improved, high yielding maize variety will increase by 10%, if the farmer joins an association. One potential benefit farmers derive from joining associations is the sharing of information. Farmers who have adopted the new varieties share their experiences with their colleagues, which in turn allow non-adopters to better inform their decisions on whether to adopt.

Emphasising on the importance of social networks on farmers' adoption decisions, Saka et al. (2005) found that being a member of farmers' association had a positive significant ($p = 0.05$) influence on farmers' level of adoption of improved rice varieties. Using the double-hurdle estimation method however, Asfaw, Shiferaw, Simtowe, and Hagos (2011) found that being a member of a farmers' association had no relationship with fertilizer technology adoption. The expected sign on the coefficient on membership in an agricultural association is hypothesised to be positive.

Tenurial Arrangement

This specifies landownership and rental arrangement of the farmer which allows the farmer control or otherwise of the amount of land being cultivated. Though tenurial arrangements may play an important role in the adoption decision, the subject is of considerable controversy. For instance, a landlord's double role as a credit provider and as a landowner; a common practice in India, creates a situation in which the landlord may not permit adoption of yield-increasing innovations, because adoption will reduce the tenants' indebtedness to the landlord due to positive benefits emanating from technologies adoption. Furthermore, the income from lending will decline more than the output share will increase since the tenant will no longer require credit (Feder et al., 1982). Land tenure in the study of Ntege-Nanyeenya et al. (1997) was found to have a positive and significant relationship with adoption of maize production technologies in Iganga District of Uganda at the 10% significance level.

Institutional support

Support to farmers come in the form of extension education and training, credit and input supplies as well as farmers' network establishments. Organisational support, quality of human resources, government support as well as regulatory pressure and non-governmental organisations' support influence adoption positively if farmers perceive the support to be satisfactory (Rogers, 2003).

Extension services

Extension service delivery to farmers of the Bontanga irrigation project area was provided by MoFA personnel, irrigation farmers' organisation, and Non-governmental organisations. Extension service provision reflects access to extension services to the adopting unit and has been found to have a significantly positive effect on adoption of agricultural technologies (Ojiako, 2011; Langintuo & Mekuria, 2008). Extension contact serves as sources of information; through innovation-diffusion theory and creates awareness of technologies to farmers. Several literature sources on technology adoption, show that extension contact stimulates farmers' adoption of agricultural technologies (Nyanga, 2012; Michael et al., (1999; Langintuo & Mekuria, 2008). For instance, Langintou and Mekuria (2008) observed a positive relationship between extension contact and adoption of improved maize varieties in Mozambique. In their study of factors influencing adoption of CODAPEC and Cocoa High-Tech technologies among farmers, Baffoe-Asare et al. (2013) also reported significantly positive relationship between extension training and adoption of CODAPEC and cocoa High-tech technologies.

Similarly, frequency of extension contact had a significant positive impact on small-holder rice farmers' decision to adopt improved rice varieties (Saka et al., (2005). Per the results presented by Kalineza et al. (1999), extension contact, through awareness creation on soil conservation technologies, had positively significant influence on all three technologies; contour ridging, tree planting, and farmyard manure technologies analysed separately. Visits by extension agents had a positively insignificant relationship with adoption of improved sorghum variety seed (Adesina & Baidu-Forson, 1985).

Actual access, perceived access and/or availability of extension services, positively influence farmers' decision to adopt rice technologies. For instance, in the case of the Fiu village farmers, the rice project was sited within the Malaita Provincial Agricultural Division. The adoption decision of farmers was thus influenced by the perceived good access to extension services which influenced their adoption decisions (Baete, 2012). Furthermore, farmers felt later that the project implementation extension services officer only paid lip services and failed to deliver on promises which eventually led to farmers discontinuing the use of the technologies. A poor extension services would negate the adoption decisions of rice farmers.

Participation in training

Farmers' participation in training describes the involvement of farmers in educational training activities with respect to specific technologies to improve farmers' knowledge and skills, through capacity building of the farmers. The purpose usually is to improve farmers' decisions making processes to adopt agricultural innovations. Participation in training is expected to have a positive impact on farmers' adoption decisions. Participation in intervention programme training was reported to have a significant positive influence on farmers' adoption of improved rice varieties (Saka et al., (2005) in assessment of factors influencing small farmers' adoption of improved rice varieties. This was also found to have highly significant positive influence ($p = 0.01$) on the probability of farmers to adopt CODAPEC and Cocoa High-Tech technologies (Baffoe-Asare et al., (2013). This is consistent with Adesina and Baidu-Forson, (1985) who reported a positive significant ($p = 0.05$) relationship of extension related workshops with adoption while assessing farmers' perceptions on adoption of improved sorghum in Burkina Faso using the tobit model.

Access to credit

Credit has been shown to influence technology adoption especially for smallholder farmers who do not have sufficient funds to run their farm operations. Literature indicates that credit availability can either positively or negatively influence technology adoption. For instance, Akpan et al. (2012), using the multivariate regression model based on ordinary least squares, found the coefficient of access to credit to be negative and non-significantly related to fertilizer use intensity in Nigeria.

Price of inputs

The price of inputs required for implementing a technology influences the adoption decision of the implementing unit/farmer. Theoretically, the assumption is that the higher the price of inputs, the lower the levels of technology adoption of farmers and vice versa. Affholder et al. (2009) showed that extra input requirement/price (nitrogen fertilizer, pesticides and mucuna seeds) was one of the factors preventing the use of direct-seeding mulch technology in Vietnam.

Environmental factors

Environmental factors connote weather and soil conditions as experienced by farmers in farm environments. These factors play on farm yields and cost of inputs. These influence farm productivity and thus moderate farmer adoption decisions. The ensuing literature discusses effects of environmental factors on farmer technology adoption.

Quality of farm environment

Feder et al. (1982) in their review indicate that the likelihood of technology adoption increasing, the better the physical environment of the farm. A more favourable environment (better soil and water availability) increases the expected utility of income from modern production and, hence, increases the probability that a farmer will adopt the new technology.

Quality of land (good soil)

The quality of land may be a major factor in deciding the use of key inputs such as chemical fertilizers or adopting improved crop varieties due to expected higher returns (Kasirye, 2013; Carletto et al., 2007). In the Fiu village of Malaita Province of Solomon Islands, farmers' rice technology adoption decision was heavily influenced by the quality of land hosting their fields due to deposits of alluvial soils through flooding. This resulted to a very fertile soil with a concomitant increased yield for farmers' rice crops (Baete, 2012).

Conduciveness of weather conditions

Suitability of agro-climatic conditions of a location or area influences farmers' decision to adopt (rice) agro-technologies. Five of this has been identified as soil quality, rainfall, sunshine, and temperature. Farmers who had training on the relevance/importance of temperature on crop production adopted the technologies (Baete, (2012).

Constraints to Adoption

These are factors, policies, infrastructure and institutional, the absence or lack of which limit the ability of adopting units; farmers, to adopt/practise technological innovations. In their study of Constraints to Adoption of Agricultural Innovations among Women Farmers in the Isokan Local Government Area, Osun State, Ayoade and Akintonde (2012), identified constraints to adoption to include failure of extension workers to reach women, lack of incentive for adoption of innovation, limited access to credit and inputs as well as lack of access to membership in cooperatives and other rural organizations.

Conceptual Framework of Technologies Adoption

This section presents a graphical (Fig 2) and narrative guide of the key elements of the study. This includes the concept of adoption, factors and variables of the study and how they connect and or influence irrigated rice technologies adoption.

Rogers (1983) and Rogers (2003) describe an innovation as an idea, practice or object that is perceived as new by an individual or other unit of adoption. Similarly, Sunding and Zilberman (2000), define an innovation as new methods, customs, practices, or devices used to perform new tasks. The introduction and implementation of the technologies are aimed at changing behaviours, knowledge, skills, attitudes, and aspirations of adopting or implementing units to positively impact on livelihoods of the adopting units. Agricultural technologies are introduced in packages that included several components, viz. improved seed variety with appropriate fertilizer application, transplanted rice technology with appropriate field preparation practices etc.

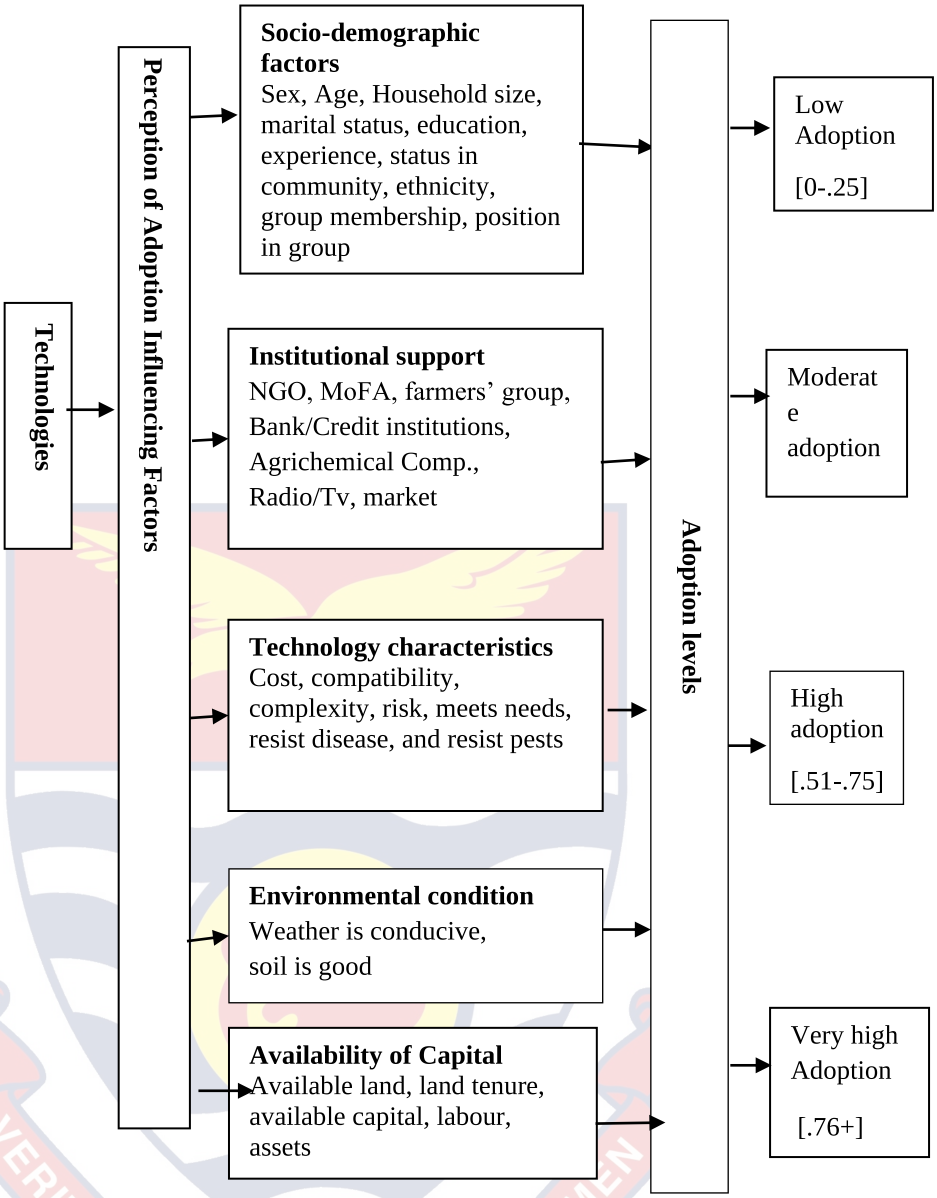

Figure 2- Conceptual Framework of Technologies Adoption.
Source: Author's construct, Seini (2013)

Technologies

In tune with the introduction of agricultural innovations, four clusters of technologies were introduced concurrently on the Bontanga irrigation project area namely:

1. Production (transplanting, ploughing, harrowing, levelling, flooding, and seedling nursing, as well as transplanting immediately after field preparation)

2. Fertilizer (4bags (200kg) compound fertilizer/acre immediately after planting, 2bags (100kg) nitrogen fertilizer/acre 3-4 weeks after planting).
3. Use of improved seed varieties.
4. IPM technologies (Intermittent field flooding and drainage).

The implementation or use of the package of innovations achieves the objective of improved production, yield, and productivity as well as efficiencies of production through synergies of the combined innovations (Feder et al., 1982). The use or adoption of any of these components is a function of farmers' attitudes towards technology, perceptions about the technology utility, cost, and farmers' capacity to purchase related inputs as well as availability of the complementary technologies.

Farmers' perceptions of technologies

Technologies are usually of external sources and perceived as new to the target environment and/or users. Technology information is disseminated to target beneficiaries through several selected communication or media channels or methods with initial purposes of introduction and/or creating awareness of the technology to the beneficiaries. Through farmers' objective and subjective assessments of the technologies, the irrigated rice farmers would form perceptions and attitudes about innovations' influences on their objectives as well as perceptions about the influences of technologies, socio-demographic characteristics, institutional and environmental factors on innovation adoption decisions through communication processes including social networks. Farmers' levels of adoption of introduced technologies would be a function of their perceptions about the technologies and the factors that determine farmers' decisions to implement the technologies.

Determinants of Irrigated Rice Technologies Adoption

The different theoretical models of adoption indicate that observed adoption patterns depend critically on complicated, and sometimes unobservable relationships between different elements. For instance, the risks associated with various technologies, the nature of farmers' attitude to risks, the existence of actual or perceived fixed adoption costs as well as the availability of cash resources to practice technologies. Differences in farmers' attitudes towards technologies, perceptions about the influences of demographics, available support, and environmental conditions influence farmers differently at different time periods. Similar innovations may therefore experience different adoption patterns in different areas and by different groups or individual farmers. Specifically, the relationship between farmers' perceptions or experienced realities about socio-demographic or other factors and adoption can take different shapes due to a host of factors including socio-demographic factors, resulting in different adoption levels.

Socio-demographic factors

Individual farmer adoption of irrigated rice technologies is proposed to be affected differently by the differences in their socio-demographic variables. Individual farmer's adoption decision is heavily influenced by personal and social characteristics; the diversity of these characteristics makes the differences in adoption possible (Greg, 2003; Rogers, 2003). The sex of the farmer has been reported to positively influence innovation adoptions of the farmer. For instance, the sex of the farmer was reported to have a significant positive effect (1.82) on mechanised harvesting technology adoption on the Kpong Irrigation Project (Djokoto & Blackie, 2014). Djokoto and Blackie further reported that the age of the farmer had a negative non-significant influence on mechanised harvesting technology adoption. In their study, household size was negatively related to mechanised harvesting technology adoption on the Kpong irrigation project whilst marital status had a non-significant negative relationship.

The levels of education of the farmers have been observed to influence technology adoption differently. At some instances, younger farmers have been found to have positive relationships with technologies adoption. Farmer's experience can influence technology adoption either positively or negatively depending on individual circumstances of the time (Djokoto & Blackie, 2014). Experience of the farmer affords him/her capacity to analyse technologies and situations better and faster in the adoption decision. Differences in experience make possible differences in technology adoption choices. Innovativeness of farmers is usually promoted by the availability and access to institutional support, designed to address constraints to farmers' innovativeness.

Institutional support

Various institutional support was proposed to play a role in the levels of farmers' technology adoption levels namely: NGO, MoFA, farmers' group, bank/credit institutions, agrochemical companies, radio/tv, and market support. Institutional support is provided in the form of access to information, education, credit, market as well as inputs and networking among farmers and between institutions. Adequate access to these services improves adoption levels resulting in improvement in farmers' capabilities to adopt technologies through perceptions of reduction in risks associated with and relevance of technology characteristics.

Technology characteristics

Selected technology characteristics for the study include cost, compatibility, complexity, risk, relevance (meets needs, disease resistance) of the technologies as these among others influence levels of innovation adoption. Technology characteristics relate differently with technologies adoption in combination with other influencing factors (Rogers, 1983; Rogers, 2003). Technologies considered to be objectively and/or subjectively costly, complex, and risky could negatively affect farmers' adoption decisions resulting in different levels of adoption, granting that the influence of these characteristics outweigh farmers' objective targets. On the other hand, if farmers consider technologies to have better advantages regarding meeting their needs, pest and disease resistances and compatible with culture and practices, their adoption decisions could be positively influenced increasing their levels of innovation adoption. The specific or perceived characteristic of an innovation has the tendency to influence farmers' adoption decisions positively or otherwise depending on the condition of farmers' environment.

Environmental conditions

Environmental conditions of the farm include but not exclusively, weather and soil conditions as temperatures and soil fertility. High temperatures usually extend the maturity periods of crops which affects the next cropping time with a possible resultant loss in productivity and efficiency

(Schiller et al., 2001). High temperatures also predispose crops to drying of pollen and poor fertilisation and poor yields. The presence of extreme tempeartures reduces farmers innovation adoption levels. Soil conditin and quality are important for irrigated rice technology adoption as it would influence technologies cost of recommended fertilizer rates and enhance technology adoption decisions. Poor soil quality would discourage farmers irrigated rice technology adoption due to increased fertilizer rates and costs (Schiller et al., 2001). The quality of the crop environment, perceived or objective, would influence farmers' irrigated rice innovations adoption.

Availability of capital

Land, labour, and capital are age old factors of production especially in agricultural enterprises. Capital, as discussed here connotes the factors or assets that farmers must necessarily or potentially have even before deciding to engage in the farming activity, namely, available land, land tenure, available capital, and available labour. Availability and access to cultivable land and or adequate land tenure arrangement or otherwise would exert an influence on farmers' technology adoption decisions. Available capital indicates available cash savings and or investments that could readily be converted to cash for immediate use on the farming activities. Irrigated rice farming and accompanying technologies are capital and labour intensive to be successful. Availability and access to these factors are proposed to improve farmers' innovativeness. However, inadequate availability of and access to these factors would most likely constrain farmers' technology adoption decisions.

Adoption levels

Technologies at the Bontanga irrigation project were introduced as a package of innovations to increase farmers' rice production yields and productivity. While the components of a package may complement each other, for instance, adequate field preparation and recommended fertilizer rates, some of them can be adopted independently (Feder et al., 1982). Farmers may thus face several distinct technology adoption options. Farmers may adopt the complete package of innovations introduced (complete adoption) or choose a subset of the package (partial adoption) that can be adopted individually according to farmer's capabilities, perceptions about the technologies and attitudes towards the innovation. Farmers will adopt an innovation if they believe that technology adoption would/may yield relatively high benefits/advantage than the preceding innovation or practice (Greg, 2003; Rogers, 2003).

Difference in farmers' socio-economic characteristics, perceived/actual influences of technology characteristics, institutional support, and environmental factors would spawn differences in levels of technology adoption. Adoption levels reflect the proportion (0-1); categorised as 0-.25 =1, .26-.55 = 2, .56-.76 = 3, and .76+ = 4; of the total cluster of introduced technologies adopted by the farmer giving his/her specific context.

CHAPTER THREE

METHODOLOGY

This chapter provides insights to the methods and procedures that have been used to conduct the study. Items included are the brief description of the study area, research design, population, sampling procedures, data collection and analysis.

Study Area

The Bontanga irrigation project area is within the Kumbungu District (formerly part of Tolon/Kumbungu District) which is one of the forty-five districts created by the erstwhile Provisional National Defence Council (PNDC) Law 207 in 1988 with Kumbungu as its Capital. The District covers an area of about 2,741 square kilometres and forms about 3.9% of the land area of Northern Ghana (Cobina, Armah, & Obiri, 2012, GSS, 2013). The District is situated between latitudes 9°17′ N and 10º06′ N and longitudes 0 º 55′ W and 1º21′ W. The District is bordered, to the north by the West Mamprusi District, to the south by Central Gonja District, to the east and southeast by the Savelugu-Nanton District and the Tamale Metropolitan area and to the west by West Gonja District. The Tolon-Kumbungu District is about 22km from the regional capital; Tamale and has a population of 122,331 made up of 56,046 males and 56,285 females (GSS, 2013).

The topography of the project area is flat, forming a gently rolling low-lying relief elevations ranging from 120 to 180 metres above mean sea level. The area falls within the White Volta river basin, well drained and watered by the Zulabong and Kulda tributaries. The Bontanga stream constitutes the catchment serving the irrigation project dam with water in the raining season.

The project area lies within the tropical continental or interior savannah climatic zone. The area experiences a single rainfall season, which starts from May and ends in October every year. The rainfall ranges between 1005 and 1150 mm, with the heaviest rains occurring in August. Day temperatures are generally high (above 35ºC) except in the Harmattan season (November-February) when temperatures can reduce to 20ºC or below, especially during the night. The mean monthly temperatures vary from 36ºC between March and April to about 27ºC in August. Relative humidity is high during the rainy season (65-85%) but may fall as low as 20% during the dry season (Cobina, Armah, & Obiri, 2012; Langyintuo & Oldham, 1997).

Several communities are served by the irrigation project (Figure 3). The immediate communities to the project, however, include Yipelgu, Saakuba, Wuba, Kpalsogu, Dalun, Vogu, Zangbalung, Bontanga, Gbulung, Kumbungu and Tamale. The people are predominantly Dagbamba with farming as the main occupation, operating small farm sizes mostly on subsistence bases.

Bontanga irrigation project is owned by Government of Ghana and managed by Irrigation Development Authority (IDA). The irrigation project is managed by Government staff made up of the manager, three AEAs and a driver in collaboration with the farmer organisation. The collaboration between farmer organisation and IDA use a strategy called FAMPIM (farmer participation in irrigation management). This consist of constituting farmers into irrigation farmers' organisations and therefore spawned the irrigated rice farmer organisation. Farmer organisation leadership and other proactive farmers were trained on group organisation and management as well as irrigation farming practices and water management in a trainer of trainers' programme. This core group served as trainers of other farmers in irrigation farming practices on the project site in collaboration with IDA management at the project area. The core group further served as organisers and distributers of complementary inputs as well as water scheduling.

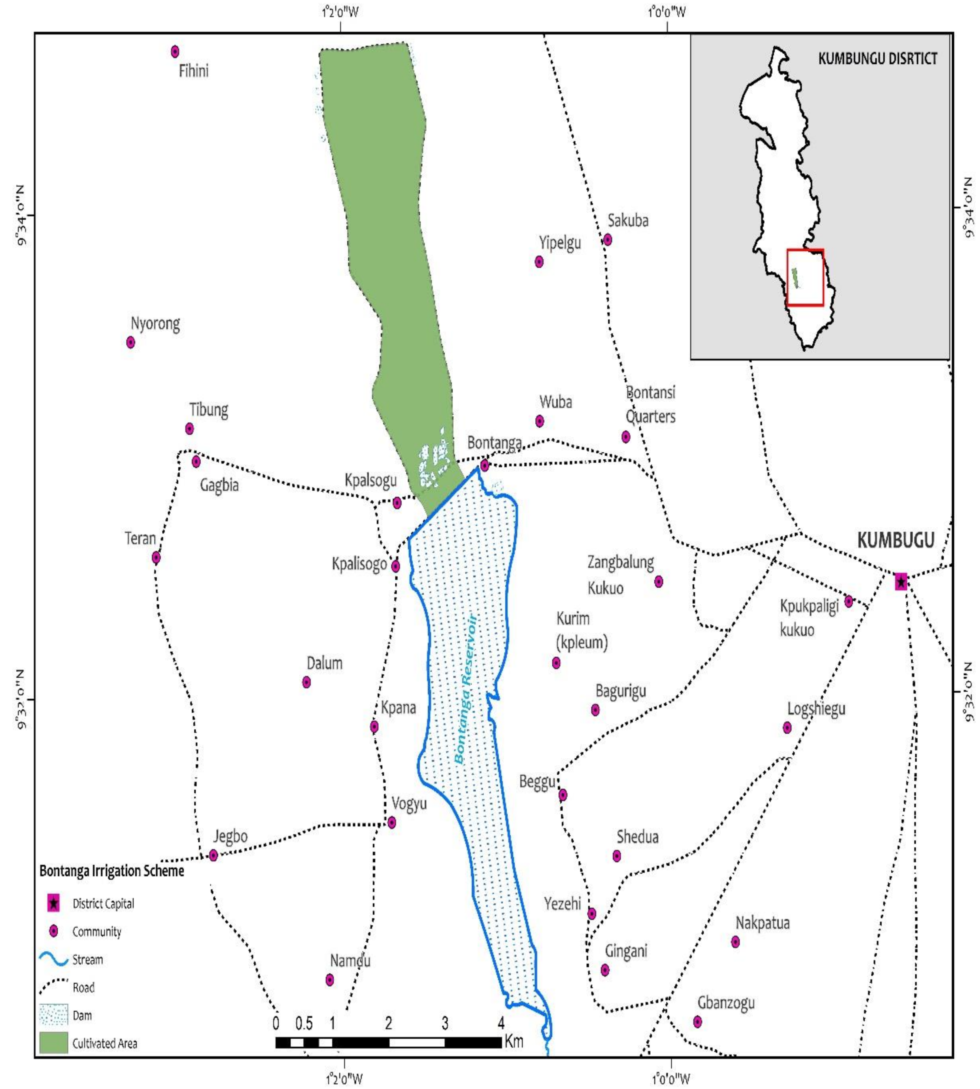

Figure 3: Map of the Bontanga irrigation area. Source: Author's construct (2013)

The project consists of an earthen dam of 12 metre height and a crest level of 5metres that delivers water to the field by gravity and incorporated in the embankment are two off-takes and a spillway, which is set to control the top water level in the reservoir. It has a storage capacity of 25 million m^3 serving a gross cultivable area of 570ha mainly cropped to rice and vegetables (MOFA, 2013).

Study Design

The study adopts a descriptive, correlational, and ordinal regression designs. The descriptive procedure enabled the researcher to describe data on demographic and socio-economic characteristics of respondents and adoption levels of irrigated rice farmers. This procedure answers questions about the current state of variables for a specific group of individual respondents (Field, 2005; Ary, Jacobs, & Razavieh, 1979; and Graveter & Forzano, 2009). The correlational design on the other hand was used to determine the relationship between variables and possible outcome of change in one variable with respect to change in other variable (Gravetter & Forzano, 2009; Abbott & Yarbrough, 1999; Rogers, 2003). The ordered logistic regression design was used to determine the best predictors of irrigated rice technology adoption and contribution of variables to irrigated rice technology adoption.

Study Population

The study population, from which the study sample was taken, is three hundred and seventy rice farmers at the Bontanga Irrigation area in the Northern Region of Ghana (Opoku, 2011).

Sampling Procedure and Sample Size

The sampling procedure ensured that individuals from the study population were selected so that findings from the study could be attributed to the population. The key considerations for the sampling accuracy, is the generalisation, which depended largely on the representativeness (how close the sample mirrors the population) (Ary, Jacobs, & Razavieh, 1979; Gravetter & Forzano, 2009; Sarantakos, 1993). To ensure sample representativeness, the probability sampling procedure was used to select respondents of the study using the random table (Gravetter & Forzano, 2009; Ary et al., 1979; Krejcie & Morgan, 1970). They further observed that the probability sampling procedure requires a sampling frame to be operational. To ensure the sample selected is representative, equal chance was given for all members of the population (respondents) to be included in the sample.

A table of random numbers was used. One critical concern in addressing sample representativeness is selection of appropriate sample size using the sample frame (Ary et al., 1979; Gravetter & Forzano, 2009; and Krejcie & Morgan, 1970). They further suggested that there is no simple way to select a representative sample size. However, methods constructed around statistical formulae are basically used to estimate a statistic and parameter value to determine the required sample size. Therefore, for the study population of 370 rice farmers (Opoku, 2011), a sampling frame was generated by assigning numbers to list of numbers provided by the irrigation authority and farmers' organisation. According to Krejcie and Morgan, (1970) a table of random number for a population of 370,197 would be the representative required sample size.

Instrumentation

A content and face validated questionnaire (Appendix B) was used to interview the selected respondent farmers. The confidentiality of farmers was ensured and guaranteed with a note provided in the instrument that communicated that the questionnaire would be used for the research only.

Section A addressed demographic characteristics, socio-economic characteristics, institutional support, and perceptions of respondents on factors affecting irrigated rice technology adoption.

Section B focused on adoption of technologies by farmers, constraints to adoption of irrigated rice technologies and perceptions of farmers on adoption of technologies. To describe the socio-demographic characteristics, farmers were asked to provide information on age and experience in years, household composition in terms of number of adult females and males as well as female and male children in the house. Types of education (formal and non-formal) was also collected.

Data measuring socio-economic characteristics included participation in extension programme, membership of farmer organisation and community group, status in group (leader/member and community (chief/member), household (head/member) respectively. Data on institutional support included levels of access, type of support received from Ministry of Food and Agriculture (MoFA), Non-governmental Organisations (NGOs) and Savannah Agricultural Development Authority (SADA). Sources of irrigation information (ranked by scores of 1 = cannot tell to 5 = major whiles the preferences for same information sources were ranked from 1= cannot tell to 5 = most preferred source).

Farmer perceptions on factors affecting adoption of irrigated rice technologies were measured by score rating of 1 = cannot tell, to 6 = strongly agree for each factor assessed. Constraints to rice technology adoption was measured by rating each assessed constraint on a scale of 0 = cannot tell, to 4 = a major constraint while technology adoption was measured by a "yes" or "no" response option for each technology assessed. Perceptions on technologies characteristics were similarly measured by scale of agreement of 0 = cannot tell, to 5 = strongly agree.

The validity and reliability of the questionnaire were established to ensure that the questionnaire measured what it is intended to measure and still remain consistent. First the content and face validity were assessed by supervisors. The instrument was pre-tested on twenty-one irrigated rice farmers at the Golinga irrigation site in the Tamale Metropolitan Assembly. The Cronbach's alpha coefficient was computed for each of the Likert type responses and constructs to establish the consistency of the items that measure the constructs. The reliability tests yielded Cronbach's Alpha coefficients ranging from 0.67 for access to institutional support, to 0.96 for perceptions about factors affecting adoption (Table 3). A Cronbach's alpha coefficient of 0.50 of the items is considered reliable (Field, 2005).

Data Collection

The structured questionnaire was used to collect data from the 197 randomly selected respondents. Literate farmers filled out the questionnaire themselves while farmers who could not read and write were interviewed using questionnaire. Trained assistants interpreted the questions to farmers in the local dialect and filled out the questionnaire. The use of the local dialect in combination with trained assistants provided timely clarification relating to technical terms to preserve the accuracy of the responses from the questionnaire.

Table 3- Results of reliability tests using Cronbach's alpha

Test areas	No. of Items	Cronbach's alpha coefficient
Perceptions about factors affecting adoption	31	0.96
Constraints to adoption	15	0.96
Innovation characteristics	7	0.87
Type of support from MoFA and NGO	15	0.79
Sources of information	12	0.75
Frequency of use of media	12	0.75
Access to institutional support	8	0.67

Source: Field survey, Seini (2013).

Data Analysis

The questionnaires collected from the respondents were screened for completeness and legibility of writings by the assistant researchers. All questionnaires were deemed good so were coded and entered into SPSS version 20 software for data analysis. Table 4 presents the variables, variable codes and appropriate statistics generated to analyse the data according to objectives of the study.

Table 4: Variable, variable codes, and measurements by objectives

Objective	Variable	Measurement	Statistics
1. Describe socio-demographic characteristics of farmers and institutional support for adoption of irrigated rice technologies at Bontanga irrigation area.	Age	No. of years	Mean, frequency, percentage
	Sex	1 = female 2 = male	Frequency, percentage, χ^2
	Formal education	1= no 2 = yes	Frequency, percentage, χ^2
	Experience	No. of years	Mean. Frequency, percentage, χ^2
	Access to services: Roads		
	Household size	No. of male adults No. of female adults No. of children	Mean. Frequency, percentage, χ^2
	Member in group	1 = no 2 = yes	Frequency, percentage, χ^2
	Statuses in community, groups, household	1 = member 2 = leader	Frequency, percentage, χ^2, z-score
	Marital status	1 = single 2 = married	Frequency, percentage, χ^2, z-score
	Support type:		
	NGOs	1 = disagree 2 = agree	
	extension	1 = disagree 2 = agree	
	farmers group	1 = disagree 2 = agree	Frequencies, percentages,

	bank	1 = disagree 2 = agree	proportions, χ^2
	agro-chemical orgs.	1 = disagree 2 = agree	
	radio/tv	1 = disagree 2 = agree	
	market	1 = disagree 2 = agree	
2. Determine the levels of adoption of irrigated rice technology package introduced to farmers at Bontanga irrigation area.	1. Adopt any of introduced technologies 2. Level of adoption	1 = not adopted 2 = yes 1 = 0.25 2 = .26-50 3 = .51-75 4 = .76+	Proportions, Frequency, percentage, χ^2, z-score
3. Establish correlates of irrigated rice technologies.	Socio-economic factors, technology characteristics, environmental factors	Sign and size of correlation (ρ)	Significance of ρ
4. Predict adoption of irrigated rice technologies from farmer characteristics, technologies characteristics, and socio-demographic and institutional support factors	From: socio-demographic factors, technology characteristics, institutional support factors, environmental factors	Ordered logistic regression	1. β-coefficients 2. exponent β (e^{β}) 3. confidence interval

Source: Field survey, Seini (2013)

First descriptive statistics such as means, percentages and frequencies were generated to check if data entered the SPSS were correct. Errors in the coding were corrected before statistics were generated.

Specifically, the appropriate statistics such as frequencies, percentages, and standard deviations (SD) and chi-square were used to examine the socio-economic characteristics of farmers (Table 5) where appropriate. Proportions and percentages were used to summarise data on perceptions of farmers of institutional support factors likely to influence adoption of irrigated rice technologies at the Bontanga irrigation area. Chi-square, using cross tabulations, was used to establish the relationships between levels of adoption of irrigated rice technologies and socio-demographic, technologies characteristics and institutional factors in the Bontanga irrigation project area.

The levels of adoption of irrigated rice technologies was analysed using adoption of individual technologies and aggregate adoption of irrigated rice technologies at the Bontanga irrigation project area. Descriptive statistics such as frequencies, percentages and proportions were used to describe adoption of individual irrigated rice technologies. The number of irrigated rice technologies adopted was used to describe levels as low, medium, high and very high. Spearman correlation coefficient statistic was used to establish the relationships between levels of adoption of irrigated rice technologies and socio-demographic factors, technologies characteristics, institutional support factors, as well as environmental conditions. The size and sign of the correlation coefficient indicate the strength and direction of the relationship while the level of significance indicates the importance of the association.

The logistic regression model was used to predict adoption level of rice technologies from socio-demographic factors, technologies characteristics, institutional support factors, as well as environmental conditions. According to National Centre for Research Methods (NCRM) (2016); Agresti and Finlay (1997), and Field (2005) the ordered logistic model was deemed appropriate because the predictor is measured in ordered categories. The formula used was given as:

$$\ln\left[\frac{\text{prob(event)}}{(1-\text{prob(event)})}\right] = \beta 0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 \text{ .... } + \beta_k X_k \quad \text{............ } \mathbf{(1)}$$

where:

$$\ln\left[\frac{\text{prob(event)}}{(1-\text{prob(event)})}\right] = Y \text{ represents the logit function}$$

Y was measured with the cut off points/levels of adoption whereby: 1 = low, 2 = medium, 3 = high and 4 = very high,

β_0 = constant, $\beta_{1,}$ β_2.............. $\beta_{31,}$ represents the coefficients of independent variables X_1 to X_{31},

X_1 = sex, X_2 = age..X_{31} = good soil. The variables, measurements and expected signs are presented in Table 5. The cut-off points or categories of the dependent variable are considered non-linear. The logit function is thus applied to linearize and normalise them to accommodate the independent variables (Agresti and Finlay, 1997; Field, 2005). Important statistics include the parameter estimates (β-coefficient), standard error, chi-square values as well as the significance (p-values) and confidence interval (%). Further, the -2 log-log (-2LL) and goodness of fit chi-squares, pseudo R-square, and Cox and Snell statistics, are statistics used to establish the model fitness and overall model explanatory power (Agresti and

Finlay, 1997; Field, 2005). Identification of the best predictors was based on the significance level of the p-values of the coefficients of the associated explanatory variables.

Table 5: Variables, measurement and expected sign

Variable	Measure	Expected sign
Adoption level (y)	1 = low, 2 = medium 3 = high, 4 =very high	
Sex (x_1)	1 = disagree, 2 = agree	+
Age (x_2)	1 = disagree, 2 = agree	+
Household size (x_3)	1 = disagree, 2 = agree	+
Marital status (x_4)	1 = disagree, 2 = agree	+
Education (x_5)	1 = disagree, 2 = agree	+
Experience (x_6)	1 = disagree, 2 = agree	+
Tech. cost (x_7)	1 = disagree, 2 = agree	-
Tech. compatible (x_8)	1 = disagree, 2 = agree	+
Tech. complex (x_9)	1 = disagree, 2 = agree	-
Tech. risky (x_{10})	1 = disagree, 2 = agree	-
Tech. meets needs (x_{11})	1 = disagree, 2 = agree	+
Tech. disease resistant (x_{12})	1 = disagree, 2 = agree	+
Tech. pest resistant (x_{13})	1 = disagree, 2 = agree	+
Available land (x_{14})	1 = disagree, 2 = agree	+
Land tenure (x_{15})	1 = disagree, 2 = agree	+
Available capital (x_{16})	1 = disagree, 2 = agree	+
Available labour (x_{17})	1 = disagree, 2 = agree	+
Have assets (x_{18})	1 = disagree, 2 = agree	+
Status in community (x_{19})	1 = disagree, 2 = agree	+
Ethnicity (x_{20})	1 = disagree, 2 = agree	-
Member in group (x_{21})	1 = disagree, 2 = agree	+
Position in group (x_{22})	1 = disagree, 2 = agree	+

Variable	Measure	Expected sign
NGO support (x_{23})	1 = disagree, 2 = agree	+
MoFA support (x_{24})	1 = disagree, 2 = agree	+
Farmers' group support (x_{25})	1 = disagree, 2 = agree	+
Bank/credit support (x_{26})	1 = disagree, 2 = agree	+
Agrochemical companies (x_{27})	1 = disagree, 2 = agree	+
Radio/tv (x_{28})	1 = disagree, 2 = agree	+
Available market (x_{29})	1 = disagree, 2 = agree	+
Conducive weather (x_{30})	1 = disagree, 2 = agree	+
Good soil (x_{31})	1 = disagree, 2 = agree	+

Source: Field survey, Seini (2013)

The p-values indicate if there is a statistically significant association between a specific explanatory variable (age for instance) and the dependent variable (level of adoption). The size of the effect of the specific explanatory variable (β) on the dependent variable is indicated by the parameter estimate (change in logit (log($\frac{P}{1-P}$)). The exponent of the β-coefficient (e^{β}) provides the actual cumulative odds ratio which indicate the magnitude of effect of explanatory variable on the dependent variable (Agresti & Finlay, 1997; Field, 2005; National Centre for Research Methods (NCRM, 2016). Variable descriptions are presented in Table 6.

Table 6- Variables and their descriptions

Variable Type	Name	Code	Description	Level	Expected Sign
Dependent	Adoption	Y	Level of adoption	Ordinal (1-4)	
Independent			**Farmer related factors**		
	Sex	x_1	My sex influence tech. adoption	Binary	+
	Age	x_2	My age influence tech. adoption	Binary	+
	Household size	x_3	Household size influence adoption	Binary	+
	Marital status	x_4	Marital status influence adoption	Binary	+
	Education level	x_5	Education level influence adoption	Binary	+
	Experience	x_6	Years in rice farming	Binary	+
			Technologies characteristics		
	Technology cost	x_7	Use tech. because it's costly	Binary	-
	Tech. compatible	x_8	Use tech. because it's compatible	Binary	+
	Tech. complex	x_9	Use tech. because it's complex	Binary	-

Variable Type	Name	Code	Description	Level	Expected Sign
	Tech. risky	x_{10}	Use tech. because it's risky	Binary	-
	Tech. meets needs	x_{11}	Use tech. because it meets needs	Binary	+
	Tech. dis-resistant	x_{12}	Use tech. because it is disease resistant	Binary	+
	Tech. pest resistant	x_{13}	Use tech. because it's pest resistant	Binary	+
	Land available	x_{14}	Have land	Binary	+
	Land tenure	x_{15}	Have tenure arrangement	Binary	+
	Capital available	x_{16}	Have capital	Binary	+
	Labour available	x_{17}	Labour available	Binary	+
	Assets available	x_{18}	Have assets	Binary	+
	Community status	x_{19}	My status in community	Binary	+
	Ethnicity	x_{20}	Ethnic group I belong	Binary	-
	Member group	x_{21}	Member in social group	Binary	+
	Status group	x_{22}	Status in social group	Binary	+

Variable Type	Name	Code	Description	Level	Expected Sign
			Institutional support		
	NGO support	x_{23}	Support from NGOS	Binary	+
	MoFA support	x_{24}	Support from MoFA	Binary	+
	Farmers' group	x_{25}	Support from farmers' group	Binary	+
	Bank/Credit support	x_{26}	Support from bank/credit institutions	Binary	+
	Agrochemical sellers support	x_{27}	Support from agrochemical sellers	Binary	+
	Radio/Tv support	x_{28}	Support from Radio/Tv	Binary	+
	Market available	x_{29}	Available produce market	Binary	+
			Environmental factors		
	Weather conducive	x_{30}	Weather is conducive	Binary	+
	Good soil	x_{31}	Soil is good	Binary	+

Source: Field survey, Seini (2013). Level of adoption: 1 = low, 2 = medium, 3 = high, 4 = very high. Independent variable options (binary: Disagree = 1, Agree = 2.

CHAPTER FOUR

DESCRIPTION OF SOCIO-DEMOGRAPHIC AND TECHNOLOGY CHARACTERISTICS, INSTITUTIONAL SUPPORT AND ADOPTION OF IRRIGATED RICE TECHNOLOGIES

Introduction

Chapter four presents the discussions relating to the socio-economic characteristics and institutional support to farmers for adoption of irrigated rice technologies. Also included are the summary, conclusions, and recommendations.

Socio-demographic Characteristics of Farmers

Age and experience of farmers

Table 7 presents results on farmers' experience in farming, age and household size. The farmers at the Bontanga irrigation area had worked between 1 and 40 years as rice farmers but 13 years on the average. The youngest farmer was 19 years whilst the oldest was 76 years. The mean age is 41 years. Household size ranged between 1 and 72 and a mean of 14 people. Households comprised respectively of 4 male and female adults, and 4 and 3 male and female children on the average. The high experience coupled with the youthful age of respondents would exert a positive effect on levels of irrigated rice technologies adoption at the Bontanga irrigation project area. The experience and age of the farmer have been shown to influence adoption levels of farmers (Baffoe-Asare et al., 2013; Baete, 2012; Mamudu et al., 2012; Mensah, 2008; Kalineza et al., 1999; Sakurai, 2002).

Table 7: The average distribution of farmers' experience, age, and household size of respondents

Statistic	Experience	Age	Household size	Adults		Children	
				Male	Female	Male	Female
Mean	13	41	14	4	4	4	3
SD	9	13	9	3	3	3	3
Minimum	1	19	1	-	-	-	-
Maximum	40	76	72	33	20	30	20

Source: Field survey, Seini (2013)

The high mean adults per household would influence irrigated rice technologies adoption because of available household labour required for the labour-intensive irrigated rice practices. The total household size also positively affects adoption of irrigated rice technologies because the high household size would motivate adoption technologies to provide household food security. However, (Obuobisa-Darko, 2015) reported that number of children negatively influenced adoption of cocoa research innovations but total household size positively influenced the adoption of the innovations.

Farm size, yield, consumption, and sale of rice

Farmers cultivated between 0.2ha and 4.8ha of land at the Bontanga irrigation project area with mean farm size of 0.68 hectares (Table 8). The average farm size of less than one hectare suggests farmers at the Bontanga irrigation area are faced with land constraint problem. However, the limited land availability is envisaged to spur farmers' technologies adoption (Kasirye, 2013).

The irrigated rice yield at the Bontanga irrigation project area ranged between 0.21 and 5.3 t/ha. The mean irrigated rice yield at the Bontanga area was less than three tonnes and falls short of the estimated potential yield of 8.0 t/ha (FAO, 2013; and MoFA, 2011). Crop yield translates to revenue earned from the farming operation (Feder, Just, & Zilberman, 1985) therefore the low rice yields at the project area implies farmers are not earning the expected revenues acrueing from irrigated rice fields. Though general levels of technology adoption was high, fertilizer adoption was constrained (Table 54) explaining the low rice yields at the project area. Generally the observed low yields are expected to influence technology adoption at the Bontanga area positively to improve revenue earnings from rice fields.

Table 8: **Distribution of farm size, yield and quantity of rice consumed and sold**

Variable	Mean	Minimum	Maximum
Size of irrigation plot (ha)	0.68	0.2	4.8
Yield tha^2	2.6	0.21	5.3
Rice consumed (ton)	0.32	0.00	1.7
Rice sold (ton)	2.30	0.00	5.06

Source: Field survey, Seini (2013).

The mean rice yield consumed (0.32t) was very low compared to rice yield sold (2.30t). This suggests that rice production at the Bontanga area is more commercial oriented than subsistence. Commercial orientation of smallholder rice farmers has the potential to raise farmers' earnings if they adopt commercialisation (Abdullah, et al., 2017; Dorsey, 2008).

Age and size of irrigation farm of respondents

About one half of the respondents at Bontanga irrigation area have access to less than one hectare of farm size for cultivation of rice (Table 9). Although age was not significantly associated, (χ^2 = 3.397, p > 0.49), younger (19-34) and middle aged (35-55) farmers had less access to land (less than one hectare of irrigation land), compared to older farmers (>55 years) who had more than one hectare of land. The high proportion (83.7%) of farmers allocated less than 1ha of land indicates that land is a constraint on the Bontanga irrigation project area and expected to influence irrigated rice technologies adoption positively (Kasirye, 2013; Pingali et al., 2008).

Table 9: Age of respondent (years) and size of irrigation farm (ha)

Age	Size of irrigation farm (ha)						Total
	<1		1–2		>2		
	Freq.	%	Freq.	%	Freq.	%	Freq. [%]
19–34	1(0.1)	0.5	0(-0.3)	0	0(-0.1)	0	1[0.5]
35–55	75(0.1)	38.1	10(0.3)	5.1	0(-1.3)	0	85[43.2]
>55	96(-0.1)	48.7	11(-0.2)	5.6	4(1.2)	2.0	111[56]
Total	172	87.3	21	10.7	4	2.0	197[100]

χ^2 (4) = 3.397, p > 0.49. (.) = z-residual > .05

Source: Field survey, Seini (2013)

Age of farmers and rice yield

Generally, the age of respondents at the Bontanga irrigation area ranged from nineteen to seventy-six years with a mean age of 41 (Table 7). There was no significant association, χ^2 (4) = 1.425, p > .05, between age and irrigated rice yields at the Bontanga irrigation project area. However, important to note that, 3.5-4.9t/ha is the most frequent yield category across all age groups, achieved by 66% of farmers. The proportion of farmers in this yield category constitutes the farmers who adopted the fertilizer technology. Farmers older than 55 years constitute over half of the farmers. Majority (63%) of the farmers older than 55 years produced yields of 3.5–4.9 t/ha. The results, χ^2 (4) = 1.425, suggest a weak, not significant positive relationship of age with rice yield/ha at the Bontanga irrigation area.

Table 10: Age of respondent (years) and rice yield (t/ha)

Age	Rice yield (tha^2)						Total[%]
	<1.5-3.49		3.5-4.99		>4.99		
	F	%	F	%	F	%	
19–34	0(-0.4)	0	1(0.4)	0.5	0(-0.4)	0	1[0.5]
35–55	12(-0.5)	6.1	59(0.4)	29.9	14(-0.3)	7.1	85[43.1]
>55	20(0.5)	10.2	70(-0.4)	35.5	21(0.3)	10.7	111[56.4]
Total	32	16.3	130	65.9	38	17.8	197[100]

χ^2 (4) = 1.425, p = .840;   (.) = Z-residual

Source: Field survey, Seini (2013)

Older farmers apply their knowledge and skills gained through experience to increase crop yields (Akpan et al., 2012). For practical purposes, it is important to consider age as an important factor in irrigated rice technologies dissemination and trainings.

Age of respondents and participation in MoFA extension training

Less than half of the respondents participated in MoFA extension training. Majority (64.32%) of respondents, who participated in MoFA extension training were the farmers older than fifty-five (55) years (Table 11). There was a weak positive non-significant association, χ^2 (2) = 4.26, p > .10, between age and participation in MoFA extension training. Older farmers are more associated with participation in extension training compared to younger farmers.

Table 11: Age of respondent (years) and participation in extension training

Age	Participation in extension education				Total F[%]
	Participated		Never participated		
	F	%	F	%	
19–34	0(-0.7)	0	1(0.6)	0.5	1[0.5]
35–55	30(-1.0)	15.2	55(0.9)	27.9	85[43.1]
>55	54(1.0)	27.4	57(-0.80	28.9	111[56.3]
Total	84	42.6	113	57.3	197[100]

χ^2 (2) = 4.26, p = 0.12; (.) =Z-residual

Source: Field survey, Seini (2013)

The older farmers participated in MoFA extension training because they knew, through experience, that extension training is still useful for irrigation practice and their farming activities outside the project site. Some farmers intimated that the mainstream MoFA extension training and education is generic and does not serve farmers' needs well. In addition, the channels and timing of information delivery do not suit farmers' convenience. In explaining farmers' poor participation in MoFA extension programmes, some farmers observed that irrigation farming is time consuming and they have little time for irregular and irrelevant visits paid by extension agents. The participation of older people in extension training is, however, important. It is expected that the older group of farmers would serve as human capital to provide knowledge and skills to the young generation of farmers through social network and information exchange.

Age of respondent and participation in irrigated rice training

Table 12 depicts results of cross tabulation of age and participation in irrigated rice technologies training. More than three quarters of the respondents participated in irrigated rice technologies training. Half of the participants are 55 years or more. There was no significant association between age and participation in irrigated rice training, $\chi 2$ (2) = 0.69, $p > .10$, at the Bontanga irrigation project area.

Irrigated rice technology training is designed to suit specific and immediate needs and aspirations of farmers at the Bontanga irrigation area. The rational choice theory model stipulates that farmers take a behavioural option that best inures to their benefits. Therefore, the higher proportion of participation in irrigated rice technologies training is thus not unusual.

Age of respondent and marital status

The relationship between age and being married was weak and not significant, χ^2 (2) = 2.84, $p > .05$, at the Bontanga irrigation project area (Table 13). More than three quarters (86.5%) of the respondents were married; more so among the farmers older than fifty-five years (55). The results are expected because the older folks are more likely to be married compared to the younger farmers through accumulated resources for the maintenance of the household.

Table 12: Age of respondent (years) and participation on irrigated rice training

Age (years)	Training on irrigated rice training				Total F[%]
	Participated		Never participated		
	F	%	F	%	
19–34	1(0.2)	0.5	0(-0.4)	0	1[0.5]
35–55	68(-0.2)	34.5	17(0.5)	8.6	85[43.1]
>55	93(0.2)	47.2	18(-0.4)	9.1	111[56.3]
Total	162	82.2	35	17.8	197[100]

χ^2 (2) = 0.689, p = .65; (.) = z-residual

Source: Field survey, Seini (2013)

Field observations indicated that women in the household including wives participate in planting and harvesting to complement farm labour. Therefore, being married increases farm labour force and sustains irrigated rice farm operations. This would therefore positively influence technology adoption. The high proportion of married farmers is important for the labour-intensive irrigated rice technology adoption at Bontanga irrigation project area since it would motivate technologies adoption options.

Though the results are non-significant, the sign of the association is in tandem with Denkyirah et al. (2016) and Ojiako (2011) respective findings that marital status exerts significant positive influence on access to credit in the Tolon District of Ghana and the number of adult women in the household had positive significant relationship with adoption and use intensity of soybean technology.

Table 13: Age (years) and marital status of respondent

Age (years)	Marital status of respondents				Total F[%]
	Single		Married		
	F	%	F	%	
14–34	0(-0.4)	0	1(0.2)	0.5	1[0.5]
35–55	19(1.1)	9.6	66(0.5)	33.5	85[43.1]
>55	15(-0.9)	7.9	96(0.4)	48.7	111[56.6]
Total	34	17.5	165	57.3	197[100]

χ^2 (2) = 2.844. p = .279. (.) = z-residual

Source: Field survey, Seini (2013).

Age and membership in irrigated rice farmers' organisation

More than half of the respondents were older than fifty-five years. A little over three quarters of the respondents were members of the irrigated farmers' organisation (Table 14). There was a significant positive association between age and being a member of the irrigated rice farmers' organisation, χ^2 (2) = 7.083, $p < .05$, at the Bontanga irrigation project area.

It has been established that age and membership in an organisation, association, and group are important social capital which guarantees or provides information, knowledge, and skills, through social networks (Kalineza et al., 1999; and Mamudu et al., 2012). The accumulated knowledge and skills of the older farmers is expected to offer an important source of information for others (Nyanga, 2012; and Langintuo and Mekuria, 2008), especially younger farmers at the Bontanga irrigation project area.

Table 14: Age of respondent (years) and membership in irrigated rice farmers' organisation

Age (years)	Membership of irrigated farmers' organisation				Total F[%]
	Member		Not a member		
	F	%	F	%	
19–34	0(-0.9)	0	1(1.7*)	0.5	1[0.5]
35–55	62(-0.6)	31.5	23(1.1)	11.7	85[43.1]
>55	93(0.6)	47.2	18(-1.2)	9.1	111[56.3]
Total	155	78.7	42	21.3	197[100]

χ^2 (2) = 7.083. p = .023. (.) = z-residual < .05

Source: Field survey, Seini (2013)

Status of respondents in community, household, and social groups

Table 15 describes respondents' positions/status with respect to the communities, households, and social groups. The results show that chiefs are involved in irrigated rice cultivation at the Bontanga irrigation area. Close to two-thirds of farmers belong to social groups within the communities. Similarly, over three-quarters of the farmers belong to the irrigated rice farmer organisations. Five percent (5%) of these group of farmers hold leadership positions in the organisations. There is indication that about three-fifth of the respondents are household heads.

It is important to note that community leaders are usually the first people who receive information on the introduction of innovations to the community and directly from the programme implementers. This is expected to influence their individual constituents' technology adoption. However, the influence on constituents is affected by the level of confidence of members in the leaders, their technology adoption, and skills levels (Baete, 2012). In contrast, Adesina and Baidu-Forson (1985) in Burkina Faso on farmers' perceptions and adoption of new agricultural technologies, indicated that being a village head had negative non-significant relationship with technology adoption.

Age and position in irrigated rice organisation

The results of the interaction between age and position in irrigatted rice farmers organisation is presented in Table 16. The highest proportion of leaders was allocated to the farmers older than fifty-five years (>55) among the membership of irrigated rice farmers' organisation, thus leadership position is allowed only to the old and much older groups of respondents among the irrigated rice farmers' organisation to take advantage of the maturity and experience gained through the ages.

There is not a significant association between age and position in irrigated rice farmers' organisation, χ^2 (2) = 0.022, p > .05, at the Bontanga irrigation project area. However, the positive relationship is important because older farmers would, through social networks, pass on knowledge and skills gained through experience, to younger generation of farmers. It is interesting; however, to note that none of the farmers less than thirty-five years (<35) was a member of a farmer's organisation (Tables 14 and 16). Younger farmers are risk-averse and more flexible in adoption behaviour hence were cautious in joining the irrigated rice farmers' organisation (Kalineza et al., 1999).

Table 15- Respondents' position in community, household, and social groupings

Position in:	Status	F (%)	n
Community	Member	93.90	197
	Chief	6.10	
Social group	Member	82.10	123
	Leader	17.90	
Household	Member	37.10	197
	Head	62.90	
Irrigation farmers' organisation	Member	94.90	156
	Leader	5.10	

Source: Field survey, Survey (2013)

The findings that group leaders are older farmers is important. Group leadership offers guidance, direction and contact to members of the group because they generally have good social networks and through their experience, possess information, knowledge, and skills uncommon to other members.

Table 16: Age of respondent (years) and respondent's position in irrigated rice farmers' organisation

Age (years)	Position in irrigated farmers organisation				Total F[%]
	Leader		Ordinary member		
	F	%	F	%	
35–55	3(-0.1	1.9	59(0)	38.1	62[40.0]
>55	5(0.1)	3.2	88(0)	56.8	93[60.0]
Total	8	5.2	147	94.8	155[100]

χ^2 (2) = 0.022. p = .596

Source: Field survey, Seini (2013)

They are usually regarded as role models in their society and groups, which offer them substantial influence on members to spur adoption of innovations. The election/selection of older farmers to leadership positions implies trust in the older farmers. The quality of leadership offered allows them influence members' technology adoption (Baete, 2012).

Experience (years) of Farmers and Irrigated Rice Cultivation

Experience connotes the number of years the farmer has been involved in irrigated rice cultivation. The experience of the respondents in irrigated rice cultivation ranged from 1 to 40 years with a mean experience of 13 years (Table 7). The high level of experience of farmers implies that experience is expected to influence technologies adoption decisions because experience offers the farmer the opportunity to gain and accumulate better knowledge and skills to better handle innovation and innovation information and thus serves as human capital for technologies adoption (Mensah, 2008; Baffoe-Asare et al., 2013; Baete, 2012; and Djokoto & Blackie, 2014) and therefore influence innovation adoption behaviour. The mean experience of thirteen years is expected to be beneficial to farmers at the project area as a valuable source of information, knowledge, and skills to other farmers especially the new and inexperienced ones. It is more important at the project area because majority are without formal education and therefore would have difficulty in accessing and understanding irrigated rice technologies information.

Further analysis sought the association between experience and farmers' age, participation in extension education training, participation in irrigated rice technologies training, membership in irrigated rice farmers' organisation, position in irrigated rice farmers' organisation, size of irrigation farm (ha), and rice yield (t/ha) in the ensuing sections.

Experience in irrigated rice cultivation and age of respondents

The mean experience and age of farmers were thirteen and forty-one years respectively at the Bontanga irrigation area (Table 7). Further, thirty-six percent of the farmers were older than fifty-five years (>55) and the most experienced farmers, more than fifteen years (>15) (Table 16). A combination of high level of experience and older farmers would serve as a reference group for information, knowledge, and skills for irrigated rice farmers at the project area and for the individual experienced farmers. Therefore, technologies adoption is expected to be influenced by the experienced and old farmers.

The chi-square statistics: χ^2 (6) = 41.317, $p < .01$, infers a positive significant relationship between farmers' experience and age. The results imply that an increase in age would result in an increase in farmers' experience or vice versa without implying any causality. Likewise, the result indicates that the experience of 6-10-year category tends to be positively associated with the 35-55-year group of farmers' experiences at a significant level of $p < .001$.

However, they are negatively and significantly related to the 56-76-year group at a $p < .01$. Conversely, the relationship between >15-year experience category and 35-55 -year old category is negative and significant whilst the >15-year experience category exhibits a positive and significant relationship with the 56-76-year old category at $p < .01$ respectively.

The positive significant association between experience and age is expected to positively influence adoption of irrigated rice technologies.

Table 17: Experience in irrigated rice cultivation and age of respondent

Experience (years)	Age category of respondents (years) 19-34 F	%	35-55 F	%	56-76 F	%	Total[%]
1-5	0(-1)	0	0(-.9)	0	2(.8)	1.0	2[1]
6-10	1(1.4)	0.5	39(3.3**	9.8	14(-.0*)	7.1	54[27.4]
11-15	0(-.5)	0	26(.9)	13.2	25(-.7)	12.7	51[25.9]
>15	0(-.7)	0	20(-.0*)	10.2	70(2.7*)	35.5	90[45.7]
Total	1	0.5	85	43.1	111	56.3	197[100]

χ^2 (6) = 41.317, p = .010, (.) = z-residual: **p < .001, *p < .01

Source: Field survey, Seini (2013)

Experience and age have both been considered human capital serving as a store of information, knowledge, and skills through social networks and each have been shown to influence innovation adoption decision options (Baffoe-Asare et al., 2013; Mensah, 2008; Djokoto & Blackie, 2014; Baete, 2012; Kalineza et al., 1999; and Mamudu et al., 2012). The findings compared with Baffoe-Asare et al. (2013) report that experience exerts a positive influence on adoption of cocoa high-tech technologies but Djokoto and Blackie (2014) reported a positive non-significant influence on technologies adoption decisions. Baete (2012); however, indicated that age is not an influencing factor on farmers' innovation adoption decisions.

Experience in irrigated rice cultivation and participation in MoFA extension training

Generally, farmers in the Bontanga area benefited from three extension service providers namely: the generic MoFA extension, irrigation farmers' organisation, and NGOs. The current discussion reflects participation and/or access to MoFA extension service as depicted in Table 18. Participation in extension training describes the involvement of farmers in MoFA educational training activities for the purpose of building farmers' capacity through improvement in farmers' knowledge, skills, and information access and interpretation. The expectation is to improve farmers' decision-making process.

The results indicate that two out of every five farmers participated in the MoFA extension education programmes. The refreshing revelation, however, is that one fifth of the participants in extension training belong to the most experienced category of farmers. The synergy of experience and participation is expected to enhance human capital of the individual farmers and source of knowledge and skills for other farmers at the irrigation area. All the categories of experience are positively associated with extension participation. The chi-square distribution, χ^2 (3) = .288, p > .10, however, indicates that the association of experience and extension participation is non-significant. The implication is that there is no evidence of a significant association between farming experience and age.

The findings compare to Saka et al. (2005) and Baffour et al. (2013) report that participation in extension training had a positive significant influence on technologies adoption.

Table 18: Experience in rice farming (years) and participation in extension training

Experience (years)	Participation in extension education				Total[%]
	Participated		Never participated		
	F	%	F	%	
1 – 5	1(.2)	0.5	1(-.1)	0.5	2[1]
6 – 10	22(.2)	11.2	32(.2)	16.2	54[27.4]
11 – 15	21(.2)	10.7	30(.1)	15.2	51[25.9]
>15	40(.3)	20.3	50(-.2)	25.4	90[45.7]
Total	84	42.7	113	57.3	197[100]
X^2 (3) = .288, p = .942					

Source: Field survey, Seini (2013)

For instance, in the determinants of cocoa high-tech technologies adoption, Baffour-Asare et al. (2013) reported a significant positive influence of experience on cocoa High-tech technologies adoption. Experience increases human capital of the specific farmer through increased knowledge, skills and capacity to effect changes that are beneficial to the farmer, hence his/her capacity to adopt technologies is enhanced. Comparably, Ojiako (2011), and Langintuo and Mekuria, (2008) have indicated that access to extension services exert a positive and significant relationship with technologies adoption.

TPB suggests that human behaviour is influenced by positive expectations from behavioural outcome. In a similar vein, RCT postulates that human behaviour or choice is influenced by the outcome of cost benefit analysis. Under both contexts, positive outcome expectations or outcomes result in positive behaviour. MoFA extension activities are generic for all crops and operations whilst irrigated rice farmers require irrigation specific technologies training which makes irrigated farmers irresponsive to the generic extension training activities. Therefore, irrelevant, and poor access to MoFA extension services culminated to the poor participation in MoFA extension services by farmers. Some farmers cited irregular visits and lack of time during irrigation activities as reasons for non-participation in extension training services.

Experience in irrigated rice farming and participation in irrigated rice technologies training

Unlike the MoFA extension education, irrigated rice technologies training is focused and specific to the introduced technologies at the project area. Irrigated rice technologies training was conducted by the farmer organisation, formed under the FAMPIM project. The purposes was disseminating specific technologies information and conducting training to irrigated rice farmers, at the project, among other administrative functions. The objective was to offer information and training to irrigated farmers on felt technologies needs to improve knowledge and skills on irrigated rice technologies practices.

Majority (more than four fifths) of farmers participated in irrigated rice technology training (Table 19). The highly experienced farmers: more than fifteen years (>15) of experience, were observed as the highest proportion of participants in irrigated rice technologies training. The result is expected because they have been educated, through their long period of participation and practice, on the value and relevance of participating in irrigated rice technologies training.

Table 19: Farming experience (years) and participation in irrigated rice technology training

Experience (years)	Training on irrigated rice technology				Total
	Participated		Never participated		
	F	%	F	%	
1-5	1(-.5)	.05	1(1.1)	0.5	2[1]
6-10	45(.1)	22.8	9(-.2)	4.6	54[27.4
11-15	43((.2)	21.8	8(-.4)	4.1	51[25.9]
<15	73(-.1)	37.1	1 7(.3)	8.6	90[45.7]
Total	162	82.2	35	17.8	197[100]

χ^2 (3) = 1.696**,** p = .674, (.) = z-residual

Source: Field survey, Seini (2013)

The participation of highly experienced and the least experienced farmers are negatively associated with participation in irrigated rice technologies training. Conversely, 6-10 and 11-15 years of experience are positively associated with participation in irrigated rice technologies training. The implication is that an increase in experience between 1 and 5 years and more than 15 years is associated with a decrease in participation in irrigated rice technologies training. The reverse is true for the experience categories of 6-10 and 11-15 year which are positively related to participation in irrigated rice technologies training at the Bontanga irrigation project area. The results, χ^2 (3) = 1.696, p > .10, however, show that the established relationships are not significant (Table 19).

The findings differ from reports of positive significant associations of experience with technologies adoption decisions (Saka et al., 2005; Baffour-Asare et al., 2013; and Adisena & Baidu-Forson, 1985).

Experience and membership in irrigated rice farmers' organisation

Farmers' experience and membership in irrigated rice technologies organisation was assessed using cross tabulation (Table 20). More than three quarters of the respondents were members of the irrigated rice farmer's organisation. The most experienced farmers, more than fifteen (15+) years, were the highest proportion; about one quarter of members of the irrigated rice farmer's organisation. The results suggest that experienced farmers are aware of the benefits of belonging to the farmer's organisation which accounts for the high enrolment into the irrigated rice farmers' organisation.

Experience in combination with being a member of a farmer's organisation, is expected to increase human capital in the project area and consequently influence innovation adoption options. There was, however, no significant relationship, χ^2 (3) = 5.651, p > .05, between experience and membership in irrigated rice farmer's organisation at the Bontanga irrigation area.

The positive association is however, practically relevant because experience increases human capital which allows the individual gain better knowledge and skills in technologies handling, understanding, and application better than inexperienced colleagues (Mensah, 2008).

Experience has been found to positively influence technologies adoption decisions (Baffour-Asare et al., 2013).

Table 20: Farming experience (years) and membership in irrigated rice farmer organisation

Experience (years)	Membership in irrigated farmers' organisation				Total[%]
	Member		Not a member		
	F	%	F	%	
1-5	2(.3)	1.0	0(-.7)	0	2[1]
6-10	37(.8)	18.8	17(1.6)	8.6	54[27.4]
11-15	40(0)	20.3	11(0)	5.6	51[25.9]
>15	76(.6)	38.6	14(-1.2)	7.1	90[45.7]
Total	155	78.7	42	21.3	197[100]

χ^2 (3) = 5.651, $p > .10$, (.) = Z-residual

Source: Field survey, Seini (2013)

Membership in an organisation creates social networks for information, knowledge, and skills sharing through which members learn from each other (Nyanga, 2012; and Langintuo & Mekuria, 2008). Information, knowledge, and skills gained through experience is expected to be shared with members of social networks. The synergy of experience and membership in organisation is expected to influence technologies adoption decisions through knowledge and skills availability on one hand and increase network sharing capacity on the other.

Experience and position in irrigated rice farmers' organisation

Three quarters of the members of farmers' organisation did not hold any leadership position (Table 21). Four percent (4%) of farmers who were members of the irrigated rice farmer organisation held leadership positions. Three out of every four leaders of the irrigated rice farmer's organisation belong to the farmers from the highest experience category, of more than fifteen years (15+). Except the experience category of more than fifteen years (15+), all the categories of experience associated negatively with being a leader of the irrigated rice farmer's organisation on the Bontanga irrigation project area.

Table 21: Farming experience (years) and position in irrigated rice farmers' organisation

Experience (years)	Position in irrigation farmer organisation				Total[%]
	Leader		Ordinary member		
	F	%	F	%	
1–5	0(-.3)	0	2(.1)	1.3	2[1.3]
6–10	1(-.7)	0.6	36(.2)	23.2	37[23.9]
11–15	1(-.7)	0.6	39(.2)	25.2	40[25.8]
>15	6(1.0)	3.9	70(-.2)	45.2	76[49.0]
Total	8	5.2	147	94.8	155[100]

χ^2 (3) = .255, p = .483, (.) = z-residual

Source: Field survey, Seini (2013)

This differs from Baete (2012) that indicates that being a group leader exerts a positive influence on membership and consequential on technical knowledge, skills, and attitudes towards members of the group. Experience, membership in an organisation and leadership individually function to increase human capital which is important in influencing farmers' technologies adoption decisions. Experience, membership, and leadership are expected to complement each other in influencing farmers' adoption decisions of irrigated rice technologies.

The results, χ^2 (3) = .2.55, p > .10, infers a positive but not a significant association between farming experience and farmers' status in irrigation farmer organisation. Implication is that there is no relation between farmer's experience and status in irrigated rice farmer organisation at the Bontanga irrigation project area.

Farmers' experience and size of irrigation farm

Farm size is the amount or area of land a farmer has access to, to conduct irrigated rice production activities. The description of experience and farm size show that size of irrigation plot per farmer ranged between less than one hectare and 2.0ha (Table 22) with a mean of 0.68ha (Table 8). More than three quarters of the respondents were allocated less than one hectare of farm. Farmers with experience of more than fifteen years dominated in the share of farm size across all categories of farm size. Except for 6-10-year experience category, all other experience categories were negatively associated with less than one hectare of farm size, whilst the reverse is also true for farm size between one and two hectares; positive association. Years of experience in the range 1-5 and 6-10 negatively relate to farm size of more than two hectares of farm size whilst 11-15 and >15-year experience categories are positively associated with same farm size category.

Table 22: Farming experience (years) and size of irrigation farm (ha)

Experience (years)	Size of irrigation farm (ha)						Total[%]
	<1		1–2		>2		
	F	%	F	%	F	%	
1–5	1(-.6)	0.5	1(1.7)	0.5	0(-.2)	0	2[1]
6–10	50(.4)	25.4	4(-.7)	2.0	0(-1.0)	0	54[27.4]
11–15	44(-.1)	22.3	6(.2)	3.0	1(0)	0.5	51[25.9]
>15	77(-.2)	39.1	10(.1)	5.1	3(.9)	1.5	90[45.7]
Total	172	87.3	21	10.7	4	2.0	197[100]

χ^2 (6) = 5.935, p = .350, (.) =Z-residual

Source: Field survey, Seini (2013)

The established trends of associations are, however, not significant. For instance, the results, χ^2 (6) = 5.935, p > .05, indicate positive non-significant association between farmer's experience and farm size at the Bontanga irrigation area. The findings differ from reports of (Baffour-Asare, et al. 2013; Mamudu et al. 2012; Konstantinos, 2012; Feder et al. 1985; Michael et al. 1999; Mensah, 2008; and Langintou and Mekuria, 2008) that, experience and farm size individually function to influence technologies adoption decisions The synergy of the positive association between high experience and large farm size, especially when the most experienced farmers dominate in all categories of irrigated farm size, is expected to influence irrigated rice technologies adoption choice options. Farm size is considered an indicator of wealth and argued as being an important factor influencing farmers' technologies adoption decisions (Mamudu et al., 2012; Konstantinos, 2012; Feder et al., 1985; Michael et al., 1999; Mensah, 2008; and Langintou & Mekuria, 2008). Experience on the other hand, is considered human capital useful to the individual and members of the social networks in influencing choice of technologies adoption options.

Farming experience and rice yield

Rice yield/ha on the Bontanga project ranged between 0.21 and 5.31t/ha with a mean yield of 2.58t/ha. Majority: two thirds of the farmers obtained rice yields in the range of 3.5 and 4.99tha^2, including one quarter of the respondents who had more than fifteen years of experience. One out of every six farmers obtained yields in the range of <1.5-3.49 and 3.5-4.99tha^2 respectively (Table 23). The high yields of 3.5 tons or more obtained by the 40% of >15-year experience category, are not surprising since they have knowledge and skills, gained through years of practice, to achieve high yields. All categories of experience, (1-15 years), are positively associated with the least yield category of less than 1.5-3.49 t/ha except for the farmers with experience of more than fifteen years (>15) while the reverse is true for yield category of more than 4.99t/ha.

There was a positive significant association between experience and rice yield/ha, χ^2 (6) =18.044, $p < .01$. The results show that farmers of experience category of 1–5 years had positive significant association with yield category of <1.5-3.49 t/ha at the $p < .01$ significance level. Rogers (2003) posits that for an innovation to be acceptable to a farmer the innovation must be profitable, acceptable by society and technologically visible. Profitability infers a combination of high yield and low technology cost. The inexperienced farmers are risk averse and would invest less in technologies adoption therefore associate positively with low yields that commensurate to their investments.

Table 23: Farming experience (years) and rice yield (t/ha)

Experience (years)	Rice yield (tonsha²) <1.5–3.49 F	%	3.5-4.99 F	%	> 4.99 F	%	Total[%]
1–5	2(2.9*)	1.0	0(-1.1)	0	0(-.6)	0	2[1]
6–10	9(.1)	4.6	40(.7)	20.3	5(-1.5)	2.5	54[27.4]
11–15	10(.6)	5.1	34(.1)	17.3	7(-.7)	3.6	51[25.9]
>15	11(-.9)	5.6	56(-.4)	28.4	23(1.8)	11.7	90[45.7]
Total	32	16.2	130	66.0	35	17.8	197[100]

χ^2 (6) = 18.044, p = .007, *p < .01

Source: Field survey, Seini (2013)

The technology must supersede preceding technology in benefits; high in yield and low adoption cost, for it to be adopted. In a similar vein, RCT stipulates that human choice behaviour is preceded by cost and benefit (high yield) analysis. This position high crop yield of introduced improved variety over conventional or preceding crops among the relative advantages as the most important factor that influences technologies adoption (Langintuo & Mekuria, 2008).

Household size and composition

Household size connotes the number of people living in the same house, feeding from the same house and under the leadership of one household head. It is usually composed of adults and children wherever applicable. Respondents' household characteristics are depicted in Tables 24 and 25. The household size ranged between 1 and 72 people per household and most occurring household size was 12 people with a mean household size of 15 people (Table 24). The mean household size for the categories of adult males and females, male and female children per household was four (4) each, four (4) and three (3) people respectively.

The number of people living in the household has implications on availability of farm labour and dependency on use of household resources. The number of people living in a house has been shown to influence technology adoption decisions. For instance, the most important determinant of farm size in Mozambique was unavailability of family labour (Langintuo & Mekuria, 2008). Kalineza et al. (1999) also reported that the number of adults who can work indicates labour availability for conservation technology in the Gairo division of Tanzania. Kalineza et al. (1999) reported that adult members of household had a positive non-significant influence on conservation technology.

Table 24: **Household size and composition**

Statistic	Total HH size	Adults		Children	
		Male	Female	male	Female
Mean	15	4	4	4	3
SD	9	3	3	3	3
Minimum	1	0	0	0	0
Maximum	72	33	20	30	20

Source: Field work, 2013.

Conversely, Djokoto and Blackie (2014) found household size to exert a negative significant influence on mechanised harvesting technology at the Kpong irrigation project of Ghana. Akpan et al. (2012) reported increased household size to decrease fertilizer use intensity of farmers. Likewise, technology adoption might be less attractive for farm families with limited family labour, especially for those in labour constrained areas (Feder et al., 1982).

Household Categories

Table 25 presents the classification of household compositions. The results show that more than four fifth of households had household size of 5-24 people/household while 9% of households had household size of 25-44 people/household.

The high mean household size of 15 people coupled with the high proportion of households with children suggests a high dependency load hence a high pressure on household resource consumption. Observations on household food consumption show that rice is not a staple food for communities within the Bontanga irrigation area. Farmers therefore sell rice farm produce to buy common staple foods such as maize and cassava. This is expected to motivate farmers' technologies adoption decisions for increase yields for household direct or covert consumption. Close to a quarter of households had less than five adult members per household.

These group of farmers' technology adoption would therefore be impinged concomitantly to labour constraint at the Bontanga irrigation area. This is due to the assertion that adult members of the household; males and females, serve as a source of unrestricted farm labour to support technologies adoption of farmers (Langintuo & Mekuria, 2008; and Kalineza et al., 1999).

The assertion corroborates Ojiako (2011) report that the number of female adults in the household exert positive significant influence on intensity of soybean technology adoption for improved yields.

Table 25- Categorised household size and composition

Composition	Category	Frequency		Mean
		n	%	
Total size	<5	12	6.1	15
	5–24	164	83.2	
	25–44	18	9.1	
	45+	3	1.5	
Adult male	<5	137	77.20	4
	5–15	57	28.9	
	16–25	2	1.0	
	26+	1	0.5	
Adult female	<5	138	70.4	4
	5–10	45	23.0	
	11–15	11	5.6	
	16+	2	1.0	
Male children	<5	141	71.6	4
	6–15	53	26.9	
	16–25	2	1.0	
	26+	1	0.5	
Female children	<5	152	77.2	3
	5–10	39	19.8	
	11–15	4	2.0	
	16+	2	1.0	

Source: Field survey, Seini (2013).

Household size and rice yield

The relationship between household size and irrigated rice yields was assessed and presented in Table 26. The results indicate a unimodal distributional trend that peaks on 3.5-4.99 t/ha, the median group with two thirds of the farmers recording yields of 3.5-4.99 t/ha. More than three quarters of the farmers with household size of 5-24 people dominated across all the yield categories with over 54% producing yields of between 3.5 and 4.99 t/ha. All household categories are positively related to lower plot yields of 1.5 to 3.49 t/ha. Lower household sizes less than five (<5) and higher household sizes greater than fourty four (>44) people exhibited positive associations with yields in the range of 3.5 and 4.99 t/ha but are negatively associated with higher yields greater than 4.99 t/ha.

Table 26: **Household size and rice yield (t/ha)**

Household size	Rice yield (t/ha)						Total[%]
	1.5-3.49		3.5-4.99		>4.99		
	F	%	F	%	F	%	
< 5	0 (1.4)	0	12(1.5)	6.1	0(-1.5)	0	12[6.1]
5-24	28(0.3)	14.2	107(-0.1)	54.3	29(0)	14.7	164[83.2]
25-44	3 (0)	1.5	9(-0.8)	4.6	6(1.6)	3.0	18[9.1]
> 44	1 (0.7)	0.5	2(0)	1	0(-0.7)	0	3[1.5]
Total	32	16.2	130	66.0	35	17.8	197[100]

$X^2(6) = 10.496$, $p = .10$; (.) = z-residual

Source: Field survey, Seini (2013)

The number of people in a household show varying levels of relationships at different households sizes. Generally, the association between household size and yields per plot was however, positive and insignificant, $\chi^2(6) = 10.496$, $p > .05$. Therefore, household size is expected to show no influece on rice yields at the Bontanga project area. The results suggest that within certain limit of household size, rice yields decrease or increase from the range of 3.5 and 4.99 t/ha. Even at the current rice yields, potential estimated yields at the project site are yet unmet.

The results differ from the assertion of Affholder et al. (2009) that large household size relates with higher yields. The results indicate that household size is not the influencing factor for improved/increased irrigated rice yields. Large household sizes achieved yields of 3 to 4.99 t/ha across household sizes compared to 1.5-3.49 and greater than 4.99 t/ha.

Household size was assessed in the context of irrigated rice production labour source, which is expected to ease labour constraint, improve yields, and positively influence irrigated rice technologies adoption decisions. Extra labour requirement limited the use of mulch layer technology in the mountain slopes of Vietnam (Affholder et al., 2009). The a priori expectation of the influence of household size on yields was not met.

Household size and consumption of irrigated rice produce

The amount of rice consumed per household ranged between eighty-five and one thousand seven hundred (1700) kg of rice produce (Table 8). The results show a unimodal distribution of amount of rice produce consumed across categories of household size (Table 27). The implication is that for all household size categories, less produce is consumed with a peak consumption at a range of 5001 and 1500 kg and decline thereafter.

The pattern of distribution suggests a positive relationship between rice yield and rice yield consumed (Tables 25 and 26). There was a significant positive association between household size and quantity of rice produce consumed, χ^2 (9) = 19.669, p > .01.

Table 27: Household size and amount of rice consumed (kg)

Hh size	Quantity of rice consumed (kg)								Total F (%)
	85-500		501-1000		1001-1500		>1500		
	F	%	F	%	F	%	F	%	
< 5	3(.2)	1.5	8(.1)	4.1	1(-.2)	0.5	0(-.7)	0	12[6.1]
5-24	39(.4)	19.8	107(.3)	54.3	13(-.9)	6.6	5(-.6)	2.5	164[83.2]
25-44	1(-1.5)	0.5	9(-.7)	4.6	5(2.3*)	2.5	3(2.7**)	1.5	18[9.1]
> 45	1(.4)	0.5	1(-.7)	0.5	1(1.3)	0.5	0(-.3)	0	3[1.5]
Total	44	22.3	12.5	63.5	20	10.2	8	4.1	197[100]

χ^2 (9) = 19.669, p = .03*; **p > .01, *p > .05 (.) = z-residual [.] = total %

Source: Field survey, Seini (2013). Hh = household

The results suggest that household size of 25-44 people tends to be consumption oriented than commercial when yield consumed is in the range of 1001 to more than 1500kg. The significant positive association is located between household category 25-44 people and consumption categories 1001-1500 at $p < .05$ and >1500 kg at $p < .01$. The implication is that an increase in number of people in the household increases consumption of rice produce for household category of 25-44 people.

The use of farmer rice produce; either for household consumption, sale or both, from irrigated rice production is entrenched in the purpose of production. The use function serves as an incentive for technologies adoption to meet predetermined needs. The TPB stipulates that individual or social expectations motivate or influence individual behaviour through attitude formation toward behaviour. A farmer with adequate food supply from alternative sources for consumption would not be keen on technologies adoption if production is driven by consumption motive or expectations. Generally, the amount of rice consumed per house is a function of the number of people living in the house, barring cultural infractions and financial resources, especially so in the rural areas.

Types of Education and Training

The results presented in Table 28 indicate that over 78% of the respondents did not receive formal education. Close to one fifth of the respondents received non-formal education of various types including Arabic/Islamic education, night school on how to read and write. Majority (78%) of the literate farmers constitute basic and Junior high school graduates whilst only 2% were tertiary school graduates.

The various forms of education and training received by farmers are presented in Table 28. Every one out of five farmers received formal education. This is not surprising because, majority of farmers in the Northern part of Ghana have not received formal education (MoFA, 2011) and was expected to affect adoption of rice technologies.

The low level of formal educaton of farmers has the potential to affect the adoption of irrigated rice technologies. For instance, formal education gives farmers the ability to perceive, interpret and adopt new information compared to those without formal education (Kalineza et al., 1999; Mensah, 2008). Weldegiorges (2014) reported that 38% of farmers at Tach-Amacheho and 46% of farmers at Mekhone districts of Ethiopia, with low levels of education, did not adopt bee-hive technologies.

Receipt of formal education connotes social capital and the capacity to improve the knowledge base of the farmer. The higher the education of the farmer, the higher the ability of the farmer to access and understand various technological information for personal and community benefits (Kalineza et al., 1999; Mensah, 2008; Weldegiorges, 2014).

Table 28- Type of education and training of respondents

Variable	Frequency	
	n	%
Formal education	42	21.32
Non-formal education	37	18.80
Participation in MoFA extension education	84	42.60
Participation in irrigated rice technologies training	162	82.20
Membership in social group	124	60.40
Membership in irrigation farmers' organisation	155	78.70

Source: Field survey, Seini (2013)

The disposition and orientation of farmers who receive formal education have a good influence on the community. Education is expected to influence members to adopt technologies (Akpan, et al., 2012; Saka et al., 2005; Djokoto & Blackie, 2014).

Membership in social groups

Approximately two thirds of the respondents are members of social groups within the community, but majority (three quarters) of the respondents are members of the irrigation rice farmer organisation (Table 28). Membership in a social or farmer group/organisation is expected to improve knowledge through social networking, sharing, and information exchange among members. These experiences should influence and improve individual and group levels of adoption of technologies.

The substantial proportion of respondents belonging to groups/organisation suggests good social capital at Bontanga irrigation area. This would serve as a platform for social networking among respondents for information sharing, group learning for improved knowledge and consequently enhance levels of adoption of technologies (Langintou & Mekuria, 2008; Nyanga, 2012).

Formal education and extension trainings

Farmers of the Bontanga project irrigation area received extension services from several sources; one from the general MoFA extension, relating general agricultural practices; farmer organisation, relating specifically to introduced irrigation innovations on the project; and NGOs. Investigations were conducted on both services to assess farmers' participations. One out of every five of the respondents participated in MoFA extension education trainings offered to farmers. Over four fifth of the respondents also participated in irrigated rice technologies training, at the Bontanga irrigation area (Table 28).

The principle under RCT indicates that individual farmers would opt for training that best solves their needs. Therefore, the high participation in irrigated rice technologies training at the Bontanga irrigation area compared to MoFA extension, is not surprising. The extension education and training provided by MoFA are generic and focus on so many issues that did not address the specific rice production needs of farmers hence the low participation.

Further interactions with farmers indicated that extension visits by MoFA was not regular. A farmer was bold to indicate that the training did not meet their needs. Participation in extension training is expected to improve knowledge, skills and experience of farmers and positively influence levels of adoption of technologies. The participation in irrigated rice technologies training should positively affect levels of irrigated rice technologies adoption (Saka, et al., 2005; Baffour-Asare et al., 2013).

Formal education and MoFA extension training

A fifth of the farmers who received formal education also participated in extension training on the Bontanga irrigation project area (Table 29). This implies that over half of the farmers who received formal education participated in MoFA extension trainings. Receipt of formal education is positively related to participation in MoFA extension training. The participation of over half of the literate farmers in extension training is expected to increase human capital at the Bontanga area and expected to benefit farmers' technologies adoption decisions through social networks (Kalineza et al., 1999; Langintuo & Mekuria, 2008; Mensah, 2008; Ojiako, 2011;).

The results indicate that the less educated a farmer, the higher the participation in extension training. However, the chi-square statistics; $\chi^2 = 2.07$, $p > .05$, indicate that there is no significant association between formal education and respondent's participation in extension education.

Farmers' participation in training describe the involvement of farmers in educational training activities with respect to specific technologies to improve farmers' knowledge and skills, through capacity building of the farmers.

Table 29: Formal education and MoFA extension participation

Formal Education	Participation in extension education				Total[%]
	Participated		Never participated		
	Freq.	%	Freq.	%	
No formal education	62(-0.5)	31.5	93(0.4)	47.2	155[78.7]
Received formal education	22(1.0)	21.3	20(-0.8)	10.2	42[21.3]
Total	84	42.5	113	57.4	197[100]

χ^2 (1) = 2.07 p = .150. (.) = z-residual.

Source: Field survey, Seini (2013)

Generally, the purpose of participation in extension training is to improve farmers' decisions making processes to adopt agricultural innovations. Participation in training is expected to have a positive impact on farmers' adoption decisions (Adesina & Baidu-Forson, 1985; Baffoe-Asare et al., 2013; Saka et al., 2005). MoFA extension describes the main-stream extension training offered by MoFA to farmers on generic topics related to general agricultural practices and technologies.

Participation in MoFA extension training is expected to equip farmers with information, knowledge, and skills to improve farmers' technologies adoption. Participation in training is expected to positively impact on farmers' adoption decisions. For instance, in assessing factors influencing small farmers' adoption of improved rice varieties, participation in intervention programme training was reported to have a significant positive relationship on farmers' adoption of improved rice varieties (Saka et al., 2005). On cocoa high-tech technologies adoption, Baffoe-Asare et al. (2013) similarly found extension participation to have highly significant positive association on the probability of farmers to adopt CODAPEC and Cocoa High-Tech technologies. This is corroborated by Adesina and Baidu-Forson (1985) report of a positive significant ($p = 0.05$) relationship of extension related workshops with adoption of improved sorghum in Burkina Faso.

Formal education and participation in irrigated rice technologies training

Irrigation farming is a knowledge intensive farming enterprise for all cultivation practices and premised the formation of irrigation rice farmer organisation through the FAMPIM project for knowledge creation and delivery. The irrigation farmers' organisation was charged with the responsibility of providing information, training, knowledge, and skills as related to irrigation technologies and practices among others. This strategy provided extension services to farmers on specialised irrigation knowledge and skills to members for capacity building towards irrigated rice technologies adoption and practice. Over four-fifths of the farmers participated in the irrigated rice farmer organisation (Table 28).

The high number of farmers' participation in irrigated rice farmers' organisation is expected to influence irrigation technologies adoption. The assessment of the relationship between formal education and participation in irrigated rice technologies training is depicted in Table 30. Over three quarters of farmers who received formal education participated in irrigated rice farmers' organisation training. This is an expected finding because formal education is expected to influence technologies adoption decisions through better ability to perceive, interpret and respond to innovation information compared to their compatriots without formal education (Kalineza et al., 1999; Mensah, 2008). It is expected that the high proportion of literate farmers' participation in irrigated rice farmers' training would improve human capital in the Bontanga irrigation area. It would as well increase the knowledge base of social networks in the area.

Table 30: **Formal education and irrigated rice technologies training**

Formal education	Training on irrigated rice technology				Total[%]
	Participated		Never participated		
	Freq.	%	Freq.	%	
No formal education	129(0.1)	65.5	26(-0.3)	13.2	155[78.7]
Received formal education	33(-0.3)	16.8	9(0.6)	4.6	42[21.3]
Total	162	82.2	35	17.8	197[100]

χ^2 (1) = 0.49, p = .48. (.) = Z-residual

Source: Field survey, Seini (2013)

Receipt of formal education is negatively associated with participation in irrigated rice farmers' organisation training. The results: χ^2 = .49, p > .10, indicate a positive non-significant association of formal education with participation in irrigated rice technologies training offered by the farmer organisation. Literate farmers are already conversant with the irrigated rice technologies training offered by the farmers' organisation.

Formal education and status in community

Community leadership confers social status on a member in the community. Table 31 depicts a description of respondents' formal education and status in community. None of the literate farmers held a leadership position in their communities. All chiefs or sub chiefs, one sixth of the farmers, did not receive formal education. It is not unusual that none of the farmers who received formal education were not chiefs because in the Dagbon tradition, chiefs are made from gates of chiefdom clans. Therefore, if none of the literate farmers belong to any chiefdom clan, they cannot be made chiefs. On the relationship of formal education and position in community, receipt of formal education is negatively associated with being a chief in the community. Similarly, being a chief on the other hand was positively related to non-receipt of formal education.

There was a positive non-significant association of formal education and status in community, $\chi^2 = 3.463$, $p > .10$. The implication is that farmers who are without formal education have the potential of becoming chiefs in the communities, barring any cultural infractions, compared to literate farmers.

Chiefs have good social networks, the trust of people, and wield the power of control, over their subjects and thus expected to exert an influence on their technology's adoption decision options (Baete, 2012). It is important to note that chiefs are generally the first point of contact at the introduction of innovations in the rural communities and the chiefs' attitude towards the innovation is expected to influence innovation adoption decisions. Chiefs are major decision-makers of the village.

Table 31: Formal education and status in community

Receipt of formal education	Status in community				Total[%]
	Member		Chief		
	F	%	F	%	
No formal education	143(-0.2)	72.6	12(0.8)	6.1	155[78.7]
Received formal education	42(-0.2)	21.3	0(-1.6)	0	42[21.3]
Total	185	93.3	12	6.1	197[78.7]

χ^2 (1) = 3.463, p = .074, (.) = z-residual

Source: Field survey, Seini (2013)

Under appropriate community entry practices, the chiefs are the first people to be informed about an innovation to be introduced into the village for the first time. Their attitude towards innovation introduction and subsiquent use of the technology influences community members' use of the technology (Baete, 2012). Adesina and Baidu-Forson (1995) found that being a community head negatively influences technologies adoption in Burkina Faso.The technical knowledge levels, skills, and trust in the leaders are important factors influencing technologies adoption of the constituents (Baete, 2012).

Formal education and status in household

Anecdotal literature indicates that household head connotes being a leader of a household and specifies who constitutes the main decision-maker and has the responsibility of taking major decisions concerning the household. The decision domain includes social and business (agriculture and related decisions). The household head takes decisions concerning incorperation of innovations into the farming practices of the household and thus influences the adoption decisions of the household.

Close to two thirds of the respondents were household heads and more than half of the household heads did not receive formal education (Table 32). Farmers who did not receive formal education are positively associated with being a household head compared to farmers who received formal education at the Bontanga area. Being a household head relates to owning a house and living therein with the family irrespective of formal education and being judged responsible to cater for the household.

Table 32: Respondents formal education and position in household

Formal education	Position in household				Total[%]
	Member		Head		
	F	%	F	%	
No formal education	47(-1.4)	23.9	108(1.1)	54.8	155[78.7]
Received formal education	26(2.6**)	13.2	16(-2.0*)	8.1	42[21.3]
Total	73	37.1	124	62.9	197[100]

X^2 (1) = 14.131, p = .000. (.) = z-residual. ** = p > .01, * p > .05.

Source: Field survey, Seini (2013)

It is relevant to note that majority of farmers did not receive formal education therefore, the quarter of farmers who received formal education are among the younger generation who did not own houses hence their poor representation as household heads. The results: χ^2 = 14.131, p < .001, reveal a statistically significant relation between formal education and status in household. Farmers who received formal education exhibit a negative significant association with being a household head, p < .05 and a positive significant association with being an ordinary member of the household, p < .01.

Formal education and membership in irrigated rice farmers' organisation

Farmers at the Bontanga irrigation area were organised into a farmer organisation through FAMPIM project, to among other functions, disseminate technology related information to farmers. Enrolling as a member of an agricultural organisation or group enhances the farmer's knowledge, skills, and ability to access innovation information through improved social networks (Nyanga, 2012; Langintuo & Mekuria, 2008).

Receipt of formal education has been found to better improve farmer ability to access, interpret and comprehend innovation information and therefore better influence innovation adoption decisions (Mensah, 2008; Kalineza et al., 1999; Akpan, et al., 2012). For instance, Mensah (2008) and Kalineza et al. (1999) indicated that formal education offers farmers the capacity to perceive, interpret and respond to innovation faster than compatriots without formal education. Following this, Akpan et al. (2012) found formal education as a positive associate of fertilizer use intensity.

The results of the relationship between membership in irrigated rice farmer organisation and receipt of formal education are presented in Table 33. One out of four of the members of the farmer organisation had received formal education. Being a member of irrigated rice farmer's organisation and having received formal education serves as human capital, hence expected to influence innovation adoption decisions.

Receipt of formal education was found to exhibit negative association with being a member of the farmer organisation. The results indicate that there was no significant association between receipt of formal education and being a member of irrigated rice farmer's organisation, $\chi^2 = .197$, $p > .10$, implying that receipt of formal education reduces the potential of a farmer being a member of the irrigated rice farmer's organisation at the Bontanga irrigation area. The findings indicate a high proportion; over three quarters, of farmers are members of the irrigated rice farmer's organisation.

Table 33: **Formal education and membership in irrigated rice farmer organisation**

Educational	Member of irrigation farmer organisation				Total	
	Member		Not a member			
	F	%	F	%	F	%
No formal education	123(-.1)	62.4	32(-.2)	16.2	155	78.7
Received formal education	32(-.2)	16.2	10(.3)	5.1	42	21.3
Total	155	78.7	42	21.3	197	100

χ^2 = .197, p = .657, (.)= z-residual > .10

Source: Field survey, Seini (2013)

The implication of the high membership to the farmer organisation reflects a good social network at the project area that would influence innovation adoption decisions. However, there is a high likelihood of poor information access, perception, interpretation, and comprehension because of the low proportion of farmers who have received formal education (Mensah, 2008; Kalineza et al., 1999). Consequently, innovation adoption decisions are likely to be impinged upon at the Bontanga irrigation project area. The high proportion of farmers without formal education would need a conscious educational effort at innovation dissemination stages to sensitise farmer's attitudes toward innovation adoption. Synergistic effects of formal education and membership in farmer's organisation namely networks, credit, information, inputs, knowledge, and skills, would influence farmer's innovation adoption options.

Formal education and status in irrigated rice farmer organisation

The findings (Table 34) indicate that one out of every five farmers who belong to irrigated rice farmer organisation receive formal education. One out of every twenty who held a membership position in irrigated rice farmer organisation, received formal education. Farmers who receive formal education exhibited a positive not significant association with being a leader of the irrigated rice farmer organisation.

Group leaders have the opportunity of being in constant contact with the membership of the organisation and combined with their leadership functions, are anticipated to influence members' innovation adoption decisions. Leadership of farmer group organisation functions as an influence on the members of the group through their knowledge and skills, and attitudes towards technologies and the members of the group.

Their influence serves to improve technologies information dissemination and adoption decisions (Baete, 2012). Formal education of members is also indicated to affect an individual farmer's innovation adoption as well as influence colleague farmers of the farmer's social networks (Akpan et al., 2012; Saka et al., 2005; Mensah, 2008; Kalineza et al., 1999).

Table 34: Formal education and status in irrigated rice farmer organisation

Educational level	Position in irrigated rice farmers organisation				Total	
	Leader		Member			
	Freq.	%	Freq.	%	Freq.	%
No formal education	6(-.1)	3.9	117(0)	75.5	123	79.4
Received formal education	2(.3)	1.3	30(-.1)	19.4	32	20.6
Total	8	5.2	147	94.8	155	100

χ^2 (1) = .098. P = .755. (.) = z-residual, p > .10.

Source: Field survey, Seini (2013)

The observed associations of formal education and status in irrigated rice farmer organisation is however, of no significant effect, χ^2 = .098, p > .10, at the Bontanga irrigation project area.

Level of Farmer's Formal Education

One in every five of the sampled farmers had received formal education (Table 28) of various levels namely: basic or primary, junior high, ordinary level, senior high and tertiary education (Table 35). Majority of the farmers, over three quarters, who received formal education could be described as semi-illiterate, deficient in the capacity to search, read and comprehend agricultural innovation information because of their low educational level and is expected to impinge on technologies adoption decision.

Table 35: Educational levels of respondents

Educational Level	Frequency	
	N	%
Basic	15	35.70
Junior high school	13	31.00
Ordinary Level	2	4.80
Senior high school	11	26.20
Tertiary education	1	2.40
Total	42	100

Source: Field survey, Seini (2013)

The relationship of level of education with participation in MoFA extension, irrigated rice technologies training, membership in irrigation farmer organisation, and status in irrigated rice farmer's organisation, was assessed and presented in subsequent sections.

Educational level attained and participation in extension education

Farmers' educational level attained and participation in extension education is depicted in Table 36. Over half of the farmers who received formal education participated in MoFA extension education training. This is anticipated to upscale the knowledge, skills and capacity to source and comprehend irrigated rice technologies information. Consequently, their human capital is expected to increase thereby improving their capacity to influence innovation adoption options.

Table 36: **Educational level and participation in extension education**

Educational level	Participation in extension education				Total
	Participated		Never participated		
	F	%	F	%	F[%]
Basic	9(0.4)	21.4	6(-0.4)	14.3	15[35.7]
JHS	6(-0.3)	14.3	7(0.3)	16.7	13[31.0]
O'level/shs	7(0.1)	16.7	6(-0.1)	14.3	13[31.0]
Tertiary	0(-0.7)	0	1(0.8)	2.4	12[28.6]
Total	22	52.4	20	47.6	42[100]

χ^2 (3) = 1.66 p = .645. (.) = standardised residual (z-residual).

Source: Field survey, Seini (2013).

Farmers' participation in extension training has been demonstrated to positively influence innovation adoption behaviour of participating farmers (Baffoe-Asare et al., 2013; Saka et al., 2005). Furthermore, farmers who have received formal education are expected to better influence technologies adoption behaviour of compatriots through their social networks.

It was observed that farmers with basic and intermediate educational levels; ordinary and senior high school, were positively associated with MoFA extension training activities compared to junior high school and tertiary educational levels. The statistics, (χ^2) = 2.460, p > .10, however, demonstrate a non-significant relationship between levels of educational attainment and extension participation. The level of education and participation in extension education of the farmer are thus not statistically related.

Educational level attained and membership in irrigated rice farmer organisation

Table 37 depicts outcome of an assessment of the level of formal educational attainment and membership in irrigated rice farmers' organisation. Over three quarters of the farmers who received formal education are members of the irrigated rice farmer organisation. Basic and junior high school levels constitute more than half of the literate farmers who belong to the irrigated rice farmer organisation. The high proportion of literate farmer enrolment as members of the irrigated rice farmer organisation demonstrates literate farmers' awareness in the value of the benefits from being members of the farmer organisation as postulated in the theories of RCT and TPB. This is especially so for holders of the lower levels of formal education who lack adequate knowledge in sourcing, reading, and interpreting irrigated rice technologies information (Mensah, 2008; Kalineza et al., 1999; MoFA, 2009).

It was observed that basic and ordinary levels of formal education are negatively associated with membership in irrigated rice farmers' organisation and junior high, senior high, and tertiary level of formal education are positively so related. The observed chi-square statistic; $\chi^2(3) = .10$, indicates there is no association between level of education and membership in irrigated rice farmers' organisation.

Formal education and membership in farmer group or organisation have been shown to influence farmers' technologies adoption decisions (Nyanga, 2012; Langintuo & Mekuria, 2008; Baete, 2012). Membership in farmer organisation of literate farmers is therefore expected to upscale adoption of irrigated rice technologies resulting from increased knowledge.

Table 37: Education level attained and membership in irrigation farmers' organisation

Educational level	Membership in irrigation farmers' organisation				Total	
	Member		Not a member			
	F	%	F	%	F	%
Basic	9(-.7)	21.4	6(1.3)	14.3	15	35.7
JHS	11(.3)	26.2	2(-.6)	4.8	13	31.0
O'level	1(-.4)	2.4	1 (.8)	2.4	2	4.8
SHS/Tertiary	11 (.6)	26.2	1(-1.1)	2.4	12	28.6
Total	32	76.2	10	23.8	42	100

$(\chi^2)(3) = 5.017$. $p = .170$ (.) = z-residual

Source: Field survey, Seini (2013)

Educational level attained and participation in irrigated rice technologies training

Participation in irrigated rice technology training, delivered by irrigated rice farmers' organisation, was examined in relation to highest educational level attained (Table 38). More than three quarters of farmers who receive formal education participated in irrigated rice technology training. The high proportion of participation in irrigated rice technologies training by farmers who received formal education implies a high level of trust in the farmers' organisation and the relevance of training offered by the irrigated rice farmers' organisation.

About half of the literate irrigated rice farmers, who participated in irrigated rice technologies training, received basic school education which exhibited a positive not significant association with participation in irrigated ricea technologies training.

Table 38: **Educational level and participation in irrigated rice technology training**

Educational level	Training on irrigated rice technology				Total[%]
	Participated		Never participated		
	F	%	F	%	
Basic	13(0.4)	31.0	2(-0.7)	4.8	15[35.8]
JHS	10(-0.1)	23.8	3(0.1)	7.1	13[30.9]
O'level	1(-0.5)	2.4	1(0.1)	2.4	2[4.8]
SHS/Tertiary	9(-0.1)	21.4	3(0.3)	7.1	12[28.5]
Total	33	78.6	9	21.4	42[100]

χ^2 (3) = 1.665 p > .672

Source: Field survey, Seini (2013)

That low level of formal educational attainment adversely affecct adoption and utilisation of agricultural innovations (MoFA, 2009) differs from the results. The association of higher levels of formal educational attainment was however, negative and not significant.

The statistics indicate that levels of formal education attained demonstrate no statistical association with participation in irrigated rice technologies training; χ^2 = 1.665, p > .10. It is important to note that level of educational attainment coupled with participation in technologies training both increase human capital through increase in knowledge, skills and capacity to source, interpret and understand technologies related information (Mensah, 2008; and Kalineza et al., 1999). Furthermore, receipt of formal education, participation in irrigated rice farmers training increases social networks of participating farmers.

Therefore, high levels of formal education and participation in irrigated rice technologies training is expected to favourably upscale innovation adoption (Baffour-Asare et al., 2013; Saka et al., 2005). DIT stipulates that extension contact and social networks are important conduits to innovation diffusion and subsequent adoption hence the participation in irrigated rice technologies training is anticipated to influence adoption decisions of irrigated rice technologies.

Educational level attained and position in irrigated rice farmer organisation

More than one fifth of the farmers received formal education (Table 8). The interaction of level of educational attainment and status in irrigated rice farmer organisation, for possible associations, is depicted in Table 39. One out of every twenty farmers who received formal education is likely to be a leader of the irrigated rice farmer organisation. Farmers with junior and senior high school levels were the only groups elected to hold leadership positions in the irrigated rice farmer organisation. The reason for the low proportion of literate farmers in the leadership of the organisation might be related to the generally low proportion of literate farmers at the project area.

Table 39- Educational level and position in irrigated rice farmers' organisation

Educational level	Position in irrigated rice farmers organisation				Total	
	Leader		Member			
	F	%	F	%	F	%
Basic	0 (-.8)	0	15 (.2)	35.7	15	35.7
JHS	1(.5)	2.4	12(-.1)	28.6	13	31.0
O'level	0(-.3)	0	2(.1)	4.8	2	4.8
SHS	1(.7)	2.4	10(-.1)	23.8	11	26.2
Tertiary	0(-2)	0	1(.0)	2.4	1	2.4
Total	2	4.8	40	95.2	42	100

χ^2 (3) = .970 p = .809 (.) = standardised residual

Source: Field survey, Seini (2013)

Both junior and senior high levels of formal education were observed to positively associate with being a leader in the irrigated rice farmer organisation. The results: χ^2 = .970, p > .10, demonstrate a positive non-significant association with level of educational attainment and being a leader in the irrigated rice farmer organisation.

The leadership qualities of trust and confidence of members in the leaders are important in influencing members' technologies adoption decisions. Coupled with receipt of formal education, being a leader in the organisation, their technical knowledge, skills and attitude towards technologies and members (Baete, 2012), and improved social networks, are envisaged to influence innovation adoption decisions (Nyanga, 2012; Langintuo & Mekuria, 2008).

Participation in extension education and irrigated rice technology training

Farmers of the Bontanga project irrigation area received extension services from two sources; one from the general MoFA extension relating to general agricultural practices, and the other from the FAMPIM PROJECT, specifically relating to introduced irrigation innovations on the project. Investigations were conducted on both services to assess farmers' participation.

One out of five farmers participated in MoFA extension education trainings offered to farmers compared to 82% participation in irrigated rice technologies training at the Bontanga irrigation area by farmers without formal education (Table 7). The RCT indicates that individuals (farmers) would opt for training that best solves their needs. Therefore, the high participation in irrigated rice technologies training at the Bontanga irrigation area is not surprising. The extension education and training provided by MoFA is generic and focuses on so many issues that may not address the specific rice production needs of farmers hence the low participation.

Moreover, interactions with farmers indicated that extension visits by MoFA was not regular. A farmer was bold to indicate that the training did not meet their needs. The low participation in extension training is expected to result in a declined growth in knowledge, skills, and experience of farmers and negatively influence levels of adoption of technologies (Saka,et al., 2005; Baffoe-Asare et al., 2013).

Support for Adoption of Irrigated Rice Technologies

This section presents the assessments of farmers' perception on selected factors that lend support for the adoption or otherwise of irrigated rice technologies. The factors have been classified into thematic areas namely: sources and use of technologies related information, institutional support, and access to resources and services.

Support in the form of services and resources play important roles in agricultural technologies adoption in terms of availability and utilisation of the services or resources. Institutional support included production and related information, training, credit, market and inputs support from the Ministry of Agriculture (MoFA), Non-Governmental Organisations (NGOs) and Savannah Accelerated Development Authority (SADA) which had been providing support to farmers during the period.

Institutional support

Table 34 presents results on production and related information, training, credit, market, and inputs support from the Ministry of Agriculture (MoFA), NGOs, and SADA.

The results indicate that over three quarters of the farmers received information support from MoFA, NGOs, and SADA (Table 40). MoFA provided information support to over half of the farmers at Bontanga irrigation area. Similarly, a third of the farmers received information support from NGOs. The results imply that MoFA played a leading role in providing access to information to irrigated rice farmers at the Bontanga irrigation project area.

This is attributed to MoFA's traditional speciality in organising and delivering content relevant information to farmers.

NGOs and SADA together provided information to a little over one third of the farmers. Over a quarter of the sample farmers received training support from MoFA, NGOs, and SADA combined. The results indicate that two out of every five farmers were trained by MoFA and one half were trained by NGOs. Therefore, MoFA and the NGOs were important in providing training support to the farmers at the Bontanga irrigation area.

Table 40- Proportion (%) of farmers that received institutional support

Support type	Percent (%) of farmers that received support			Total (%)
	MoFA	NGOs	SADA	
Information	54.8	28.9	7.1	68.5
Training	43.1	49.2	17.8	77.2
Inputs	12.7	19.3	31.0	51.8
Market	3.6	11.7	2.0	16.8
Credit	1.5	3.6	13.7	17.8

Source: Field survey, Seini (2013). n = 197

NGOs were dominant in providing training (49%) and market (12%) support to farmers though to a small proportion of farmers. The seeming dominance in market support exhibited might be attributed to the introduction of the Jasmine seed variety and produce market for farmers' rice produce by USAID.

The purpose of providing extension training support was to improve and facilitate farmers' technologies adoption decisions-making processes.

Training support is aimed at providing and sharpening farmers' production and management skills to improve efficiency and effective practices. The provision of/and farmer participation in extension interventions have been reported to exert positive significant influences on farmers' technology adoptions (Adesina & Baidu-Forson, 1985; Baffoe-Asare et al., 2013; Saka et al., 2005). The institutional support in information and training is therefore anticipated to promote adoption of irrigated rice technologies.

Credit support to farmers was virtually negligible from all institutions under study. SADA provided credit support to less than one fifth of the farmers whilst MoFA and NGO provided credit support to less than four (4%) per cent of the farmers. Though the proportion of farmers served was low, it was observed that SADA was the best institution in providing credit support to farmers in the form of agricultural credit and inputs.

The results indicate that farmers at the Bontanga irrigation area lack credit support which could constrain farmers' adoption decisions of irrigated rice technology at the project area because farmers' differential access to credit or capital has been shown to account for the differential technologies adoption and rates of technologies adoptions (Feder et al., 1982; Michael et al., 1999; Nyanga, 2012).

Market support for irrigated rice produce has been found to be very negligible from all the listed institutions. For instance, though NGOs were the best in providing market support, they did so for less than 0.12 of the irrigated rice farming population. Farmers at the Bontanga irrigation area lacked market support. This suggests that the market support provided by the USAID along the introduction of Jasmine seed variety had not taken effect or not effective enough or did not cover a good proportion of the farmers. This inadequate market support could constrain irrigated rice technologies adoption at the Bontanga irrigation area.

Inputs, especially fertilizer and weedicide are a critical component for irrigated rice production for increased yield and productivity of the crop. Support to farmers in relation to accessibility and affordability of inputs is anticipated to influence farmers' technology adoption options. The effect of SADA's support was felt in input support where they provided input support to about a third (31%) of the farmers. SADA was found to have supplied farmers with fertilizer and weedicides on credit or credit funds to purchase inputs. The coverage with respect to proportion of farmers served was however, very low (14%), to promote adoption of irrigated rice technologies.

Except information support, the other institutions were logistically constrained and capacity incompetent, to be able to serve all farmers which led to a selection bias in service or resource delivery. The total effect of all institutional support indicates that in irrigated rice technology options, best results achieved were for both training and information delivery.

The cumulative support provided by all institutions to farmers is depicted in Table 40. The most important institutional support to farmers was training, provided to over three quarters of the farmers. Information support to respondents accounted for less than three quarters of the farmers. Generally, the results reveal that farmers lack access to institutional support for important services as credit, input, training, and market at the Bontanga irrigation project area and therefore farmers are confronted with constraints to adoption of irrigated rice technologies.

This compares with the assertion of Feder et al. (1982) that lack of credit, capital, limited access to information, and inputs constitute constraints to rapid technologies adoption. The findings further compare to Feder et al., (1985); Nyanga (2012); Michael, Robert, and Dankyi (1999) respectively that constrained and differential access to services and resources explain why innovations fail to diffuse and be adopted and thus explain the differential innovation adoption and adoption rates.

Access to Resources and Related Services for Irrigated Rice Production

Farmers' perception on access to resources and services namely roads, inputs, irrigation land, extension, mechanisation, and credit, produce market and irrigation water on irrigated rice technologies adoption are depicted in Table 41. Access describes the ease of availability and affordability of the resource or service. Inadequate access to a resource or service makes the service or resource a constraint to innovation adoption decisions.

Constrained and differential access to services and resources are reasons why innovations fail to diffuse and be adopted (Feder et al., 1982) and explains the differential innovation adoption and adoption rates (Nyanga, 2012; Michael, Robert, & Dankyi, 1999).

More than a quarter of the farmers indicated that road services at the Bontanga irrigation area was good and by this proportion of response, road services at the Bontanga irrigation area is poor and therefore expected to constrain irrigated rice technologies adoption. Inadequate road services are anticipated to constrain input and market access and thus influence farmer innovation adoptions.

Table 41: **Farmers' perception on access to resources and services for irrigated rice production**

Services	Perception: Good	
	n	%
Roads	41	20.8
Inputs	23	11.7
Land	80	40.6
Extension	35	17.8
Mechanization	63	32.0
Credit	8	4.1
Market	101	51.3
Irrigation water	182	92.4

Source: Field survey, Seini (2013). n = 197

Access to inputs is considered good only by 12% of the farmers implying that access to inputs at the Bontanga irrigation area is inadequate and therefore a constraint on adoption of irrigated rice technologies. Poor access to inputs implies that the input is unavailable, unaffordable or a distant away from point of use. The poor road services are expected to affect input availability, cost in terms of time, and likely to increase input prices. Higher cost and prices of inputs lower the levels of farmers technologies adoption (Rogers, 2003).

This compares with RCT model postulation that human choices are influenced by cost and benefit analysis therefore high cost and/or price of inputs is anticipated to influence adoption innovation decisions. For instance, Affholder et al. (2009) reported that the price of nitrogen fertilizer, pesticides and Muccuna seeds prevented the use of direct-seeding mulch technology in Vietnam.

Two out of every five farmers indicated acces to land was good. Thus, access to land at the Bontanga irrigation area is poor and anticipated to adversely influence technologies adoption decisions. That non-availability of cultivable land has been highlighed as the major constraint to adoption of agricultural innovation (de Janvry et al., 2011; Carletto et al., 2007; Pingali et al., 2008) compares with the findings. de Janvry et al. (2011) posit that small land size increases liquidity constraint and lowers innovation adoption of farmers however, limited availability of land spurs the use of organic fertilizer under poor resource settings (Kasirye, 2013; Pingali et al., 2008). This is so because human behaviour is influenced by cost-benefit analysis as postulated by RCT and expected outcome of human behaviour as in TPB. Therefore, if the outcome of adoption behaviour yields better dividends, farmers adopt the innovation irrespective of size of land.

The results show that access to extension services at the Bontanga irrigation area was poor because less than one quarter of the farmers considered extension services as good i.e., over 82% of the farmers indicated access to extension services was poor. DIT hypothesises that agricultural information, knowledge, and skills are provided through extension service agents and peers through social networks. Thus, access to extension services create and sustain human capital in farmers through provision of information and training for increased knowledge and skills hence envisaged to affect technologies adoption.

Baete (2012) posited that availability of extension services positively influenced farmers' adoption of rice technologies in the Fiu village of Malaita province. Baete further posits that the project was within the Malaita provincial agricultural division therefore offered a good access which influenced farmers' adoption decisions. The poor access to extension services is therefore expected to exert a negative influence on farmers' adoption decisions of irrigated rice technologies.

The results indicated that about one third of the farmers considered mechanisation services to be good at the Bontanga irrigation area. It is an important notice that the irrigation project has no machinery to serve farmers and mechanisation services are therefore provided by private tractor owners who charge high prices or are late in providing the services, as noted by some farmers. It is not surprising therefore that only a third of the farmers considered mechanisation services to be good. Constrained access to mechanisation services is thus anticipated to constrain innovation adoption because all field preparation practices; ploughing, harrowing, levelling, and puddling, were mechanised operations. Thus, timely availability and affordability of mechanisation serves as key to irrigated rice technologies adoption and continuous use at the Bontanga irrigation area.

The majority (96%) of the farmers considered access to credit as poor. The high proportion of farmers' perception of poor credit access is anticipated to negatively influence technologies adoption options at the Bontanga irrigation area. Credit access was cited as responsible for the low adoption of fertilizers at the Bontanga irrigation project area. The findings compare with the report of Akpan et al. (2012) that access to credit had a negative significant influence on fertilizer use intensity in Nigeria. Langintuo and Mekuria (2008) also intimated that because cash is required to purchase complementary inputs, constrained capital or accumulated savings, this prevented small holder farmers from investing in technologies. Variations in access to credit has been cited as being responsible for variations in adoption and rates of technologies adoption (Nyanga, 2012; and Michael et al., 1999). The influence of constrained access to credit is particularly true for indivisible technologies/machinery related technologies (Feder et al., 1982).

The produce consumption and sales pattern of farmers (Table 8) suggest that the farmers are commercially oriented therefore access to produce market is very relevant for adoption of technologies. Half of the farmers perceived access to market to be good at the Bontanga irrigation area. The introduction of jasmine rice variety was complemented with market support to promote and scale up the adoption of the seed variety and explains the very high adoption of improved seed technology and the moderate perception on access to market.

The provision of market support was also expected to prevent market women from taking undue advantage of the farmers produce as well as solving the constraint of unavailable market. However, the provision of market access alone would not solve the challenge because farmers would access credit from market women to secure complementary inputs in lieu of access to farm produce. The results imply that half of the farmers face market constraint at the project area and therefore is expected to influence farmers adoption decisions.

Results indicate that among the services under study, access to irrigation water was considered good by a majority (92%) of farmers. This is expected because the only reason farmers are at the irrigation site is to take advantage of the available irrigation water to complement their rainy season farming activities. The findings corroborate the assertion of Feder et al. (1982) that unconstrained access to complementary inputs such as water, seeds, chemicals etc. promotes rapid technologies adoption process. The availability of irrigation water is envisaged to influence irrigated rice technologies adoption at the Bontanga area.

Sources of Irrigated Rice Technologies Information

DIT stipulates that innovation information is communicated to farmers through appropriate channels of communication in the dissemination and adoption process. Table 42 presents irrigated rice farmers' sources of technologies related information namely: radio, television, friends, family members, group meetings and farmers' forum and demonstrations.

Radio was found to be the major information source used by about three quarters of the respondents. Internet was considered as the least source of information for irrigated rice technology. Three percent (3%) of farmers indicated that internet was a major information source because of the large proportion of farmers who did not receive formal education. Agricultural print material and internet are channels for the literate (Dauda, Chado, & Igbashal, 2009) therefore the result for internet is expected.

Radio is a common electronic media for the rural communities which can be relied on even in the absence of electricity and common to rural farmers. It was observed that Simli radio (a Danish NGO) broadcasts farming news programmes in the local dialect within the district Bontanga irrigation project is situated. Radio was found compatible with their language (Rogers, 2003) and explains the popularity of radio as a major information source.

The results compare to the position of Mirani et al. (2001) in the study of perceptions of farmer technology adoption in India, that farmers had ranked radio as first information source. In tandem with the results, in a study on use of information sources and services, Adio et al. (2016) showed that 45% of farmers rated radio as a moderate information source.

Table 42- Distribution of information sources for irrigated rice technologies

Statistic	Information sources											
	Radio	Group meetings	Friends	Family members	Farmers forum	Demonstrations	Television	Input suppliers	Res. Institutions	Educ. Institutions	Print	Internet
(%)	94.9	86.3	85.3	74.1	64.0	57.4	50.3	49.2	38.6	29.4	13.7	3.0
1	25.4	52.8	42.6	42.6	44.7	45.2	23.9	46.7	33.0	27.9	12.7	0.5
2	69.5	33.5	42.6	32.5	19.3	12.2	26.4	2.5	5.6	1.5	1.0	2.5
SD	.44	.49	.50	.50	.46	.41	0.50	.22	.35	.22	.27	.41

Source: Field survey, Seini (2013). Scale: 1 = a source, 2 = major source.

Respectively, a quarter, half, and close to half of farmers rated group meetings, friends, family members, farmers' forum, and demonstration as major information sources. The findings compare with the report of Dauda et al. (2009) that 38% and 29 % of the farmers sourced information from friends and radio respectively and that 62, 23, and 13 % respectively prefer extension, friends, and radio as sources of farming information. The findings further compare with Dauda et al. (2009) that 49% of farmers sourced information from extension agents, through meetings, farmers' forum, and demonstrations. The findings, however, differ from Adio et al. (2016) findings of 84% and 85% moderate rating for friends and television because these information sources are rated as major ones at the Bontanga irrigation area.

Half of the farmers considered television as an information source and 26% of the farmers rated television as a source which compares with Mirani et al. (2001) position, in the study of perceptions of farmers' technology adoption in India, that farmers ranked television as second.

Agricultural print material and internet were not considered as an important information source at the Bontanga irrigation project area because of the very high proportion of farmers who did not receive formal education. In tandem with the results, Mirani et al. (2001) reported that print material was rated as third information sources for ploughing information.

The result is expected because for farmers without formal education, the language on television and print is inappropriate. Furthermore, agricultural print materials are unavailable in the rural communities. Internet as a source of information is an elitist information source (Dauda et al., (2009) and explains why agricultural print material and internet, are not sources of information, for farmers who did not receive formal education. The results compare to Nzonzo (2016) that the major sources of information on input availability are television 5%, radio 21%, for irrigated farmers of Mwea irrigation of Kenya. Nzonzo furthermore, indicated that for quality of inputs, 18% and 27% of farmers used television and radio respectively but internet was used by only 1% of farmers.

The results indicate that social networks such as friends (50%), family members (43%), group meetings (39%), farmers' forum (30%) and demonstration (21%), were perceived as major sources of irrigated rice technologies information. This implies that social capital in the form of social networks are important major sources of irrigated rice technologies information. Singh and Pandy (2008) posit that the top-down extension system determines the role of organisations and communication methods/techniques used and the relevance is usually questionable. Singh and Pandy (2008) included educational institutions (Agricultural University), Department of agriculture extension as well as input suppliers, electronic media (radio, tv among others), print as well as neighbours and family members. The results corroborate with Singh and Pandy (2008) that rice farmers, in order of effectiveness, ranked neighbours, family members, and radio as major information sources. The results show that input dealers are not important sources of irrigated rice technologies information.

However, in the study of farmers' perceptions on farmers' perception and factors affecting adoption of improved dual-purpose cowpea, Kristjanson et al. (2005**)** show that in order of importance, extension agents, neighbours and traders are the three most important information sources.

Use Frequency of Information Sources

The relevance of information sources was sought through the frequency of use of the selected sources of information in accessing technologies related information as presented in Tables 43.

The results indicate that 94% of the farmers used radio in accessing information relating to irrigated rice technologies. However, over half of the farmers always used radio. Radio being the most frequently used source of information has been influenced by the presence of Simli Radio; an FM radio station within the catchment area of the Bontanga irrigation project area at Dalun. Simli radio is a rural development radio station established by DANIDA to deliver rural development related educational programmes to people in the local language. This differs from Bachhav (2012) where 9.7% of farmers use radio as a source of farming information in the Maharashtra community of India.

Group meetings (86.3%), friends (83.2%), farmers' forum (61.4%), and demonstrations (55.3%) constitute the traditional methods of information delivery by the extension services and were found to be used with varying high levels of frequency which explain the patronage of these sources by irrigated rice farmers at the Bontanga irrigation area.

Over half, one third and one third of farmers respectively use group meetings, farmers' forum, and demonstrations frequently. The results imply a trust of farmers in the importance of social networks and irrigated rice farmers' organisation and/or other extension service providers in providing relevant irrigated rice technologies information. The Irrigation farmer organisation was also instituted to co-manage the project as well as training in delivering information to the colleagues and use these sources in delivering their extension functions. The results are in tandem with Bachhav (2012) that close to two thirds of farmers use Government office as sources of farming related information in the Maharashtra community of India.

Over half and close to half of farmers frequently used friends and family members respectively as information sources at the Bontanga irrigation area. The findings compare with Bachhav (2012) where over three quarters of farmers accessed farming information from colleague farmers. Friends and family members have been found to be relevant sources of information to farmers, further emphasising the importance of social capital through peers in the form of social networks.

Table 43- Use frequency of information sources for irrigated rice technologies

Statistic	Information sources										
	Radio	Group meetings	Friends	Family members	Farmers forum	Demonstrations	Input suppliers	Television	Res. Institutions	Educ. Institutions	Print
Freq (%)	85.6	70.5	71.1	58.9	41.1	35.5	74.1	31.5	16.7	9.6	6.6
1	34.5	56.3	54.3	45.7	32.0	32.5	25.9	23.9	16.2	9.6	6.6
2	51.3	14.2	16.8	13.2	9.1	3.0	48.2	7.6	0.5	-	-
Mean rate	3	2	2	2	2	2	2	2	2	1	2
SD	0.65	0.59	0.59	0.61	0.67	0.59	0.51	0.68	0.53	0.48	0.51

Source: Field survey, Seini (2013) n = 197. Scale: 1 = not frequently, 2 = frequently, 3 = always

The information sources revealed as relevant for irrigated rice technologies information were, in order of rank, radio, group meetings, friends, family members, and farmers' forum. This is supported by Nzonzo (2016) that radio was the third source of information for agricultural practices and used by a fifth of farmers in accessing information on inputs at Mwea irrigation area.

Simli Radio; within the jurisdiction or catchment area of the project area, broadcasts various educational programmes including agricultural programmes, in the local dialect. This explains the dominance of radio as a frequently used source to access irrigated rice technologies information. The main method of information dissemination and training irrigated farmers on the Bontanga irrigation area is through the farmers' organisation, explaining why farmers frequently used group meetings as information source. Information and knowledge through this source is then passed on to friends and family with whom they interact on daily basis, further consolidating reasons for always using these information sources as stipulated in the DIT and is expected to influence irrigated rice technologies adoption decisions and adoption rates.

Farmer Perceptions on Factors Affecting the Adoption of Innovations

Selected factors: farmer, technology, capital, social, institutional, and environment related factors/characteristics were included in assessing farmer perceptions on factors influencing adoption of irrigated rice technologies. Farmers indicated their agreement or otherwise that the selected factors influence their adoption decisions. A chi-square analysis was conducted using proportions, to describe the distributions and relationships of these characteristics to adoption levels of irrigated rice technologies (Table 44).

Farmer related factors

The results of factors included under farmer characteristics namely: gender, age, household size, marital status, educational level and farming experience is presented Table 44.

There was an increasing distribution trend in responses across adoption levels 1-4 ranging from 0-10% for famers' agreement rating. A quarter of the farmers agreed that gender influenced their adoption decisions. This implies that there is an overwhelming evidence that gender does not influence adoption decisions of irrigated rice technologies. There was no significant association between farmers' rating of gender and adoption levels, $\chi^2(3) = 1.43$, $p > .05$. The results compare to Baete (2012) that gender does not influence farmers' decision to adopt rice technologies in the village of Fiu in the Solomon Islands.

Table 44- Distribution of farmer perceptions of the effect of farmer characteristics on adoption levels of irrigated rice technologies

Characteristic	Level of adoption				F(%).	n	$\chi^2(3)$	Sig.
	1	2	3	4				
Gender	0.0	1.7	4.4	9.9	16	181	1.43	.70
Age	0.0	2.1	2.6	12.1	16.8	190	3.27	.35
Hh size	0.0	3.6	7.7	20.1	31.4	194	3.02	.39
Marital status	0.0	4.2*	3.6	12.0	19.8	192	8.54	.04
Education	0.0	2.9	5.2	22.4	30.5	174	2.62	.43
Experience	0.5	2.1	5.7	24.2	32.5	194	4.09	.25

Source: Field survey, Seini (2013). Adoption level: 1 = low, 2 = moderate, 3 = high, 4 = very high.

The influence of gender on technologies adoption has been a function of type and location. For instance, Akpan et al. (2012); Vidogbena, et al., 2012) and Sakurai (2002) posited that male farmers are more likely to adopt agricultural technologies than female farmers which corroborates with the results. Akpan et al. (2012) however, also report that the coefficient of gender is significant and positively related to fertilizer use intensity. On climate smart agriculture technologies, Khatri-Chhetri et al. (2017) indicated various scenarios of the influence of gender on technology adoption in India. They showed that female farmers had negative non-significant association with site specific nutrient management and crop insurance technologies and negative significant relationships with rainwater harvesting and storage, climate smart housing for livestock and contingent crop planning technology.

On the contrary, Khatri-Chhetri et al. (2017) reported positive significant influence of female farmers on IPM, and weather-based crop advisories technologies. Irrigated rice technologies require intensive strenuous physical labour; therefore, it is unexpected that gender did not influence farmer adoption levels at the Bontanga irrigation project area. On the Kpong irrigation project in Ghana, Djokoto and Blackie (2014) reported that male farmers were more likely to adopt mechanised harvesting technologies than female farmers which differs from the findings of the study.

The distribution of responses across adoption levels occurs in increasing trend along the adoption continuum from 0-12.1% for the agree category. Seventeen percent (16.8%) of respondents had positive perceptions that age affects adoption decisions of irrigated rice technologies. From the overwhelming farmers' perspective, age is not an influencing factor in technology adoption decisions at the Bontanga irrigation area. The $\chi^2 = 3.27$, $p > .05$ reveals that there is no significant association between adoption levels and farmers' age. This is in tandem with Adesina and Baidu-Forson (1995) that age had a non-significant negative association with technology adoption in Guinea.

The results, however, differ from Adesina and Baidu-Forson (1995) and Kristjanson (2005) respectively that age had a positive significant (10%) association in Burkina Faso and a highly significant (1%) positive association with dual-purpose cowpea technologies adoption.

The distribution of positive perception ratings (31.4%) on effect of household size across adoption levels 1-4 displayed increasing trends of frequencies. The results indicate over a fifth of the positive responses were more associated with the very high adoption levels (4). The result, $\chi^2 = 3.02$, $p > .05$, and low positive perception (31.4%), demonstrates that household size does not influence adoption levels of irrigated rice technologies. This differs from Kristjanson et al. (2005) that household size had a significant (1%) positive association with improved dual-purpose cowpea adoption.

Household size proxies for household labour and food consumption. Large household size is envisaged to positively influence irrigated rice technologies adoption either through household labour (Kalineza et al., 1999; Langintuo & Mekuria, 2008; and Feder et al., 1982) or an incentive to produce sufficient food for family sustenance. The results differ from Akpan et al. (2012) report of negative positive association with fertilizer use intensity.

For marital status, about a third of the respondents conceded that marital status affected adoption levels of irrigated rice technologies at the

Bontanga irrigation project area. Three out of every twenty-five farmers were at very high adoption levels (4). The results, $\chi^2 = 8.54$, $p < .05$, indicated that there is a positive and significant association between marital status and adoption levels located at the medium adoption level (2). The implication of the findings demonstrates that farmers who perceive marital status to influence adoption levels are significantly and positively related to moderate (2) adoption level. The findings are in tandem with Denkyirah et al. (2016) that marital status in the Tolon District of Ghana had a significant positive influence on access to credit. However, the results differ from Ayoola (2012) findings of no association of marital status with adoption of yam miniset technology.

The results of formal education and adoption levels show that about a quarter of the farmers at the Bontanga irrigation area perceived formal education to exert an influence on levels of irrigated rice technology adoption and progressively distributed across adoption levels 1-4 respectively from 0 to 22.5%. The low proportions of perception responses demonstrate that formal education is not an influencing factor on adoption levels of irrigated rice technologies.

There was no significant association between formal education and adoption levels, $\chi^2 = 2.62$, $p > .05$, at the Bontanga irrigation area. The findings are not unusual because of the high proportion of farmers who did not receive formal education at the project area. The findings; however, differ from Mensah (2008) and Kalineza et al. (1999) that technologies adoption is more associated with levels of education. It is important to note that irrigated rice cultivation is typically a commercial endeavour engaged in by the literate and non-literate, making formal education irrelevant to irrigated rice cultivation and related technologies adoption. The results are therefore not unusual but fail to meet a priori expectation.

The distribution of response frequencies for farmers' experience show increasing trends across adoption levels ranging from 0.5 to 24.2%. However, about a third out of the respondents contend that the experience of the farmer influences adoption decisions of irrigated rice technologies. The low proportion of farmers who perceive farmers' experience to influence adoption of irrigated rice technologies, implies that farmers' experience in irrigated rice cultivation does not influence irrigated rice technologies adoption.

The results: $\chi^2 = 4.09$, $p > .05$, further indicate that farmers' experience though positive shows no association with adoption levels of irrigated rice technologies. The effect of experience on technologies adoption has been controversial in the literature. For instance, Mensah (2008) opined that experience exhibits different associations for different technologies and locations due to increased human capital.

The results compare to the respective findings of Djokoto and Blackie (2014) and Khatri-Chhetri et al. (2017) of a positive not significant association with mechanised harvesting at the Kpong irrigation project and weather-based advisories, laser levelling and adoption of contingent crop management technologies. However, Baffoe-Asare et al. (2013) and Mensah (2008) report of a significant positive influence differs from the results of the study. In analysing several technologies separately in the Indian context, Khatri-Chhetri et al. (2017) equally present several scenarios of influence exerted by experience on technologies adoption. Khatri-Chhetri et al. (2017) also reported that experience exerted a positive significant association with site specific nutrient management, IPM, and laser levelling, while rainwater harvesting, and crop insurance technologies were negative and significant.

Technology related factors

The characteristics of any given technology has been shown to exert influences on its use and rate of use (Adesina & Zinnah, 1993; Adesina & Baidu-Forson, 1985; Baete, 2012; and Rogers, 2003). Framers' perceptions of the effect of selected characteristics such as cost, compatibility, complexity, riskiness, meeting needs (relative advantage), and disease and pest resistance were assessed and presented in Table 45.

Technology cost relates to the sum of expenditure of related components of the technologies incurred by the farmer or adopting unit i.e. total operational cost relative to the use of the technology. The distribution of positive perception responses (45%) of cost of technologies on adoption levels show an increasing trend across the adoption levels. The very high adoption level (4) recorded the highest proportion (32%). This indicates that farmers' attitudes towards adoption would be negative if farmer cost-benefit analysis is unfavourable and would discourage technologies adoption. However, there was no significant association, $\chi^2 = 3.60$, $p > .05$, between technology cost and adoption levels of irrigated rice technologies at the Bontanga project area though the relationship is positive. The implication of the result is that technologies cost does not influence technologies adoption.

The findings thus compare the assertions of Mensah (2008); Affholder et al. (2009); and Rogers (2003) of a negative association between cost of technologies adoption. High cost of technologies would reduce the benefits from the technology adoption, consequently unfavourable attitudes towards technologies are formed. Likewise, risks associated with adopting the technology are increased which results in non-adoption (Rogers, 2003). The positive association though not significant indicates that farmers who perceive technology/operational cost influence technologies adoption are associated with higher adoption levels. It should; however, be noted that farmers are rational and if farmers observe or perceive higher returns or benefits from technologies adoption, they will adopt the technologies irrespective of the cost as postulated in the RCT model.

Table 45- Distribution of farmers' perceptions on effect of technology characteristics on adoption

Technology characteristic	Level of adoption				%	n	χ^2 (3)	Sig.
	1	2	3	4				
Cost	0.5	2.6	9.4	32.3	44.8	192	3.60	.31
Compatible	1.6	4.3	14.5	36.6	57.0	186	4.11	.25
Complex	0.6	2.2	7.2	34.3	44.2	181	10.13	.02
Risky	0.6	1.7	7.8	35.0	45.0	180	10.52	.02
Meet needs	0.6	8.6	18.4	44.3	71.8	174	7.55	.06
Disease resistant	0.6	3.4	10.7	43.5	58.2	177	14.12	.003
Pest resistant	1.1	2.8	101	45.8	59.8	179	17.75	.000

Source: Field survey, Seini (2013). Adoption level: 1 = low, 2 = moderate, 3 = high, 4 = very high.

Technology compatibility describes the harmony of the technology with knowledge, practices, and culture of the adopting unit. The more compatible an agricultural innovation, the more likely farmers would tend to adopt it. The distribution of responses across adoption levels progressively increase from 1.6 to 37%. Close to two thirds of the farmers indicated that technology compatibility influences adoption of irrigated rice technologies at the Bontanga irrigation project area. The fallouts of the distribution of farmers' responses demonstrate that the introduced innovations were compatible with their systems of farming and culture. This is therefore envisaged to exert a positive influence on adoption decisions on irrigated rice technologies.

Further examination of the results; $\chi^2 = 4.11$, $p > .05$, however, indicate the existence of a positive non-significant association between technology compatibility and farmers' adoption levels. The positive association of the results alludes to the assertion that compatible innovation exhibits positive relationships with technologies adoption. The positive association between compatibility and adoptions is important, for practical purposes, for technologies development, though non- significant. The positive association is in tandem with Rogers (2003) and Baete (2012) that compatible innovations spur farmers' technologies adoption.

Innovations come with varying relative ease or complexity of understanding and use by most members of the social system. Complexity describes the degree to which an innovation is perceived as difficult to understand and/or use by the adopting unit. Rogers (2003) posits that the more complex an innovation, the more negatively it influences adoption decision of the adopting unit. In assessing perceptions on technology complexity, responses show increasing distributional trends along adoption levels. About

44% respondents agree that technology complexity influence their adoption decisions.

This implies that technologies adoption is decreased because technologies are complex. Therefore, the technologies were considered complex by less than half of the farmers at the Bontanga irrigation project area. The introduced innovations are thus simple to understand and use by majority of farmers and therefore expected to negatively influence adoption by farmers. There was a significant positive relationship; $\chi^2 = 10.13$, $p < .05$, of technology complexity and adoption levels of irrigated rice technologies. The inference is that; complex technologies are associated with decreasing technologies adoption levels. The findings compare Rogers (2003) who states that complex technologies negatively relate with technologies adoption. The technologies are considered less complex for majority of farmers because they are compatible with the rice cultivation practices. If the cost benefit analysis results in higher returns, the less than 45% of farmers who consider innovations to be complex would also adopt the innovations for the expected higher returns as stipulated in the RCT.

On the perceptions on riskiness of technologies, 45% of farmers agreed that technology adoption is influenced by risks associated with the technologies. Riskiness of technology thus decreases adoption levels; hence farmer adoption levels is expected to be scaled down. There was a significant positive relationship between technology riskiness and adoption, $\chi^2 = 10.52$, $p <.05$. This implies that the higher the risk associated with a technology, the lower the levels of irrigated rice technologies adoption.

The findings compare to Rogers (2003) that more risky technologies exert negative influences on farmers adoption decisions. The inference is that the risk of an innovation is significantly relevant to farmers' decision processes. Other considerations might be exerting dominant influences than the risks associated with the innovation. The educational training by MoFA, irrigated rice farmers' organisation, and social networks precluded the riskiness associated with the technologies. It is for the dissipation of the riskiness and uncertainties that communication gains relevance in the innovation dissemination process (Rogers, 2003). The results further suggest that farmers are risk-averse and used the innovations even in the light of associated riskiness.

Technology characteristics namely: meeting needs, disease and pest resistance are proxy for relative advantage and/or relevance over the preceding technology. Lower cost, higher yields, early maturity, and less input requirements are some of the considerations discussed under relative advantage. A combination of these factors would converge on the farmers' needs of high yields in irrigated rice cultivation. Results show that, for meeting farmer needs, majority; more than three quarters, agree that technologies are adopted for the improved yields exhibited over preceding technologies. Over 44% of respondents are very high-level adopters. The results, however, show a significant positive association with levels of technologies adoption, $\chi^2 = 7.55$, $p < .10$.

Responses for disease resistance of rice varieties similarly illustrated an increasing distribution trend across adoption levels peaking at 43.5% for positive perception ratings. It is observed that about two third of the farmers perceived disease resistance of improved seed varieties influenced technologies adoption decisions. It is opined that the educational activities of the farmer group, has absolved the uncertainties associated with disease resistance of improved seed varieties and therefore allowing farmers form positive or favourable perceptions of diseases associated with improved seed varieties. The results, $\chi^2 = 14.12$, $p < .05$, demonstrate a highly positive significant association between disease resistance and levels of technologies adoption. Respondents who have positive perception of the influence of disease resistance on technologies adoption, are more associated with very high adoption levels (4). This is an expected outcome and it is envisaged to positively influence irrigated rice technologies adoption.

About two thirds of the farmers had a positive perception that pest resistance of the improved seed varieties influence adoption decisions. Close to half of the farmers with positive perception of the influence of pest resistance on technologies adoption were very high-level adopters (4). This infers that the introduced improved seed varieties are pest resistant and therefore expected to positively influence innovations adoption at the Bontanga irrigation area.

There is a very high significant positive association, $\chi^2 = 17.75$, $p < .001$, between pest resistance and adoption levels of irrigated rice technologies at the Bontanga irrigation project area. There is thus a very high probability; one in a thousand, that a farmer who perceives that improved seed variety is pest resistant, would be associated with a very high adoption level of the technology. The implication therefore is that, technologies that are pest resistant have a high chance of being adopted by farmers at the Bontanga irrigation area. Pest resistance of crops functions to improve or sustain potential crop yields of farmers.

The findings are comparable with Rogers' (2003) position that technologies with better relative advantage would be adopted by adopting units. The findings also compare with the assertions that relative advantage in form of prestige, convenience and high crop yield over preceding variety (Langintuo & Mekuria, 2008) and improve food security, high yield and early maturing, improved income and convenience (Baete, 2012), is one of the most important influencing factor in farmers' adoption decisions. Rogers (2003) further asserts that for a technology to be acceptable, the technology must supersede preceding technologies in profitability, social acceptability and be technologically visible.

In principle, disease and insect pest resistance would result in improved yields and consequentially improve returns and income therefore, meeting the farming needs of the farmer, hence the positively significant associations with adoption levels of technologies; $\chi^2 = 7.55$, $p < .10$. Enhancements in yields of improved seed varieties because of the disease and pest resistances would spur farmers' adoption of irrigated rice technologies through positive/favourable perception and expectations of higher returns as postulated in TPB and RCT models. Furthermore, in corroboration with the results, Adesina & Baidu-Forson (1985); and Saka et al. (2005) respectively report that yield performance of sorghum variety and yield rating of improved rice variety were positive and significant.

Respondents agreed that relevance (technologies meet needs) influence their irrigated rice technologies adoption decisions. Though the association is non-significant, if farmers' objective and/or subjective assessment of the technology reveals that need expectations are met, they would adopt the technologies. The results are in tandem with Ajzen (2006) and Scott (2000) who indicated that technologies or crop varieties that result in higher yields are more likely to influence farmers' adoption decisions compared to those that produce lower yields.

Resource related factors

Resource connotes the factors or assets that farmers must necessarily or potentially have access to, in the decision to engage in farming endeavour, namely: land, land tenure arrangement, capital, and labour. Perceived or objective access to or otherwise of these resources would exercise determining influences/associations on farmers' decision to use technologies. The results of a chi-square assessment on farmers' perceptions on the influence of capital related factors on farmers' adoption decisions are presented in Table 46.

About two thirds of the respondents perceived that adoption decisions are influenced by land availability on the Bontanga irrigation area with about 43% being very high-level adopters (4). There is a significant positive association between land availability and adoption levels of irrigated rice technologies at the Bontanga irrigation area, χ^2 (3) = 8.64, $p < .05$. Size of irrigation plot on the Bontanga irrigation area are very small (Table 8) and therefore expected to be a disincentive to technologies adoption. However, Deininger and Ayalew (2008) posited that land availability alone may not spur agricultural innovation adoption.

Table 46- Distribution of farmers' perceptions on effect of resource factors on technology adoption

Factor	Level of adoption				%	n	χ^2 (3)	Sig.
	1	2	3	4				
Land available	1.1	4.9	10.8	42.7	59.5	185	8.64	.03
Land tenure	1.1	3.3	7.1	34.2	45.7	184	10.66	.01
Capital available	0.5	3.7	6.4	33.2	43.9	187	8.69	.03
Labour available	0.5	5.5	9.9	38.5	54.4	182	5.06	.17
Have assets	0.6	1.7	2.3	30.1	34.7	176	27.05	.000

Source: Field survey, Seini (2013). Scales: Levels of adoption: 1 = low, 2 = moderate, 3 = high, 4 = very high.

Even in countries with secured property rights but poorly developed financial markets, land availability may not reduce credit constraints and therefore would not necessarily influence innovation adoption negatively.

The limited farm size would motivate farmers to adopt technologies to achieve higher returns by adopting other technologies components, such as transplanting, levelling, and fertilizer technologies to meet rice farming needs. The findings compare to Kasirye (2013) and Pingali et al. (1987) that limited availability of land influenced the use of organic fertilizer in poor resource settings. The results corroborate with the findings of Khatri-Chhetri et al. (2017) on small farm holders of Rajasthan in India, that small land holders have positive non-significant relations with use of IPM, climate smart animal housing however, it was significantly associated with weather based advisories. Under the same study, the results indicated small land holdings negatively and non-significantly relate to site specific nutrient management and laser levelling technologies.

Forty-six (46%) of respondents perceived that technologies adoption is influenced by land tenure arrangement and about a third of the farmers are associated with very high adoption level. The results, χ^2 (3) = 10.66, $p < .05$, indicate there exists a significant positive association between land tenure arrangement and levels of technologies adoption on the Bontanga irrigation project area. The findings compare with the report of Ntege-Nanyeenya et al. (1997) of a positive and significant relationship of land tenure with adoption of maize production technologies in Iganga District of Uganda. This is expected because there is a secure land tenure arrangement on the Bontanga irrigation area. Parcels of land were distributed by the irrigation management in collaboration with the farmer organisation. Some farmers insinuated that with time, the parcels of land have been sold or rented to the farmers creating a secure tenancy therefore, the secured land tenure arrangement is envisaged to positively influence technologies adoption options.

The distribution of responses for capital availability over levels of adoption show 44% of respondents agreed that capital influences technologies adoption decisions. One-third of the respondents are associated with very high adoption levels (4) of adopters. There is a significant positive relationship, χ^2 = 8.69, $p < .05$, between capital availability and technologies adoption levels. Increasing capital availability therefore has the potential to influence irrigated rice technologies adoption or vice versa without any causal connotations. Capital constitutes accumulated savings in the form of cash, credit, equipment as well as upfront investments in inputs the farmer could use or immediately turn into cash for farm operations and or investment. Differences in farmer capital availability results in differences in rates of technologies adoption

(Michael et al, 1999; Nyanga, 2012). Constrained savings and credit access would therefore constrain capital availability with a consequential reduction in adoption of irrigated rice technologies. There was a progressive increment in proportion of respondents across adoption levels indicating that adoption levels increase with increasing capital availability. It is important to indicate that capital investment is not a constraint because capital investment regarding irrigation facilities had been absorbed by government, thus capital investment requirement by farmers has been evened out for all farmers. The frequency distributions suggest that technologies adoptions are constrained by inadequate operating capital.

About half of the respondents indicated that labour availability influenced technologies adoption decisions with about 39% associated with very high adoption levels. There is however, a positive not significant association between labour availability and adoption levels of irrigated rice technologies, $\chi^2 = 5.06$, $p > .10$. The findings imply that adoption levels increase with increasing availability of/or access to labour. The result, however, show no statistical evidence to reject the null hypothesis of no relation with adoption levels of irrigated rice technologies. The findings compare to Ojiako (2011) report of positive significant relationship between adoption and use intensity of soybean technology and labour expenses. The results though not significant differs from Affholder et al. (2009) that labour exhibits a negative influence on adoption of direct-seeding mulch-based cropping systems through extra labour requirements.

Results of the relationship between adoption levels and assets indicated over one third of the respondents perceived of having assets influence technologies adoption at the Bontanga irrigation area. In addition, close to a third are associated with very high adoption levels (4). An observation of cell frequencies of farmers' perceptions distribution shows that the availability of/or having assets to practise technologies increase in ascending order along adoption levels. Over one third of the respondents were associated with very high adoption level (4). There exists a very high significant positive association, $\chi^2 = 27.05$, $p < .001$, between having assets and adoption levels of irrigated rice technologies. Farmers who have assets to practise irrigated rice technologies are highly associated with higher adoption levels of technologies. This demonstrates that higher levels or amounts of assets relate with higher adoption levels. Assets connote cash deposits, accumulated savings in the form of cash, inputs as well as animals and household labour that could be relied on to facilitate irrigated rice technologies adoption. Access to any one or a number of these would move a farmer to higher adoption levels of irrigated rice. The low proportion of farmers at the lower adoption levels suggest farmers are faced with asset constraints and fail to adopt higher proportions of technology packages. This is expected to motivate farmer adoption decisions to earn income to acquire the needed assets.

Social related factors

The characteristics under consideration include ethnicity, status in the community, position held in the group, and membership of social group. A chi-square analysis was conducted on these factors in relation to levels of irrigated rice technologies adoption and presented in Table 47.

Status in community connotes being either a chief or an ordinary member in the community and farmers were assessed on whether the status in the community influences technologies adoption behaviour. Majority (95.5%) of the respondents indicate status in community does not influence technologies adoption behaviour. The results show that one out twenty farmers perceived status in community of influencing technologies adoption decisions. The overwhelming proportion of responses against the influence of community status on adoption levels implies that being a leader/chief in the community is not an important factor influencing adoption decisions.

Table 47- Farmers' perception on effect of social factors on technology adoption

Factor	Level of adoption				F	n	χ^2 (3)	Sig.
	1	2	3	4				
Status in community	0.0	1.7	1.1	1.7	4.5	178	6.13	.02
Ethnicity	0.0	0.6	0.6	1.7	2.8	181	.70	.87
Group membership	0.0	2.1	1.6	10.1	13.8	188	5.83	.12
Status in group	0.0	1.1	1.1	5.8	7.9	190	2.00	.57

Source: Field survey, Seini (2013). Scales: Levels of adoption: 1 = low, 2 = moderate, 3 = high, 4 = very high.

However, the evidence suggests there is high positive significant relationship between adoption levels and status in the community; $\chi^2 = 9.55$, $p < .05$. The implication is that; community leaders are more associated with higher adoption levels compared to ordinary members of the community at Bontanga irrigation area. The results differ from Adesina and Baidu-Forson (1985) that community leadership had a negative relationship with technologies adoption. The role of the community or group leadership in technologies adoption lies in the influence they exert on members' technologies adoption decisions (Baete, 2012). Being among the first to receive technologies introduction information and receiving the information from the technology's introducers offer chiefs the opportunity to adopt the technologies and therefore explain their significant association with adoption levels of technologies.

Ethnicity was assessed regarding the relationship with farmer adoption behaviour. Less than one third of the respondents perceived ethnicity to influence farmer adoption decisions at the Bontanga irrigation area implying ethnicity as not being an influencing factor on adoption levels. In tandem with this assertion, the results; $\chi^2 = .76$, $p > .10$, showed there is a positive but not significant association between ethnicity and adoption levels of irrigated rice technologies. The findings suggest a uniform ethnic grouping or non-discriminatory ethnic relationships at the Bontanga irrigation area. The respondents are almost of the same ethnicity and therefore ethnic affiliations do not play an influencing role in farmers' adoption levels. Other factors namely: profitability and/or relevance might be the dominant influencing considerations.

The findings differ from Khatri-Chhetri et al. (2017) that cast (ethnicity) had a negative non-significant influence on technologies adoption. Khatri-Chhetri et al. (2017) however, indicated that ethnicity had a positively significant influence on weather-based advisories, and this compares to the findings.

One out of every seven farmers, perceived membership in a social group to influence adoption behaviour at the Bontanga irrigation area. One in ten farmers were very high-level adopters. The results: $\chi^2 = 5.45$, $p > .10$, demonstrate there is a positive not significant association between membership in a group and adoption levels of irrigated rice technologies. Consequently, being a member of a social grouping has no relationship with adoption levels of irrigated rice technologies. Farmers would either adopt or fail to adopt an irrigated technology irrespective of their affiliation with social groupings. The positive coefficient meets a priori expectation because being a member of a social group is expected to improve individual and compatriots' adoption behaviour. The results compare to Asfaw et al. (2011) findings of no relationship between membership in social/farmers group and adoption of fertilizer technology.

However, the findings differ from Langintuo and Mekuria (2008), in their neighbourhood studies that adoption rates are positively associated with being a member of group/association. Correspondingly, findings of Saka et al. (2005) demonstrate a positive significant influence on adoption of improved rice varieties technologies.

Status in social group was assessed regarding its association with technology adoption behaviour. The fallout of the assessment was that one in every thirteen respondents, perceived status in social groupings to influence adoption of irrigated rice technologies. There was, however, no significant association between status in social group and adoption levels of technologies, $\chi^2 = 1.65$, $p > .10$. Irrespective of farmers' status in a group, they would either adopt or reject the technologies. In practice, the proportion of leaders in social group is always very low compared to total respondents and the effect of their decisions would always be masked. Their main effect is realised in the influence exerted on members of association/group they belong to in the form of technical knowledge, skills towards the technologies and the members of the group. For instance, Baete (2012) observed that farmers of the Solomon Islands discontinued the use of rice varieties because the group leaders lacked knowledge and skills in fertilizer, pest and disease management skills.

Institutional factors

Institutional support for irrigated rice technologies adoption was assessed in examining farmers' perceptions on the influences of institutional supports received from NGOs, extension services, farmers' group, as well as banks/credit institutions, agrochemical suppliers, radio/tv and market availability for produce. Cross tabulation with chi-square analysis was conducted to establish relationships of respondents with adoption levels of irrigated rice technologies (Table 48). Over a quarter of the respondents perceived NGO support to having an influence on irrigated rice technologies adoption decisions at the Bontanga irrigation project area with one fifth of the respondents being among the very high adoption level i.e. majority of the farmers who consider NGO support to influencing technologies adoption are very high level adopters.

The results, χ^2 (3) = 7.33, p < .10, infer a low significant and positive relationship of NGO support with adoption levels of irrigated rice technologies. NGO support at the Bontanga irrigation area was inadequate (Table 39) because of the low proportion of farmers served. Therefore, the results are unexpected. However, the results conform to Rogers' (2003) assertion that organisational support would influence farmers' technologies adoption positively if farmers perceive the institutional support to be satisfactory.

Results for extension services support indicate that over one quarter of respondents perceive that extension services support affects adoption behaviour of irrigated rice technologies.

Table 48- Farmers' perception on effect of institutional support on technology adoption

Support type	Level of adoption				F	N	χ^2 (3)	Sig.
	1	2	3	4				
NGO	0.0	2.1	3.7	20.7	26.6	188	7.33	.06
Extension	0.0	2.2	4.9	25.4	32.4	185	10.14	.02
Farmers group	0.0	2.1	6.8	29.3	38.2	191	9.36	.03
Bank	0.0	1.1	2.7	25.0	28.7	188	18.88	.000
Agrochemical org.	0.0	1.6	3.2	23.9	28.7	188	14.02	.003
Radio/tv	0.5	2.2	9.8	36.4	48.9	184	10.35	.02
Market	1.0	6.3	15.6	45.3	68.2	192	.57	.90

Source: Field survey, Seini (2013). Adoption level: 1 = low, 2 = moderate, 3 = high, 4 = very high.

Also, more than one third of the respondents who perceive extension services support of having an influence on adoption decisions are very high-level adopters. There was no evidence not to accept the null hypothesis of no association between extension services support and adoption levels of irrigated rice technologies, χ^2 (3) = 10.14, $p < .05$.

The findings met the a priori expectations because, farmers of the Bontanga irrigation project area had been exposed to several extension programme sources; NGO, MoFA, and farmers' organisation of the project in which majority of the farmers participated. Irrigated rice farmers' organisation specifically offered extension training on targeted irrigated rice technologies to achieve potential yields of improved seed varieties. The strategy was to improve adoption of irrigated rice technologies.

The results compare to the literature; (Baffoe-Asare et al., 2013; Kalineza et al., 1999; Langintuo & Mekuria, 2008; and Michael et al., 1999) that extension services positively influence farmers' technologies adoption decisions through awareness creation and knowledge dissemination to farmers. Saka et al. (2005); and Adisena and Baidu-Forson (1985), similarly reported positive significant influences of extension participation on small farmer adoption of improved rice varieties and extension workshops and adoption.

Over one third of the respondents observed that farmers group support influences adoption of irrigated rice technologies and close to a third are very high-level adopters. The trends of distributions indicate that farmers with positive perception of the influence of group support are positively associated with higher adoption levels.

The results, $\chi^2 = 9.34, p < .05$, show a positive significant relationship between farmer group support and adoption levels of irrigated rice technologies. The results imply that farmers who perceive farmer group support influences adoption are more associated with higher adoption levels compared to farmers who perceive farmers group influences otherwise.

Membership to an agricultural organisation by a farmer has served as a source of information and knowledge through social networking to the extent that farmers within a group learn from each other (Nyanga, 2012; and Langintuo & Mekuria, 2008) which improves individual decision-making. The results further conform to Saka et al. (2005) and Langintuo and Mekuria (2008) that being a member of an association/group positively and significantly relates to farmers' adoption decisions. However, the results differ from the findings of Asfaw et al. (2011) of no relationship with farmers' adoption decisions.

The frequency distributions on bank/credit institutions support and adoption levels exhibit close to one third of the respondents perceived that technologies adoption is influenced by credit services received from banks and or credit institutions (Table 48). The low proportion of farmers asserting that bank/credit institutions support, influence adoption decisions is however, expected because there is limited bank/credit support availability at the Bontanga irrigation area. The results show that about a quarter of farmers with positive perceptions of the influence of bank/credit institutions support are associated with very high adoption levels. There was a very high positive significant relationship, $\chi^2 = 18.88$, $p < .001$, with bank/credit support and adoption levels of irrigated rice technologies at the Bontanga irrigation project area. The results are envisaged to positively impact on technologies adoption at the project area.

This implies that adequate access to bank/credit support has the potential to relate positively with technologies adoption levels. The inference is that credit availability/access from banks/credit institutions positively influence technology adoption because cash is required to purchase seed and complementary inputs. Nyanga (2012) and Michael et al. (1999) related that differences in access to credit or capital are among the causes of varying rates of technologies adoption. Therefore, banks/credit institutions support to farmers in the form of credit for farmers to access inputs and related production operations would spur farmers' adoption levels. This is because cash is required to purchase technologies complementary inputs (Langintuo & Mekuria, (2008).

The findings compare to results of Langintuo and Mekuria (2008) and Saka et al. (2005) of positive significant association of credit with technologies adoption. The findings, however, differ from Akpan et al. (2012), that the coefficient of access to credit was negative and non-significantly related to fertilizer use intensity in Nigeria.

Agrochemical suppliers' supports prove relevant when they provide access to inputs and/or services namely: extension services, agrochemicals including fertilizers and credit sales to farmers. The assessment of farmers' perceptions of agrochemical suppliers' support in relation to technologies adoption show that a third of the respondents conceded that adoption decisions are influenced by agrochemical suppliers' support. Further, about a quarter of the respondents with positive perceptions of the influence of agrochemical suppliers' support on adoption of irrigated rice technologies are associated with very high adoption levels. The low proportion of responses demonstrates that very few farmers have access to agrochemical dealers' support for adoption of irrigated rice technologies, therefore access to inputs and/or credit constrained adoption of components of the technologies at the Bontanga irrigation area. The results show a significant positive association of agrochemical suppliers' support with adoption levels of irrigated rice technologies, $\chi^2 = 14.02$, $p < .05$. This infers that positive perception of agrochemical suppliers' support exerts a positive influence/association on adoption levels of irrigated rice technologies.

The distribution of responses for radio and television's influence on adoption levels of technologies (Table 48), indicates that about half of the respondents perceive that radio/television influences technologies adoption decisions and more than one third are associated with very high adoption levels. The results, $\chi^2 = 10.35$, $p < .05$, provide evidence of significant positive association of radio/television support with adoption levels of irrigated rice technologies, which implies that positive perception of radio/television support has the potential to positively influence adoption levels of innovations at the Bontanga irrigation area. The findings compare to Nzonzo (2016) assertion of positive influence of radio/television on farmer adoption decisions.

Radio and television are major electronic sources of information for farmers and channels frequently used to deliver and disseminate information to large audiences, at the same time, faster as compared to other channels. Whilst radio is better used for general emergency information delivery, demonstrations are usually conducted as television programmes for farmers on technologies practices. Generally, the object is to influence farmer innovation adoption decisions.

The distribution of farmer perception ratings on the influence of market availability for produce indicates that over two thirds of the respondents allude that market availability influences adoption decisions of irrigated rice technologies at the Bontanga irrigation project area and over

45% are associated with very high adoption level (4) compared to lower adoption levels. This is an expected result because irrigated rice cultivation is usually commercial oriented and require access to produce market to spur technologies adoption. Further, the introduction of the highest adopted rice variety; Jasmine, was complemented with market access to rice farmers on the Bontanga project area. The results, $\chi^2 = .57$, $p > .05$, however, suggest there was no evidence to reject the null hypothesis of no association of market support/availability with adoption levels of irrigated rice technologies. Though the results are not statistically significant, it provides practical significance of the influence of access to produce market on adoption of irrigated rice technologies.

Environment-related factors

Suitability of agro-climatic conditions of a location or area influences farmers' decision to adopt (rice) agro-technologies. Five climatic conditions have been identified by (Baete, 2012) as soil quality, rainfall, sunshine, and temperature.

Table 49 presents the results relating to environmental factors of conducive weather and good soils. About two thirds of respondents supported the assertion that farmers' adoption levels of irrigated rice technologies were influenced by conducive weather conditions and about half are associated with very high adoption level (4). This implies that farmers appreciate the effects of bad weather conditions regarding irrigation farming practices. There was positive, very high significant relationship, $\chi^2 = 19.28$, $p < .001$, between adoption levels and conducive weather conditions. Therefore, conducive environmental temperatures and sunshine positively influence farmer adoption levels of irrigated rice technologies. In tandem with the results, Baete (2012) noted that suitability of agro-climatic conditions namely: soil quality, rainfall, sunshine and temperatures influence farmers' decisions to adopt agro-technologies and that farmers with adequate knowledge on the influence of weather conditions' effect on crop production adopted the technologies. Anecdotal literature indicates that conducive weather conditions promote healthy plant growth and good yields through good pollination and fertilisation; and maximise irrigation water use, through reduction in dammed water evaporation and evapotranspiration.

About two thirds of respondents perceived good soil affected adoption decisions of irrigated rice technologies at the Bontanga irrigation area. Close to half of the respondents are associated with very high (4) adoption level. The results further illustrate that there exists a very high significant association between good soils and adoption levels of technologies, $\chi^2 = 19.71$, $p < .001$.

Table 49- Farmers' perception on effect of environmental factors on technology adoption

Factor	Level of adoption				F(%)	n	χ^2 (3)	Sig.
	1	2	3	4				
Good soil	1.1	2.1	11.1	45.5	59.8	189	19.71	.000
Conducive Weather	0.6	2.2	12.4	48.3	63.5	178	19.28	.000

Source: Field survey, Seini (2013). Level of adoption: 1 = low, 2 = moderate, 3 = high, 4 = very high.

According to Kasirye (2013), good soil fertility would negatively influence farmers' adoption of improve fertilizer technologies in anticipation of higher returns. In a study of social capital and agricultural technologies adoption among Ethiopian farmers, Nizam, Tim, and Khalid (2017) reported infertile soil had a negative non-significant association on soil water conservation and productivity enhancing technologies in Ethiopia.

The findings are in tandem with Baete (2012) that farmers' knowledge of the relevance/importance of weather conditions on rice production, through experience and/or training, would influence their perceptions on the influence of weather on adoption behaviour. Baete further asserted that farmers trained on the relevance of weather conditions on crop production adopted technologies. Correspondingly, poor soils would increase production cost through increased fertilizer requirement.

The quality of land has been cited (Baete, 2012; Kasirye, 2013; and Carletto et al., 2007) as a major factor influencing the use of key inputs as fertilizers and improved seed varieties. Poor soils have the tendency to increase cost of irrigation technologies thereby reducing earnings through increased production cost and reduced yields if farmers are unable to meet fertilizer cost. Consequently, adoption of fertilizer technologies would be negatively influenced because farmers would be financially constrained.

The inference of the findings indicate that weather conditions and good soils are favourable for irrigation technologies adoption at the Bontanga irrigation project area and expected to influence adoption of irrigated rice technologies.

Factors Constraining Irrigated Rice Technology Adoption

This section presents descriptions of conditions and/or factors that limit farmers technology adoption options and decisions. Results of the analysis are depicted in Table 50.

High input price

Ninety-eight percent (98%) of responses rated high input price as a major constraint to adoption of irrigated rice technologies and about two thirds are associated with very high (4) adoption levels of irrigated rice technologies adoption (Table 50). The implication of the very high proportion of response for a major constraint is that farmers are experiencing high input price regimes and therefore high input price was responsible for the low adoptions of input related technologies namely: fertilizer, pesticides and fungicides on the Bontanga irrigation area.

Table 50- Farmer perceptions on constraints to technology adoption

Constraint	Level of adoption				F(%)	n	$\chi^2(3)$	Sig.
	1	2	3	4				
High input price	1.5	8.7	24.6	63.1	97.9	195	3.48	.32
Inadequate access to input	1.5	7.7	23.1	62.6	94.9	195	1.98	.58
Inadequate access to credit	1.1	8.6	22.7	62.2	94.6	185	4.20	.24
Poor extension	0.5	8.2	24.5	55.6	88.8	196	18.72	.000
Insect pest prevalence	0.5	7.8	24.9	55.4	88.6	193	18.77	.000
Low produce price	1.6	8.4	24.1	54.5	88.5	191	9.60	.02
Disease prevalence	0.5	7.3	24.4	55.4	87.6	193	12.48	.006
Poor soil fertility	1.6	7.5	23.0	51.9	84.0	187	4.74	.19

Constraint	Level of adoption				F(%)	n	$\chi^2(3)$	Sig.
	1	2	3	4				
Poor mech. Access	1.1	7.4	20.1	54.0	82.5	189	.74	.86
Poor soil quality	1.6	6.6	21.4	52.7	82.4	182	4.76	.19
Poor labour access	1.6	7.8	18.7	51.3	79.3	193	2.85	.42
Inadequate market	1.6	5.3	20.3	51.9	79.1	187	4.08	.25
Poor quality roads	1.5	6.6	19.9	50.0	78.1	196	2.20	.53
Inadequate land	1.7	8.3	18.2	49.7	77.9	181	2.93	.40
High temperatures	1.1	8.6	16.6	40.0	66.3	175	8.37	.04

Source: Field survey, Seini (2013). Scale: Adoption levels: 1 = low, 2 = moderate, 3 = high, 4 = very high.

The outcome, $\chi^2 = 1.98$, $p > .10$, nonetheless, indicates there is nonsignificant association between high input price and adoption levels of irrigated rice technologies. However, two thirds of respondents are associated with very high (4) adoption levels of irrigated rice technologies adoption. The inference drawn from the results is that the more positive perception of the influence of high input price, the more the farmer is associated with higher adoption levels of irrigated rice technologies adoption, though the association is non-significant. The major input for irrigated rice technologies adoption is fertilizer which registered moderate adoption.

In tandem with the results, Alarima, Adamu, and Masunaga (2011) reported that over 51% of farmers rated high input cost as very severe constraint to Sawah production system in Nigeria. Correspondingly, Ayoade and Akintonde (2012) reported that limited access to credit and inputs are major constraints to technologies adoption in the Isokan Local Government area of Nigeria. Affholder et al. (2009) also showed that extra input requirement/price; nitrogen fertilizer, pesticides, and seeds, was one of the factors preventing the use of direct-seeding mulch technology in Vietnam.

This result thus demonstrates that high input prices, though important, does not constrain adoption of irrigated rice technologies. Resource endowed farmers prepare to meet the high input prices of complementary inputs and would therefore adopt the innovations because of the high expected returns as stipulated in the RCT and TPB models irrespective of the prices. On the other hand, if farmers do not experience disease and insect pest problems it would not be rational to adopt the fungicide and insecticide technologies because improved seed varieties were disease and pest resistant.

Inadequate access to input

Inadequate access to credit describes high input prices, non-availability, and long distances to sources of inputs. These scenarios constrain farmer access to inputs or increases the prices thereof, hence constrain farmer adoption of input related technologies.

The distribution of responses for inadequate access to inputs show that the majority (95%) of respondents considered inadequate access to inputs as a major constraint to adoption of irrigated rice technologies Table 50). About two thirds are associated with very high adoption levels.

The results demonstrate that there exists no significant association between inadequate access to inputs and adoption levels of irrigated rice technologies, $\chi^2 = 1.98$, $p > .10$. The null hypothesis of no association is thus upheld. The findings compare Ayoade and Akintonde (2012) that poor access to inputs was identified by women farmers as a constraint to technologies adoption in Nigeria. The findings of Ayoade & Akintonde were also a positive and not significant relationship between inadequate input and innovation adoption.

The findings differ from Affholder et al. (2009) that high input price or extra input requirement negatively influenced the use of direct-seeding mulch technology in Vietnam. It is important to note that though majority perceived inadequate inputs as a major constraint to adoption of irrigated rice technologies, two thirds of the respondents are associated with very high adoption levels. This implies that input availability is not the main driver of adoption of irrigated rice technologies.

Inadequate access to credit

The outcome of the analysis indicates that inadequate access to credit was perceived as a major constraint by majority (97%) of the farmers. About two thirds are more associated with very high adoption levels than lower adoption levels. The findings compare Alarima, Adamu, and Masunaga (2011), that lack of capital, non-availability of loans/credit and lack of finance agencies were rated by 70% of farmers as severe constraints to the Sawah production system in Nigeria.

The results provide evidence of non-significant association between inadequate access to credit and adoption levels of technologies on the Bontanga irrigation project area, $\chi^2 = 4.20$, $p > .10$. The results compare to Akpan et al. (2012) that inadequate access to credit was not a significant constraint to fertilizer use intensity in Nigeria. The results, however, differ from Langintou and Mekuria (2008) that lack of credit had the potential to reduce farmers technology adoption. Saka et al. (2005), similarly reported a not significant negative influence of access to credit on adoption rates and fertilizer use intensity of smallholder farmers.

Credit has been shown to negatively influence technology adoption especially for smallholder farmers who do not have sufficient funds to run their farm operations (Akpan et al., 2012; Alarima, Adamu, and Masunaga, 2011). Literature indicates that credit availability can either positively or negatively influence technology adoption (Feder et al., 1982; Langintou and Mekuria, 2008; Saka et al., 2005). Inadequate access to credit though an important constraint to adoption of irrigated rice technologies, was not the driver influencing technologies adoption because about two thirds of respondents are very high (4) level of adopters. Indeed, inadequate access to credit did not constrain farmer adoption of irrigated rice technologies decisions.

Poor extension services

Extension services are institutional services provided to farmers by varying service providers namely: MoFA, the NGO fraternity, through several channels as radio, television, demonstrations, group discussions and social networks and the irrigated rice farmer organisation to influence innovation adoptions.

Table 50 show that majority (89%) of respondents considered poor information support from MoFA extension services as a major constraint to adoption of irrigated rice technologies. Further, about two thirds of the respondents who were positive of the influence of poor extension services on adoption of irrigated rice technologies were associated with very high (4) adoption levels compared to lower adoption levels of technologies. The results suggest that though poor extension services are considered a major constraint to adoption of irrigated rice technologies, two thirds of the farmers' adoption were not influenced. It is otherwise opined that, MoFA extension delivery was not effective enough to influence farmers' innovation adoption decisions. Hence the inference is that other factors are responsible for constraining innovation adoption decisions. The extension service delivered by the irrigated rice farmer organisation, provided content relevant extension service to farmers compared to MoFA or that farmers do not participate in extension service interventions from MoFA. The results, $\chi^2 = 18.72$, $p < .001$, show that poor extension services are highly associated with very high adoption levels of technologies.

The implication is that farmers with positive perception of the influence of poor extension services is highly associated with adoption levels of irrigated rice technologies. The poorer the extension service, the higher the adoption levels of irrigated rice technologies. The perception that poor extension service is a major constraint corroborates Ayoade and Akintonde (2012) that limited extension services to women in Isokan Local Government Area of Nigeria was identified as a serious constraint to technologies adoption. Access to and participation in extension training interventions have been found to guarantee innovation adoption decisions (Saka et al., 2005; Baffoe-Asare et al., 2013; Ojiako, 2011; and Langintuo & Mekuria, 2008).

Insect pest prevalence

The majority (89%) of respondents perceived insect pest prevalence as a major constraint to adoption of irrigated rice technologies decisions. More than half of the respondents are associated with very high (4) adoption levels. The results, $\chi^2 = 18.77$, $p < .001$, exerts evidences that there is a positive significant association between adoption levels of irrigated rice technologies and insect pest prevalence. The results demonstrate that positive perceptions of the influence of insect pest prevalence is associated with higher adoption levels.

This implies that farmers, through experience and experimentation, have learnt and devised techniques to contain the risks associated with the prevalence of insect pest or farmers are just shear risk-lovers. RCT and TPB respectively postulate that human choices and behaviour are influenced by cost benefit analysis and positive favourable expectations from the outcome of behaviour. Therefore, if there exist insect pest problems but farmers anticipate better returns from technologies adoption, their innovation adoption decisions would be positively influenced. The prevalence of insect pest causes crop loss through sucking fresh booting grain, feeding on and shattering mature grain during landing and flight of swamp of birds. Observations and interactions with farmers revealed that bird prevalence is a menace at the project area and farmers have to continuously scare birds at the booting stage up to rice harvesting; a costly and highly inconvenient operation and consequently causing pre-harvest losses. The result is thus an expected one.

Low produce price

Produce price is of important consideration for rice farmers especially commercially oriented farmers therefore farmers would be sceptical adopting technologies if produce price is low. Majority (88.5%) of farmers perceived low produce price as a major constraint to adoption of irrigated rice technologies decisions (Table 50). More than half (55%) of the respondents are associated with very high (4) adoption levels. There was a positive significant association of low produce price with adoption levels of irrigated rice technologies, $\chi^2 = 9.60$, $p < .05$.

The findings thus infer that positive perceptions that low produce prices are a major constraint to adoption levels of irrigated rice technologies is associated with higher adoption levels of irrigated rice technologies adoption. Under conditions of low produce price, farmers adopt irrigated rice technologies for higher returns, to compensate for the lost earnings consequential to the low produce price. According to Saka et al. (2005), intensity of use of improved rice varieties was positive and significant association with positive perceptions of yield of improved rice varieties. The findings are anticipated to positively affect irrigated rice technologies adoption.

Disease prevalence

Rice diseases were anticipated by the project implementers therefore application of fungicides was introduced as a component of the technologies package which was adopted by two thirds of the respondents (Table 54). The results of farmers' perception of disease prevalence as a major constraint to adoption of irrigated rice technologies (Table 50), demonstrate that disease prevalence was considered a major constraint to adoption of irrigated rice technologies by majority (87%) of the respondents and more than half (55.4%) of the respondents were associated with very high (4) adoption levels. Implication is that disease prevalence is a factor that impinges on adoption of technologies at the Bontanga irrigation area.

The results are an outcome of subjective assessment and farmer experiences because rice diseases were not observed on the Bontanga irrigation area, otherwise the adoption of disease control technologies practices have masked the expression of disease symptoms. Disease control and prevention is not an individual farmer's task; it requires the cooperation of all farmers in a wider farming location. Therefore, it is opined that the risk of diseases had been eliminated through the cooperation of all farmers through the coordination of the leadership of the irrigated rice farmer organisation at the project area. The association of disease prevalence as a major constraint to adoption levels of irrigated rice technologies was positive and significant, $\chi^2 = 12.48$, $p < .01$, at the Bontanga irrigation area. Thus, a positive perception of disease prevalence as a major constraint is associated with higher adoption levels of irrigated rice technologies hence anticipated to influence adoption of irrigated rice innovation.

Poor soil fertility

Majority (84%) of respondents rated poor soil fertility as a major constraint to adoption of irrigated rice technologies and more than half are associated with very high (4) adoption levels (Table 50). The results show that poor soil fertility is not associated with adoption levels of irrigated rice technologies at the Bontanga irrigation area, $\chi^2 = 4.74$, $p > .10$.

The recommended fertilizer rates at the project area have been doubled; 200kg and 100kg of compound and nitrogen fertilizers respectively, to accommodate the poor soil fertility conditions at the project area. Especially so under irrigation conditions where soil nutrients are leached out due to continuous field flooding. The adoption of the fertilizer technologies would mask poor soil conditions from the untrained farmer. Therefore, farmers' perception of poor soil fertility as a major constraint is expected and hence anticipated to enhance adoption.

The effect of poor soil fertility is expressed in increased input cost due to extra fertilizer requirements or reduced yields to resource poor farmers who cannot afford extra fertilizer cost. For the resource endowed farmers, poor soil fertility conditions promoted adoption of fertilizer technologies. This differs from the findings of Baete (2012) in the Solomon Islands where farmers' rice technologies adoption was positively influenced by fertile soils resulting from deposits of alluvial soils through rainwater flooding. Schiller et al. (2001) similarly reported that poor soil quality exerted negative influence on adoption of farmer irrigated rice technologies due to increased fertilizer rates and consequential cost.

Poor access to mechanisation services

About 4 out of five farmers rated poor mechanisation services as a major constraint to adoption of irrigated rice technologies decisions and more than half are associated with very high (4) adoption levels compared to lower levels (Table 50). There exists no evidence of significant association with adoption levels of irrigated rice technologies, χ^2 = .74, $p > .10$. Positive perception of poor access to mechanisation services as a major constraint to adoption of irrigated rice technologies is associated with higher adoption levels though not significant.

The result compares to Owombo et al. (2012) that 54% of respondents perceived mechanisation services to be inaccessible. Owombo et al. further posited that perceived access to mechanisation services had a significant and positive association with adoption of innovation decisions which differs from the findings. There was no institutional support for mechanisation service at the project area, hence farmers accessed mechanisation services from private operators which constrained farmer access to mechanisation services. Though mechanisation services are a constraint, non-reliance on institutional mechanisation support does not constrain their irrigated rice technologies adoption decisions.

Poor soil quality

Soil or land quality connotes physical characteristics of the soil. The requirements for soil/land quality differ from crop to crop and very relevant especially for irrigated rice cultivation with respect to water use efficiency.

The results (Table 50) indicate that four out of every five farmers rated poor soil quality as a major constraint to adoption of irrigated rice technologies decisions and over half are associated with very high (4) adoption levels. The results, however, indicate that there was a positive, not significant association of poor soil quality and adoption levels of irrigated rice technologies at the Bontanga irrigation project area, χ^2 = 4.76, p > .10. The quality of soil is a major factor in deciding the use of key inputs especially fertilizer, water, and improved seed varieties (Kasirye, 2013; Schiller et al., 2001). Poor soil quality thus constrains farmers' technologies adoption decisions. Baete (2012) supposition that good soil quality results to improved technologies adoption compares with the results that poor soil quality constrains farmers' technologies adoption decisions. Rice fields had been appropriately located by project implementers to ensure suitability for rice cultivation and accounts for farmers' continuous use of plots for rice cultivation.

Poor labour access

Access to labour features as an important factor in adoption of irrigated rice technologies. More than three quarters of respondents rated poor access to labour as a major constraint indicating that farmers of the Bontanga irrigation project area experience difficulties in securing labour for farming operations. The results, $\chi^2 = 2.85$, $p > .10$, are unexpected, but demonstrate evidence of not significant positive association between poor labour access and adoption levels of irrigated rice technologies. Inadequate access to labour is expected to negatively influence adoption of irrigated rice technologies because irrigated rice cultivation is labour intensive.

This compares to Alarima, Adamu, and Masunaga, (2011) that over 60% of farmers rated labour as a severe constraint to Sawah farming system in Nigeria. On production and on-farm constraints, labour was similarly rated by 83% of respondents as a severe constraint in the study of Alarima, Adamu, and Masunaga, (2011).

Non-availability of produce market

Over three quarters of respondents conceded that non-availability of produce market is a major constraint, and more than half are associated with very high (4) adoption levels (Table 50). This indicates that non-availability of produce market is an important limiting factor to irrigated rice technologies adoption on the Bontanga irrigation project area.

The results, χ^2 = 4.08, p > .10, further show that non-availability of produce market exert a positive but not significant association with adoption levels of irrigated rice technologies at the Bontanga irrigation project area. High proportion of farmers (79%) conceded inadequate produce market was a major constraint to adoption of irrigated rice technologies yet are associated with higher adoption levels (52%). This indicates therefore, that other considerations, such as high crop yields that meet farmer aspirations, moderated adoption of irrigated rice technologies, other than availability of produce market.

Poor quality of roads

More than three quarters of respondents judged poor road quality as a major constraint to adoption of irrigated rice technologies at the Bontanga irrigation area, and half are related to very high (4) adoption level (Table 50). It was observed that except the main road from Tamale to Bontanga, all other link roads are in very bad state; the result is thus expected. The result, χ^2 = 2.20, p >.10, denotes that the null hypothesis of no association of poor-quality roads and technologies adoption, is upheld. There is no significant relationship between poor road quality and adoption levels of irrigated rice technologies at the Bontanga project area.

Farmers who consider that poor road quality influenced adoption of irrigated rice technologies are positively associated with higher adoption levels compared to lower levels. The very high technologies adoption of farmers (Tables 51, 53, 54) in combination with this result indicates that farmers adopt irrigated rice technologies irrespective of the quality of roads. Poor road quality would affect irrigated rice technologies adoption in various pathways including poor access to inputs, high input prices, and poor access to markets among others.

Inadequate land availability

Over three quarters of farmers rated inadequate land availability as a major constraint to adoption of irrigated rice technologies with half more associated with very high (4) adoption levels compared to lower levels (Table 50). This is an expected outcome because most farmers have access to less than one hectare of land distributed to farmers by farmer organisation and therefore providing a secure land tenure arrangement. Inadequate land availability had a positive but not significant association with adoption levels of irrigated rice technologies, χ^2 = 2.93, p > .10. Though with a positive relationship, inadequate land availability does not affect innovations adoption decisions at the Bontanga irrigation project area because farmers have predetermined land size. This would thus spur farmer technologies adoption to maximise yields to meet farming needs.

The findings compare to Deininger and Ayalew (2008) that land availability alone may not spur adoption of agricultural technologies. De

Janvry et al. (2011) also posited that land is relevant in influencing technologies adoption only for farmers with large tracts of land who can afford to experiment with technologies before full scale adoption. Farmers with land constraints may adopt innovations for anticipated higher returns inherent in the agricultural innovation as postulated in the RCT. Therefore, the results are expected to exert a positive influence on adoption of irrigated rice technologies adoption.

High temperatures

The results on high temperatures demonstrate that about two thirds of respondents rated high temperatures as a major constraint and two out of every five farmers are associated with very high (4) adoption levels. The results, $\chi^2 = 8.37$, $p < .05$, upheld the null hypothesis of no association with levels of technologies adoption. High temperatures have the disadvantage of reducing irrigated water use efficiency, reducing dam water volume, and increasing rice maturity periods, making the results rational and expected. High temperatures are external to the control of farmers, hence farmers are trained and educated to plant early to mitigate the effects of pests and high temperatures. The results compare to Baete (2012) that farmers trained on the relevance of temperature on crop production adopted the technologies.

CHAPTER FIVE

LEVELS OF ADOPTION OF IRRIGATED RICE TECHNOLOGIES BY FARMERS

Introduction

This chapter presents the level of adoption of the irrigated rice technologies introduced to farmers at the Bontanga irrigation area. The chapter presents and discusses results on technologies classified into thematic areas namely: pre-planting/planting, fertilizer, improved seed and IPM technologies each of which consist of components.

Adoption Levels of Pre-planting and Planting Technologies

The components and proportion of farmers who adopted pre-planting and planting technologies are presented in Table 51. The pre-planting technologies were generally adopted by majority of farmers. For instance, almost all farmers adopted the ploughing technology whilst over three quarters of farmers adopted the transplanting technology. Farmers complained that cost of transplanting a hectare of field was very high, therefore this explains why all farmers did not adopt the transplanting technology though they knew transplanted fields give higher rice yield than direct seeded fields. One reason given for adopting transplanting technology was that 'the transplanting technology produce far higher yields compared to direct seeded rice. One third of the farmers, indicated they failed to adopt transplanting technology because they felt it is expensive and time consuming.

Technology cost regarding time spent in nursing, transplanting and inadequate cash, constrain transplanting technology adoption. The results find support in the literature. For instance, the results compare to Kariyasa and Dewi, (2013) that 87%, 96% and 76% of farmers respectively adopted land preparation, improved seed varieties and integrated pest management technologies.

Table 51- Farmers adoption of production related irrigated rice technologies

Pre-planting/planting technologies	n	%
Ploughing	196	99.5
Harrowing	193	98.0
Flooding	192	97.5
Levelling	176	89.3
Seedling nursing	147	74.6
Transplanting seedling immediately after field preparation	134	68.0
Transplanting	134	67.5

n = 197. Source: Field survey, Seini (2013)

Ndagi et al. (2016) also demonstrate that majority of respondents of lowland rice farmers in Lavun area, adopted transplanting technologies. Three quarters of respondents adopted the seed nursing technology. This compares with Ndagi et al. (2016) that 82% of farmers adopted the seedling nursing technology. Farmers who failed to adopt the nursing and transplanting technologies indicated that cost of the technologies was a major factor constraining adoption. This is in tandem with DIT which postulates that cost of innovation prevents farmers from adopting the technology. However, the observed high adoption for the same innovation finds explanation in the RCT and TPB. Respectively they stipulate that, irrespective of the cost, expectations of higher behavioural outcomes result in positive intentions towards behaviour (TPB) and perceived/objective higher benefits of improved yields from behavioural choice motivate choice options (RCT).

The results indicate that the adoption of ploughing, harrowing, and field levelling were respectively very high, ranging from 97.5-99.5%. The adoption of these technologies is machinery intensive and dependent, therefore the high proportion of adoption implies adequate access to machinery at the Bontanga irrigation area. Ploughing, harrowing, and levelling are divisible technologies and farmers can choose to adopt the single technology especially under resource constraint conditions.

The observed high proportion of adoption therefore implies farmers have access to mechanisation services and that adoption of these technologies are not constrained by cost. Could also emanate from farmer expectation of high yields from adoption as stipulated by the TPB and RCT. Ploughing, harrowing, and levelling are the first set of irrigation farm operations therefore, farmers draw from accumulated savings to undertake the technologies. Anecdotal evidence indicates farmers have been ploughing and harrowing their fields for farming operations, therefore the very high adoptions also reflect compatibility of these technologies with their farming culture.

The findings compare with Rogers (1983 and 2003) in the DIT, that compatible, accessible, and relatively advantageous technologies are better adopted by adopting farmers. It further indicates farmers perceived/observed benefits from technology adoption outweigh benefits of preceding technologies as stipulated in the RCT. This further indicates that technologies are compatible with their rice production and cultural practices (DIT).

Ploughing, harrowing, and levelling are considered compatible, accessible, and relatively advantageous than preceding innovations and therefore motivate very high technology adoption.

A high adoption of 68% was observed for rice transplanting technologies which is a labour and cost intensive irrigation operations. Some farmers observed that though transplanted rice yields much higher than other planting technologies, cost of the technology and the time spent during the operation constrained adoption. This compares with Rogers' (2003) assertion in the DIT that costly technology lends itself to none or poor adoption.

Adoption Levels of Fertilizer Application Technologies

The fertilizer technologies were the least adopted among the introduced technologies (Table 52). The findings relating fertilizer technologies indicate that close to half (49.2%) of the farmers adopted the compound fertilizer technology of applying 200kg/acre after planting. Almost two thirds (58.4%) of respondents adopted the nitrogen fertilizer technology of applying 100gk/acre of nitrogen fertilizer 3-4 weeks after planting (Table 52). The more than 40% of farmers who did not use 100kg of nitrogen and the 50% who did not use 200kg/acre of compound fertilizer indicated that: they "cannot afford the cost of fertilizer" and "price of fertilizer is too high". Fertilizer technologies are divisible technologies and with the comparatively high price of compound fertilizer, farmers would rather use the less costly nitrogen fertilizer. Other resource poor farmers did not use one or more of the fertilizer technologies completely, resulting in reduced adoption levels for the technology. The low levels of adoption for 200kg/acre of compound fertilizer might compromise attaining the potential yield levels of seed technology.

The results compare with Ndagi et al. (2016) and Kariyasa and Dewi (2013) respectively that majority of respondents were low adopters of fertilizer application technologies and 47% of farmers implemented the fertilizer technologies. The findings further corroborate Akpan et al. (2012) and Rogers (2003) that the high price of fertilizer adversely influences fertilizer use intensity and adoption by arable crop farmers.

Table 52- Farmers adoption of fertilizer technologies

Fertilizer technologies	**n**	**%**
100kg of nitrogen fertilizer/acre 3-4 weeks after planting	115	58.4
200kg of compound fertilizer/acre immediately after planting	97	49.2

Source: Field survey, Seini (2013). Note: 50kg = 1bag fertilizer

Adoption Levels of Improved Rice Varieties

All farmers were found planting improved seed varieties at the Bontanga irrigation project area. Jasmine variety was however, most adopted (72.1% of the respondents) (Table 53). Few farmers adopted Afife (10.7%), Bumbas (3.0%), Thailand (0.5%), and Andii (0.5%). Thirteen (13%) percent of the farmers did not use any of the introduced improved seed varieties but were using or experimenting with, together with other farmers, other improved seed varieties found at Golinga and Libga irrigation project areas both in the Northern Region of Ghana.

The high level of adoption of jasmine rice is attributed to its introduction along with access to market by USAID, to solve the constraint of non-availability of rice market in the adoption of jasmine rice. It would seem, from the very high adoption of jasmine variety, that farmers replaced the preceding varieties with the jasmine variety. Market availability for jasmine could have motivated farmers favourable attitudes towards adoption of jasmine variety. This results, compare with Kristjanson et al. (2005), on farmer perceptions of/and factors affecting adoption of improved dual-purpose cowpea in Nigeria, that 69% and 55% respectively adopted the seed variety because the seed had higher grain and has advantage over local varieties.

Several other lesser known improved varieties were being experimented by 79% of the respondents. Thailand and Andii are earlier and obsolete varieties introduced at the project area and have been competed out by higher returns of the new seed varieties.

Table 53- Farmer adoption of improved irrigated rice seed technologies

Improved rice seed varieties	n	%	SD
Jasmine	142	72.1	.45
Afife	21	10.7	.31
Bumbas	6	3.0	.17
Thailand	1	0.5	.07
Andii	1	0.5	.07
Others	156	79.2	-

Source: Field survey, Seini (2013). n = 197

Adoption Levels of IPM Technologies

The adoption of the IPM technologies were quite high, ranging from 91% for intermittent flooding, 86% for intermittent drainage and 61% (two thirds) adoption for insecticide application at milky/booting stage (Table 54). The IPM technologies are complementary to the improved seed varieties in maintaining established high rice yields of the seed technology. The use of the IPM technology would ensure rice crop protection through transplanting to the booting stage using weed and insect pests and disease control and prevention. Further, the cost of pests and disease control and/or treatment on occurrence is also reduced when IPM technologies are adopted.

Table 54- Farmer adoption of IPM technologies of irrigated rice production

Integrated pest management technology	Frequency	
	n	%
Intermittent flooding of field	179	90.9
Intermittent draining of field	170	86.3
Fungicide application before transplanting	126	64.0
Insecticide application at milky/booting stage	120	61.0

Source: Field survey, Seini (2013). n = 197

Thus, the effect of the high use of flooding and drainage could be eroded by the low use of insecticide and weedicide since they are complementary. IPM technologies are expected to make possible the expression of the potential yields of improved seed varieties. However, the incomplete use of the full components of the technology would reduce yields. Farmers were also observed physically scaring birds from destroying rice grains on farms to reduce pre-harvest losses.

The findings compare to Kariyasa and Dewi (2013) report that IPM was implemented by 76% of the respondents because IPM results in high yields. The incomplete adoption of IPM components finds explanation in the three theories (TPB, RCT and DIT) of the study.

Adoption Levels of Irrigated Rice Technologies

To examine the overall adoption of irrigated technologies, adoption was classified in terms of proportion of technologies, out of the total package of fourteen (14), adopted by the farmer. The levels of adoption were categorised into four levels:

1 = low, if 25% (approximately four) technologies were adopted.

2 = medium, up to 50% (7 technologies) were adopted.

3 = high, if up to 75% (approximately 11) technologies were adopted, and

4 = very high, if more than 75% (more than 11 technologies) were adopted (Table 55). The proportion of farmers under the respective levels of 1, 2, 3, and 4 were 1.5%, 8.6%, 24.4%, and 65.5% (two thirds of farmers).

The proportion of farmer adoption increased along the adoption levels peaking at adoption level 4 (Table55). Thus, higher adoption levels were more likely than lower levels of adoption. The findings suggest that farmers are unable to adopt the full range of the technology package due to varying resource endowment levels. The results are consistent with Mariano, Villano, & Fleming (2012) that with multiple technologies, respondents are unable to adopt the full set of technology at the same time. They suggested that farmers, under multiple technologies scenarios, adopt the progressive technology adoption approach as a function of resource constraints.

The results indicate that all the components of the technology package were not adopted. Three quarters of the farmers are classified as most high-level adopters indicating these famers adopted only 75% of the technology package spread over levels 1-3.

Table 55- Levels of irrigated rice technologies adoption

Number of technologies adopted	F		Adoption level
	n	%	
0-4	3	1.5	low = 1
Up to 7	17	8.6	moderate = 2
Up to 11	48	24.4	high = 3
11+	129	65.5	very high = 4

Source: Field survey, Seini (2013).

This trend compromised the synergistic effects of the technology package aimed at increasing rice yields. The technologies adoption was premised on farmers attaining potential rice yields of 6.5-8t/ha (FAO, 2013; Nguu, 2013) through complete adoption of the introduced technology package. Increase and sustained rice production is guaranteed by the adoption of improved rice production technologies (Norman and Kebe (2007).

The recurring low yields experienced at the Bontanga irrigation area could be attributed to the poor adoption of fertilizer and IPM technologies because the synergistic effects of technology package were compromised. However, it is important to note that adoption of agricultural technologies is subject to technology and social-economic characteristics (Morris, Tripp, & Dankyi, 1999). Similarly, Rogers (2003) include technology cost as one of the characteristics that constrain adoption.

Theoretical Framework and Adoption of Technologies

TPB, RCT and DIT, each of which focuses on the individual as a unit of decision making, were used to guide and explain irrigated rice technologies adoption at the Bontanga irrigation area. The study described the adoption of multiple irrigated rice innovations introduced to farmers at the Bontanga irrigation project area.

The package of pre-planting and planting technologies are capital intensive innovations and therefore liable to be constrained by inadequate access to cash or capital yet were adopted by majority of farmers. The high proportion of farmers' technologies adoption and levels of adoption is attributed to subjective expectations or actual better returns from the use of the innovations. Thus, TPB and RCT could explain farmers' behavioural choices. For instance, TPB is premised on the assumption that human behaviour intentions are influenced by behavioural attitudes through subjective norm or social pressure and perception of behavioural constraints. Social pressure as a moderator of technology adoption is excluded or enforces adoption behaviour because all colleagues are involved in the irrigation farming and therefore enhances innovations adoption behaviours. Furthermore, farmers still have cash from the immediate main cropping season and therefore are not cash or capital constrained for innovation adoption. The absence of social pressure and constraints allow farmers form stronger intentions towards behaviour of innovation adoption.

On the other hand, RCT stipulates that human choices are directed by outcome of cost, benefits, and risk analysis. Farmers would implement technologies choice options if farmers are certain of higher returns from technology choice options available. However, farmers do not have the information about the technology to assess them. This constraint is absolved by DIT using appropriate communication channels, in this study, by the irrigated rice farmers' organisation.

It is important to note that the decision to be a member of the irrigated rice farmers' organisation is influenced by subjective norms of the TPB and the expectation of higher benefits of being a member of the group than otherwise stipulated in the RCT. The reverse is also true for non-adopters and membership to the irrigated rice farmer's organisation. In the main, the influence of cost of technology attributes of the DIT does not seem to explain farmer's adoption decisions because even though farmers indicate the technologies are costly or expensive in terms of time and labour, the technologies were still adopted except for the few non-adopters.

Generally, the adoption of fertilizer technologies namely nitrogen and compound fertilizers, was comparably poor due to the cost of fertilizers. These innovations are complementary and divisible, therefore the adoption of one can precludes the adoption of the other especially under resource constrained scenarios. Farmers might have spent available cash capital on the preceding pre-planting and planting innovations and thus cash constrained to completely use the fertilizer innovations. Therefore, resource constrained farmers could choose not to adopt the fertilizer innovations due to relative cost considerations as premised in the DIT on technology attributes. Farmers could also choose, on the postulate of RCT, to adopt the cheaper nitrogen fertilizer against the relatively expensive compound fertilizer if expected returns are better than preceding innovations even if the potential yields of the improved seed varieties are not met.

Relative to the preceding technology, a postulate of DIT on technologies attributes, offers the foremost explanation of the complete adoption of the improved seed varieties. The higher yields of improved seed varieties allowed farmers form stronger positive intentions towards human behaviour; adoption of the improved seed variety as stipulated by TPB. Therefore, farmers rationally chose improved seed variety against traditional varieties as the best option in the RCT.

Improved seed varieties were made available by the USAID along with introducing the jasmine seed variety, therefore precluding the constraint of inadequate access to improved seed. According to TPB, the intention towards human behaviour is also influenced by subjective controls or constraints. Therefore, eliminating the control of inadequate seed access made farmers form intentions towards improved seed adoption at the Bontanga irrigation area. These implies that the theories complement each other in influencing farmers irrigated rice technology adoption decisions at the Bontanga irrigation area and are not mutually exclusive.

IPM technologies were adopted by an appreciable proportion of farmers to almost complete adoption for intermittent field flooding. That the cost of water for flooding is not immediately felt by farmers because they do not have to pay immediately before use, is worth noting. This makes the technology seemingly less costly, or there exists a secure credit for water use, and therefore lends itself to adoption by farmers as postulated by the DIT relating to cost of technology and TPB regarding elimination of credit constraint.

The use of field flooding and draining eliminates insecticide application at milky stage to the barest minimum and therefore insecticide adoption becomes irrational except for control purposes as in the RCT. The implementation of the IPM technologies is; however, aimed at enhancing yield performance of improved seed varieties, therefore, as postulated in the RCT, farmers would choose to adopt IPM innovations if net benefits are higher than cost incurred in using the innovations, especially the flooding and draining technologies which was expected to reduce net insecticide applications.

TPB stipulates that pressure from social norms influence human behaviour. A positive expectation of reducing weed pests, insect pests and diseases positively influence the adoption of IPM innovations. Similarly, the expectation of increased yield from planting improved rice seed varieties motivated farmers' adoption of yield enhancing technologies to either meet subsistence or commercial production needs.

CHAPTER SIX

CORRELATES OF ADOPTION LEVELS OF IRRIGATED RICE TECHNOLOGIES

Introduction

Chapter six examines the relationships between farmer specific, socio-economic, technologies, and environmental factors and institutional support and levels of adoption of rice technologies.

Relationship between Farmer Specific and Socio-economic Factors and Adoption of Irrigated Rice Technologies

This section describes the correlates of adoption levels and selected farmer characteristics namely: sex, age, household size, marital status, and formal education (Table 56). There was no significant relationship between adoption levels and sex, age, household size, marital status, and formal education of farmers.

Experience of farmers was observed to have a very weak positive and significant association ($\rho = 0.21$, $p < 0.004$) with adoption levels of irrigated rice technologies. The positive coefficient associated with experience indicates that the higher the experience of the farmer, the higher the adoption level of irrigated technologies. The results compare with Baffoe-Asare et al. (2013), and Baete (2012) that experience of the farmer had a significant positive effect on adoption of agricultural technologies. Djokoto & Blackie's (2014) findings differ from the results that famers' experience had a positive but non-significant association with mechanised harvesting technology.

Table 56- Correlation of levels of adoption with farmer specific characteristics

Variables	Gender	Age	Hh size	Marital status	Education	Experience	Land tenure arrangement
Coefficients	-.05	.08	-.01	-.02	.09	.21	.14
p-value	.48	.31	.92	.79	.23	.004	.06
N	181	190	194	192	174	194	184

Source: Field survey, Seini (2013). Hh = household

Gender produced a very weak or even negligible negative nonsignificant association, ρ = .05, $p > .05$, with adoption levels of technologies at the Bontanga irrigation area. Male farmers were associated with lower levels of technologies adoption. This compares with Baete (2012) that gender of respondent does not influence farmers decision to adopt rice technologies in the village of Fiu of the Malaita province. This; however, differs from Akpan et al. (2012); Djokoto and Blackie (2014); Vidogbena, et al. (2012) and Sakurai (2002) that male farmers are more likely to adopt agricultural technologies than their female counterparts. For Akpan et al. (2012) and Djokoto and Blackie (2014), the coefficient of gender is significant and positively associated with fertilizer use intensity and harvesting technologies respectively and male farmers are more likely to increase fertilizer use intensity and harvesting technologies compared to their female folks. Household size had a very weak/negligible negative non-significant association, ρ = -.01, $p > .10$, with adoption levels of technologies at the Bontanga irrigation area.

The findings differ from that of Akpan et al. (2012) and Djokoto and Blackie (2014) respectively that increase in farmer's family size decreases the fertilizer use intensity and a negative significant association with mechanised harvesting technology in the study areas. The results further differ from Kalineza et al. (1999) of positive non-significant association of household size with technologies adoption. Household size is relevant to adoption of irrigated rice technologies because household is a source of farm labour and related to food consumed in the household. They are expected to influence farmers to adopt irrigated rice technologies because a large household would have access to labour and would be motivated to adopt irrigated rice technologies to increase yields to feed the household members. Langintuo and Mekuria (2008) and Feder et al. (1982) have emphasised the relevance and positive relationship of household size in agricultural technology adoption. However, the very weak negative coefficient and non-significant influence of household size implies that household size is not an important factor to consider for programming purposes at the Bontanga irrigation project area.

The comparison of marital status with adoption levels of technologies demonstrate that marital status had a negative negligible non-significant, $\rho = -.02$, $p > .10$, association with adoption levels of technologies at the Bontanga irrigation area. This negative coefficient implies that being married relates negatively with farmers' innovation adoption levels, without any causal connotations. It is however, important to note that the association was negligible and nonsignificant.

The results compare with Ayoola (2012) that marital status did not relate with yam miniset technology adoption in the Kogi and Benue States of Nigeria. However, the findings differ from Denkyirah et al. (2016) that marital status had a significant relationship with credit in the Tolon Ditrict of Ghana.

The inference is that being married virtually had no association with farmer adoption levels of irrigated rice technologies.

There was a very weak or even negligible positive nonsignificant, $\rho = 0.08$, $p > 0.10$, relation of age with adoption levels of irrigated rice technologies. The indication is that the association of age and adoption levels of irrigated rice technologies is very weak and non-significant. Age is reported to exhibit different associations with technology adoption at different locations and circumstances. Though the relationship is negligible, the findings compare with Akpan et al. (2012); Kalineza et al. (1999); and Mamudu et al. (2012) that older farmers are more likely to be associated with adoption levels of technologies. Age of respondents therefore does not associate with adoption levels of irrigated rice technologies at the Bontanga irrigation project area.

There was a very weak positive and not significant relationship, $\rho = .09$, $p > .10$, between formal education of farmers and adoption levels of irrigated rice technologies at the Bontanga irrigation project area. The study holds a hypothesis that there is no association between formal education and levels of adoption of irrigated rice technologies. The null hypothesis which states that there is no significant association between formal education and levels of adoption of irrigated rice technologies is accepted. Literature indicates that farmers who had formal education can perceive, interpret, and respond to new information much faster as compared to those who are without or low formal education (Kalineza et al., 1999; Mensah, 2008). The positive but negligible and not significant association of education with adoption levels is thus unexpected. Formal education therefore is not expected to influence adoption of irrigated rice technologies. The results compare with Baete (2012) that education was not associated with adoption of rice technology. However, it differs from Akpan et al. (2012); Mensah (2008); and Saka et al. (2005) that education of the farmer had a positive significant relationship with technology adoption.

Land tenure describes landownership, use and rental arrangement that grants the farmer control over the land use. The correlation results; $\rho = .14$, $p > .05$, demonstrate that land tenure exhibited a positive non-significant association; $\rho = .14$, $p > .05$, with adoption levels of irrigated rice technologies at the 5% significance level, though significant at the 10% level (Table 56). Farmers' positive perception of the influence of adequate land tenure arrangement was associated with higher adoption levels of irrigated rice technologies. This positive coefficient meets a priori expectation because there is secure land tenure arrangement at the Bontanga irrigation area through land allocations by the farmer organisation (Opoku, 2011), and is expected to influence farmers' technologies adoption decisions. The findings compare with Ntege-Nanyeenya et al. (1997) that land tenure was positively associated with the adoption of maize production technologies in the Iganga District of Uganda at the 10% significance level.

Relationship between Adoption Levels of Irrigated Technologies and Technology Specific Factors

Technology characteristics exert varying influences on adoption decisions. This section discusses results of the relationship between adoption levels of irrigated rice technologies and technology characteristics namely:

cost, compatibility, complexity, risk, and meeting needs, disease and pest resistance.

Table 57 presents the correlation coefficients and related p-values on the relationship between technology characteristics and adoption levels of irrigated rice technologies. The cost of technologies had a very weak positive significant, $\rho = .17$, $p < .05$, relationship with adoption level of irrigated rice technologies. This implies that level of adoption increases with increasing technology cost. Farmers who perceived technologies to be costly are ironically associated with adopting irrigated rice technologies. This implies that cost of technologies does not constrain farmers' adoption of irrigated rice technologies.

The conformity, similarity, and harmony of technology with the culture and practices of farmers connote compatibility of the technology.

Table 57- Correlation of adoption with Technologies characteristics

Technology characteristic	Coefficient (ρ)	p-value	n
Cost	0.17*	.02	192
Compatibilty	0.003	.96	186
Complexity	0.23**	.00	181
Riskiness	0.24**	.00	180
Meeting needs	0.05	.48	174
Disease resistance	0.29**	.00	177
Pest resistance	0.26**	.00	179

Source: Field survey, Seini (2013). ** < .1%; * < 5%

Compatibility of technologies had a negligible positive and not significant relationship with levels of adoption of irrigated rice technologies, $\rho = .003$, $p > .10$, at the Bontanga irrigation project area. It is important to note that the coefficient is insignificant in its association with levels of adoption of irrigated rice technologies. Farmers' agreement to the assertion that innovations are compatible is associated with higher adoption levels though not significantly so.

Regarding the positive sign of the coefficient, the results compare with Ming-Horng and Chieh-Yu (2011) that compatibility had a positive non-significant association with SMEs business performance. The findings also compare with Rogers (2003) that compatible innovations are positively associated with farmers' adoption decisions. Pre-planting technologies, except levelling are traditional rice cultivation activities. Through experience the other technologies have become part of farmers' rice cultivation practices. Thus, all technologies have been rendered compatible with time, rendering compatibility nonsignificant.

Farmers' positive perception of the influence of technologies complexity exerted a weak, positive, and highly significant, $\rho = .23$, $p < .001$, association with adoption levels of irrigated rice technologies. The implication is that complexity exerts a negative relationship with technology adoption levels. However, farmers who perceive complexity to reduce adoption levels are weakly associated with higher adoption levels. Naturally, though farmers have been involved in rice cultivation, the traditional technology have been devoid of seed nursing and transplanting, flooding, and levelling which are complex practices to the untrained farmer. The educational training of farmer organisation at the project area resolved the complexity inherent in the technologies. Farmers also learnt to understand and use technologies from social networks, therefore farmers' positive relationship with higher adoption levels. The results compare Rogers (2003) that the more complex a technology, the more negatively it associates with technologies adoption decisions. The findings compare with Ming-Horng and Chieh-Yu (2011) that complex technologies had positive associations with SMEs business performance.

The positive perception of the influence of riskiness of technologies on adoption levels of irrigated rice technologies exhibited a very weak positive and highly significant association; $\rho = .24$; $p < .01$, with adoption levels of technologies. This implies risky technologies reduce technologies adoption. Farmers who asserted that technologies adoption are negatively influenced because of their risky attributes are oddly associated with higher adoption levels. Extension communication processes are used during innovation dissemination to remove or reduce uncertainties and risks associated with technologies to promote technologies adoption (Rogers, 2003). The findings therefore imply extension agents were successful in dispelling the uncertainties/riskiness associated with the technologies. Further, the results suggest that introduced technologies were safe to use. The findings compare Rogers (2003) that the riskier a technology, the less likely the technology would be adopted.

The qualities of disease and pest resistance of technologies are considerations subsumed under relative advantage over preceding technologies. Disease resistance, $\rho = .29$, $p = .001$ and pest resistance, $\rho = .26$, p = .000, of technologies had very weak positive and highly significant associations with adoption levels of technologies (Table 57). Disease and pest incidences were however, not observed at the project area. Improved seed varieties were disease and pest resistant and therefore maintenance of potential crop yields motivated farmers' adoption of irrigated rice technologies. The results compare with Ming-Horng and Chieh-Yu (2011) that relative advantage had positive associations with SMEs business performance. Furthermore, Baete (2012); Langintuo and Mekuria (2008); and Rogers (2003) also indicated that relative advantage significantly associated with farmers' adoption decision.

Technologies meet needs (relative advantage), $\rho = .05$, $p > .10$, also had non-significant positive association with adoption levels of technologies. The positive association is expected and compare with Rogers (2003) because technology meeting farmers' needs of high yields (relative advantage) positively associate with farmer technologies adoption decisions. Similarly, the findings ae in tandem with Langintuo and Mekuria that the most important factors that influence technologies adoption include yield of improved seed varieties (Langintuo & Mekuria, 2008) and improved food security, high yielding, early maturing, and improvement in income (Baete, 2012).

Relationship between Adoption Levels of Irrigated Technologies and Resource Related Factors

Resource in the form of cash, assets, land, and savings is an important prerequisite for the establishment of enterprises especially for farming. The resource related factors included in the analysis were available capital, have labour, and assets (Table 58). Generally, adequate availability or access to resources are expected to positively influence technology adoption decisions of farmers.

Farmers' positive perception of the influence of capital availability on adoption levels was moderate, positive, and highly significant; $\rho = 0.24$, $p < .01$, associated with adoption levels of irrigated rice technologies. Capital availability therefore exert a positive influence on levels of adoption of irrigated rice technologies at the Bontanga irrigation area. Inadequate capital availability would negatively associate with adoption levels. Experience and rationality with respect to expected high returns would however, cloud capital considerations for technologies adoption. Farmers would seek credit from diverse sources to adopt technologies for high expected returns. The results compare with Michael et al. (1999) and Nyanga (2012) that differential access to capital is an influencing factor in deferential rates of technologies adoption especially so with divisible and lumpy technologies.

Table 58- Correlation of adoption with capital related factors

Variable	**Available capital**	**Available labour**	**Available assets**	**Available land**
Coefficients	.24**	.13	.28**	.13
p-value	.001	.07	.000	.07
N	187	182	176	185

Source: Field survey, Seini (2013).

There was a weak positively significant correlation; $\rho = .28$, $p < .001$, between farmers' adoption levels of irrigated rice technologies and assets to practice technologies (Table 58). Farmers who perceived adoption decisions are influenced by available assets correlated positively with higher adoption levels of irrigated rice technologies adoption. Therefore, assets and adoption levels are related or promote each other. The lack of sufficient accumulated savings by smallholder farmers may prevent them from having the necessary capital for investing in new technologies (Feder et al., (1985). The results corroborate Langintuo and Mekuria (2008) that cash is required to purchase seed and complementary inputs and that moving a farmer with no access to assets to a position of access to assets has the potential to positively associate with the adoption rate and intensity of use of improved maize varieties.

There was a nonsignificant weak positive correlation between adoption levels of irrigated rice technologies and labour availability; $\rho = .13$, $p < .10$. This implies that available labour and adoption levels complement each other in either direction without any causal connotations. The findings failed to meet a priori expectation though positively related. The results corroborate the study of Affholder et al. (2009) on direct-seed mulch-based agricultural practices that inadequate labour in combination with cash had a negative relationship with the adoption of the technology.

There was a weak positive not significant; $\rho = .13$, $p < .10$, correlation between available land and adoption levels of irrigated rice technologies. Farmers who perceive available land influence their adoption decisions are none significantly correlated with adoption levels of irrigated rice technologies. An improvement in land availability would slightly improve adoption levels without causal implications because land size at the Bontanga irrigation area is small (Table 8). Other complementary factors might need to be involved for the influence of land on technologies to be much felt.

However, under conditions of insecure land rights, land alone may not influence technology adoption (Deininger & Ayalew 2008; Minde et al., 2008). The findings also compare with de Janvry et al., (2011); Kasirye, (2013); and Pingali & Gerpacio, (2008) that large farmland owners can afford to experiment with technologies and are more likely to be associated with early adopters.

Relationship between Adoption Levels of Irrigated Technologies and Social Related Factors

Factors that are considered under social factors include status in community, ethnic group, member in social group, and status in social group. These factors are associated with human capital and social networks and have been shown to influence technology adoption decisions.

Table 59 depicts the results of the correlation analysis conducted on the association between selected social factors and levels of irrigated rice technology adoption at the Bontanga irrigation area. Position in group and adoption levels of irrigated rice technologies exhibited weak and positive correlation; $\rho = .16$, $p < .03$. The result provides evidence that being a leader of a group is associated with higher adoption levels of irrigated rice technologies at the Bontanga irrigation project area. To protect their integrity and trust of group members, leaders do not only always attend meetings but are usually among the first to report for meetings and can be first to receive technology information from the programme implementers and trainers. The leaders are therefore ahead of members in information, knowledge, and skills to adopt innovations as innovators and appropriately guide and influence group members' innovation adoption decisions.

Farmers in a group learn from each other how to grow and market new crop varieties through social networks. Social networks' effects have been considered important for individual adoption decisions and that in the context of agricultural innovations, farmers share information and learn from each other (Nyanga, 2012 and Langintuo & Mekuria, 2008).

Table 59- Correlation of adoption with social related factors

Variables	Status in community	Ethnic group	Member in social group	Status in social group
Coefficients	-.01	.09	.09	.16*
p-value	.89	.25	.20	.03
N	178	181	188	190

Source: Field survey, Seini (2013).

The results are thus expected and anticipated to influence technology adoption decisions. The results compare to Baete (2012) that not only are group leaders positively associated with technology adoption but influence group members technology adoption decisions. Baete further indicated that irrigated rice farmers of the Malaita province of Solomon Islands discontinued the use of maize production technologies because leaders of group/co-operatives lacked the requisite knowledge and skills appropriate for fertilizer, pest and disease management. Baete further indicated that the technical knowledge, skills, and trust of members in leadership are the important factors influencing technology adoption. The findings differ from Adisena and Baidu-

Forson (1985) that being a village leader exhibited a non-significant and negative association with technology adoption.

Status in community (chief/member) had a neglegible negative not significant correlation with adoption levels of irrigated rice technologies; $\rho = -.01$, $p > .05$. Positive perception of the influence of status in community on adoption levels of irrigated rice technologies was not correlated. Community leaders are key decision-makers of their communities and constitute the first people to be informed about a new technology introduced into the village or community for the first time. Their decision to welcome the technology and its subsequent use influences other members to use the technology and is expected to positively correlate with adoption levels of irrigated rice technologies. The results therefore do not meet a priori expectation.

Chiefs of a community wield influence and control over community members which does not extend to individual farming decisions. Otherwise farmers must have trust in leadership's knowledge and skills for their adoption behaviour to be influenced. Furthermore, the proportion of chiefs compared to proportion of farmers is low therefore their effect on adoption levels is masked. The results compare with Adesina et al. (1985) that being a village head was negatively related to agricultural technologies adoption.

Ethnicity had a very low or negligible positive correlation; $\rho = .09$, $p > .01$, with adoption levels of irrigated rice technologies, which is expected of the characteristic at the project area. Ethnicity serves as human capital where people of similar ethnicity better interact and exchange information and knowledge compared to different ethnicities and is found to positively influence technology diffusion and adoption (William, 2008). The more similar the ethnic divide, the better ethnicity enhances technologies adoption decisions. It is important to note that the project is located within communities of uniform tribal orientation and there is no ethnic diversity within farmers of the Bontanga irrigation area. Ethnicity, therefore, was expected to exhibit a positive correlation with adoption levels at the project area.

The results, however, differ from Reem, Anne-Marie, and Louis (2013) that ethnicity had a negative relationship with the intention to adopt internet technologies. Ricardo, Jeffrey, and Mario (2016), also showed that membership to Mojeno ethnic group, of the Bolivian rain forest, was negatively related with adoption of technologies owing, to participation in messianic movements. The similarity of ethnicity at the project area explains the non-correlation of ethnicity and adoption levels of irrigated rice technologies.

The findings; $\rho = .09$, $p > .10$, on being a member in social group and adoption levels of irrigated rice technologies demonstrated a very weak or negligible positive non-significant correlation implying that being a member of a social group does not correlate with adoption levels of irrigated rice technologies at the Bontanga irrigation project area. Membership of a social group enhances human capital through social network interactions which are expected to influence individual and compatriots' technology adoption decisions, through knowledge and information sharing by social networks. The results therefore are unexpected.

Literature suggests that network effects are important for individual adoption decisions because farmers learn from each other, how to grow and market crop varieties, especially for agricultural innovations (Nyanga, 2012;

Langintuo & Mekuria, 2008). The findings differ from that of Nyanga (2012) and Langintuo and Mekuria (2008) that farmers in a group share information which enhanced adoption rates.

Relationship between Adoption Levels of Irrigated Technologies and Institutional Support Factors

Institutional support under consideration included NGO, MoFA, farmers group, bank/credit, agro-chemical, and radio/tv and market availability. These are assessed in the light of the influences institutional support exert on technology adoption decisions. Institutional support to farmers focuses on extension education, training, credit and input support, and network establishment through group or cooperative formations.

It was observed that the correlation between NGO support and adoption levels were moderate, positive and highly significant; $\rho = .32$, $p < .001$ (Table 60). Therefore, farmers' positive perception of the influence of NGO support is moderately correlated with adoption levels of irrigated rice technologies. The positive significant association of NGO support emanated from the provision of services by NGOs which motivated and improved farmer technology adoption decisions. This implies that NGO support in the form of extension education and training, credit support and linkages to markets are important considerations for enhanced technology adoption at the Bontanga irrigation area and the results are therefore expected.

The results of the analysis on MoFA extension support and adoption levels; $\rho = .35$, $p < .001$, show extension services support had a moderate positive and highly significant correlation with adoption levels of irrigated rice technologies. Higher response categories or farmers' positive perception of

MoFA extension services' influence on irrigated rice technology adoption are correlated with higher adoption levels of irrigated rice technologies. Therefore, extension support provided through MoFA has been effective in influencing the relationship of extension support with adoption levels of irrigated rice technologies at the Bontanga irrigation project area. Improvement in MoFA extension support would improve adoption levels or vice versa. The results compare with Adesina and Baidu-Forson (1985), Baffoe-Asare et al. (2013), and Saka et al. (2005) that extension services support had positive significant relationship with technology adoption.

Table 60- Correlates of adoption and institutional support

Support type	Coefficients (ρ)	p-value
NGO	.32	.000
MoFA	.35	.000
Farmers group	.29	.000
Bank/credit	.46	.000
Agro-chemical sellers	.39	.000
Radio/tv	.23	.000
Available market	.04	.63

Source: Field survey, Seini (2013).

The results on farmers' group support and adoption levels of irrigated rice technologies adoption; $\rho = .29$, $p < .001$, demonstrate a weak positive and highly significant correlation. The results imply that farmers' positive perception of the influence of farmers group support on irrigated rice technologies correlated with higher adoption levels of irrigated rice technologies. The findings are an expected outcome because farmer groups offer support to members, to promote technology adoption, through extension education, training, and organisation of input supplies, water distribution and plot allocations as well as enhancing human capital and social networks at the Bontanga project area.

The importance of farmer organisation in influencing irrigated rice technology adoption is explained through the preclusion of inadequate extension services and contact, poor input access, which constrains adoption of irrigated rice technologies. Adequate provision of these services by the farmer organisation spurs farmers' enhanced adoption of irrigated rice technologies.

The findings compare with Langintuo and Mekuria (2008); Ojiako (2011); Michael, Robert, and Dankyi (1999); and Nyanga (2012) that extension services had significantly positive relationship with technology adoption, through stimulating farmers adoption of technologies. Further, Langintuo and Mekuria, (2008) observed that being a member of a group enhances technology adoption. The provision of extension services, input supplies, water distribution etc. supports are expected to influence farmers irrigated rice technology adoption options.

The assessment of the relationship between bank/credit institutions support shows that bank/credit institutions exhibited a moderate positive correlation with adoption levels of irrigated rice technologies at a very high significance level; $\rho = .46$, $p < .001$. The evidence fails to accept the null hypothesis of no correlation between banks/credit institutions support and adoption levels of irrigated rice technologies. The implication is that farmers' positive perceptions of the influence of bank/credit institutions support on technology adoption is associated with higher adoption levels of irrigated rice technology adoption.

Under poor resource conditions, provision of credit and/or access to credit spurs farmers' higher adoption levels because irrigated rice cultivation is capital intensive and any form of credit support, either in the form of cash or inputs would motivate farmers to adopt technologies. Therefore, banks/credit institutions provide financial or credit support to farmers to solve problems of credit constraints associated with technology adoption decisions to enhance technologies adoption.

The results differ from Akpan et al. (2012) that access to credit had a negative non-significant association with fertilizer use intensity in Nigeria. On the other hand, the findings compare respectively with Feder et al. (1982) and Langintuo and Mekuria (2008) that among other factors, access to credit enhanced rapid technology adoption. Provision of access to credit had the potential to positively associate with adoption rate and use intensity of improved maize varieties. An improvement in bank/credit institutions support would enhance adoption levels of irrigated rice technologies.

The results: $\rho = .39$, $p < .001$, indicate that agro-chemical companies' support had a moderate, positive, and highly significant correlation with adoption levels of technologies adoption. There is the potential for adoption levels to increase with an increase in agrochemicals support by 40% and vice versa, without any causal implications.

Support from agrochemical companies are offered to farmers in the form of timely and convenient access to inputs and/or sale of inputs on credit as well as provision of extension education and training on how to use agrochemicals. The provision of inputs to farmers on credit would also provide extra cash for farmers to engage in other cash expenditures which would further provide the impetus for adoption of irrigated rice technologies. The findings are therefore expected because the provision of extension services and training enhances the effectiveness and efficiency of farmers input utilisation through improved knowledge and skills in chemical utilisation. Similarly, the provision of inputs either on cash or credit, eliminates the constraint of non-availability of complementary inputs.

The findings compare with that of Affholder et al. (2009) and Feder et al. (1982) respectively that removing the constraint of high input price and improving access to inputs motivated farmers to adopt technologies and unconstrained access to credit would positively correlate with farmers' technology adoption.

The results of radio/tv yielded a weak positive and highly significant correlation between radio/tv support and adoption levels of irrigated rice technologies; $\rho = .23$, $p < .001$. Higher response categories correlated with higher adoption level of irrigated rice technologies adoption, implying that farmers who perceived radio/tv support influenced technologies adoption are correlated with higher adoption levels of technologies.

Improving radio/tv support in the form of information and knowledge has the potential to improve adoption levels of irrigated rice technologies. As preferred sources of information, radio and television were preferred by 95% and 50% whilst 86% and 32% used radio and television in accessing technology related information (Table 42 and43). The support from radio/tv therefore solved the constraint of lack of or inadequate access to information, thereby improving farmers' adoption levels of irrigated rice technologies at the Bontanga irrigation project area. The findings compare with Feder et al. (1982) that removing the constraint of limited access to information improves technologies adoption.

The results: $\rho = .04$, $p > .10$, show that available market had a very weak or negligible positive non-significant correlation with adoption levels of irrigated rice technologies. The results fail to provide evidence to reject the null hypothesis of no correlation between market availability and adoption levels of irrigated rice technologies. Farmers' positive perception of the influence of market availability on levels of irrigated rice technologies adoption is correlated with higher adoption levels of technologies but non-significant. The results are unexpected because for commercial oriented farmers, market availability for farm produce is important for influencing technology adoption.

The results compare with Rogers (2003) that organisational support, in the form of market among others positively associate with adoption if farmers perceive the support to be satisfactory.

Relationship between Adoption Levels of Irrigated Technologies and Environmental Related Factors

Environmental factors describe soil and weather conditions relative to the farm enterprise. Soil conditions describe soil fertility and physical conditions of the soil whilst weather condition describes environmental temperatures. The results describe the influence of good soil and conduciveness of weather on adoption levels of irrigated rice technologies (Table 61).

Conducive weather exhibited a moderate positive and highly significant correlation; $\rho = 0.32$, $p < 0.001$, with adoption levels of irrigated rice technologies. Conducive weather conditions suggest low temperatures at the project area which reduces evaporation of dam water and plant evapotranspiration. Reduced water evaporation and evapotranspiration would promote use efficiency and effectiveness with a consequential increased return through reduced water cost. Low/appropriate temperatures also have the advantage of reducing cropping periods through maintaining crop maturity periods with a resultant increased return.

Good soil and adoption levels of irrigated rice technologies also demonstrated a moderate positive and highly significant correlation; $\rho = 0.30$, $p < 0.001$. The hypothesis of no significant correlation between good soils and adoption levels of irrigated rice technologies was rejected. There is evidence not to accept the null hypothesis of no significant correlation of environmental factors (conducive weather and good soil) with adoption levels of irrigated rice technologies at the Bontanga irrigation project area. Adequate weather conditions complemented by good soil qualities enhance relative advantage of the technologies through improving irrigated rice yields at the Bontanga irrigation area and the results are expected. The irrigation dam collects enough water during the rainy periods, lower temperatures to retain and sustain dam water through reduced evapotranspiration.

Table 61- Correlation of adoption with environmental factors

Variables	Conducive weather	Good soil
Coefficients	.32**	.26**
p-value	.000	.000
N	178	189

Source: Field survey, Seini (2013)

The findings compare with Kasirye (2013); Carletto et al. (2007; and Baete (2012) that quality of land is a major factor in deciding the use of key inputs such as chemical fertilizers, or adopting improved crop varieties due to expected higher returns. While farmers adopt the recommended fertilizer rates of 200kg/acre and 100kg/acre compound and nitrogen fertilizer respectively, they do not realise any poor soil conditions of lands and will consider lands to be good instead of the reverse. The positive association, however, is expected as it enhances relative advantage of the technologies, hence improves farmers' technology adoption decisions. The findings also compare with Feder et al. (1982), that more favourable farm environment; favourable temperatures, better/good soil and water availability positively correlate with the probability of a farmer adopting new technologies.

CHAPTER SEVEN

PREDICTORS OF TECHNOLOGY ADOPTION LEVELS

Model Assessment

This section examines the plausibility of use of ordinal regression for determining the predictors of adoption levels of irrigated rice technologies, the fitness of data to the model and the approximate coefficient of determination (pseudo-R^2) of the included variables (Table 62).

The ordinal regression model tests the assumption or null hypothesis that the location parameters, otherwise the slope coefficients are the same across response categories for all levels of dependent variables; proportional odds assumption, using the difference in -2LL between the null hypothesis and general model. The findings, -2LL χ^2 = 27.56, $p > .05$, demonstrate plausible proportional odds assumption, therefore fail to reject the null hypothesis of proportional odds and the model is thus appropriate. This indicates a good fit of the data to the model and that the general model makes a significant improvement on the model fitness.

Whether the model improves the ability to predict the outcome was next examined by comparing -2LL chi-squares of a baseline to the final model with all included variables. The results, χ^2 = 70.48, $p < .001$), for the final model, indicate the overall model predicts adoption levels of irrigated rice technologies significantly better than the model with adoption levels included alone, in other words, the baseline model. The highly significant model chi-square testified that the model with the selected predictors is significantly a better model than the model without the predictors. There is sufficient evidence to reject the null hypothesis that the model without the predictors is as good as the model with the predictors. The final model therefore provides significant improvement over the baseline with intercept-only model. The model thus gives better fit and prediction than the baseline model and therefore a good model for the data.

In linear regression, the coefficient of determination (R^2) is used to summarise the proportion of variance in the outcome/dependent variable that is accounted for by independent variables. This is however, constrained in the ordinal regression model. Therefore, approximations; Cox and Snell, Nagelkerke pseudo-R^2, are estimated for the significance or strength of the association of the model's contribution. Nagelkerke pseudo-R^2 = 0.613, shows that the model explains 61% of the levels of irrigated rice technology adoption.

The Pearson chi-square and the Deviance assess the goodness-of-fit of the data to the model. The Pearson χ^2 = 216.56, $p < .01$ and the Deviance χ^2 = 86.86, $p > .05$, provide significances that are at variance to each other, though ought to agree. The Pearson chi-square indicates a poorly fitting data while the Deviance statistic indicates a good fitting data. This is expected because National Centre for Research Methods (2016), cautions against being too dogmatic about the p-values because Pearson and Deviance statistics are very sensitive to large data and empty cells. Furthermore, Field (2005) also cautions that in practice, it is not possible to get all the diagnostics to agree. Generally, it is therefore opined that the model was a good fitting model for the data and predicted adoption levels of irrigated rice technologies.

Best Predictors of Adoption Levels of Irrigated Rice Technologies

This section presents the findings of the ordinal regression analysis conducted to describe the predictors of the adoption levels of irrigated rice technologies at the Bontanga irrigation area. The variables included in the model have been grouped into thematic areas namely; farmer-related factors (sex through to experience), technologies-related factors (cost through to pest resistance), capital-related factors (land availability through to assets), as well as social-related factors (status in community through to position in group), institutional support factors (NGOs through to market support) and environmental-related factors (conducive weather condition and good soil) (Table 62). The 5% α level of significance, from the regression results, was used to determine the best predictors of adoption levels of irrigated rice technologies.

Farmer-Related Factors

Farmer-related factors included gender, age, household size, marital status, formal education, and experience. Two of these set of factors namely, age and household (hh) size are negative predictors, while gender, marital status, through to farmers' experience are positive predictors of adoption levels of irrigated rice technologies.

Gender

Gender usually describes the roles prescribed for people based on their sex and this study investigated the perceived influence of a farmer's gender on levels of adoption of irrigated rice technologies (Table 62). The findings, β =

2.46, χ^2 = 1.72, p > .10, show that gender is a positive non-significant predictor of adoption levels of irrigated rice technologies at the Bontanga irrigation project area. The positive coefficient suggests that being a male or female, depending on the famer's sex, would improve technology adoption.

Table 62- Results of the ordinal regression of adoption of irrigated rice technologies

Parameter	(β)	SE	χ^2	Sig.	Exp(β)	95% CI	
						Lower	Upper
Gender	2.46	1.88	1.72	.19	11.65	-1.22	6.13
Age	-4.79	2.06	5.38	.02	0.01	-8.83	-.74
Household size	-10.99	4.29	6.56	.01	1.69e-05	-19.40	-2.58
Marital	2.51	1.92	1.72	.19	12.31	-1.25	6.27
Education	.47	1.36	.12	.73	1.60	-2.20	3.14
Experience	13.85	4.72	8.62	.00	1.03e+006	4.60	23.09
Tech. cost	1.09	1.09	1.01	.32	2.98	-1.04	3.22
Tech. compatible	-.88	.76	1.37	.24	0.41	-2.36	.60
Tech. complex	-1.65	1.27	1.69	.19	0.19	-4.14	.84
Tech. risky	-1.74	1.33	1.71	.19	0.18	-4.35	.87
Tech. meets needs	-.62	.94	.44	.51	0.54	-2.46	1.22
D-resist	1.29	1.36	.90	.34	3.63	-1.37	3.95
P-resist	1.60	1.50	1.14	.29	4.96	-1.33	4.54
Available land	1.52	1.11	1.86	.17	4.56	-.66	3.70
Available capital	-1.87	1.33	1.98	.16	0.16	-4.46	.73
Available labour	.860	1.497	.33	.57	2.36	-2.08	3.80
Assets	-4.94	1.55	10.10	.00	0.01	-7.99	-1.89
Status in community	.92	1.84	.25	.62	2.51	-2.69	4.53
Ethnicity	-1.40	1.10	1.63	.20	0.25	-3.55	.75
Member in group	-2.44	1.45	2.82	0.09	0.09	-5.29	.41

Parameter	(β)	SE	χ^2	Sig.	Exp(β)	95% CI	
						Lower	Upper
Position in group	-3.37	1.65	4.18	.04	0.04	-6.59	-.14
Land tenure	.59	1.37	.18	.67	1.80	-2.10	3.28
NGO support	-2.69	1.53	3.08	.08	0.07	-5.69	.31
MoFA support	.50	1.20	.18	.68	1.65	-1.84	2.85
Farmer group support	2.45	1.18	4.33	.04	11.55	.14	4.75
Bank/credit support	1.57	1.40	1.26	.26	4.79	-1.17	4.31
Agrochemical companies	-2.78	1.77	2.47	.12	0.06	-6.24	.69
Radio/tv	.76	1.131	.45	.50	2.14	-1.45	2.98
Available market	-.05	.92	00	.96	.95	1.85	.75
Conducive weather	2.77	1.23	.06	.03	15.88	.36	5.18
Good soil	2.65	1.48	3.24	.07	14.21	-.24	5.55
Diagnostics	χ^2	DF	Sig.				
Logit : -2LL	70.48	31	.000				
Pearson	216.56	153	.001				
Deviance	86.86	153	1.00				
Parallelism: -2LL	27.56	31	.644				
Pseudo-R^2	0.61						

Source: Field survey, Seini (2013). Rating: Disagree = 1, Agree = 2.

The non-significance of the results is further demonstrated by the confidence interval of -1.22 and 6.13 which include zero.

The inference is that gender does not predict adoption levels of irrigated rice technologies at the Bontanga irrigation area. The non-significance of gender at the Bontanga irrigation area is due to the fact that respondents are individual farmers with varying circumstances, and therefore take independent decisions for their respective farms, irrespective of their gender.

Based on the sign of the coefficient, the results compare to Akpan et al. (2012); Vidogbena, et al., (2012); Sakurai (2002); and Djokoto and Blackie (2014) that male farmers are more likely to adopt agricultural technologies than female farmers. Mariano et al. (2012) and Akpan et al. (2012) also asserted that the coefficient of gender was positive. These, notwithstanding the findings indicate that gender is not a significant predictor of irrigated rice technologies adoption at the Bontanga irrigation area. The results also compare with Baete (2012) from work done in the Fiu village of the Malaita province, that gender does not influence farmers' decision to adopt rice technologies. The findings are further supported by Ghmire, Huang, and Shrestha (2015), that gender is a non-significant derminant of adoption of improved rice varieties in Nepal.

Age of respondent

The age of the farmer describes the number of years of the farmer at the time of the survey. The age of the farmer was a negative significant predictor, $\beta = -4.79$, $\chi 2 = 5.38$, $\exp(\beta) = 0.01$, $p < .05$, of adoption levels of irrigated rice technologies at the Bontanga irrigation area. Farmers with positive perception of the influence of age on adoption levels were associated with lower adoption levels of irrigated rice technologies and moving a farmer from a positive to a negative perception of the influence of age on technologies adoption, has the potential to reduce a farmer's adoption levels by 1 time. It also implies that older farmers are less prone to be at higher adoption levels of irrigated rice technologies adoption compared to younger farmers.

Generally, the age of the farmer has the potential to allow the farmer to gather experiences, accumulate savings, investments and capital, over the years, and therefore expected to influence the farmers' technology adoption options and the results therefore are against a priori expectations. Literature on the influence of age on technology adoption has been controversial. While some report age as a positive determinant, others indicate it is a negative predictor of agricultural innovations. For instance, Kalineza et al. (1999); and Mamudu et al. (2012), suggest that older farmers might have gathered much more experience that allows them to adopt innovations, whilst younger farmers may be risk-averse and thus more flexible in their adoption behaviour and likely to adopt agricultural innovations.

The results differ from Akpan et al. (2012); and Sakurai (2002), respectively that age and education of small-holder arable crop farmers are positive determinant of fertilizer use intensity and that younger, male farmers are more likely to adopt modern varieties compared to older male farmers. However, it compares with Nyanga (2012); Langintuo and Mekuria (2008); and Saka et al. (2005) respectively, that age was a negative determinant of adoption of conservation agriculture, improved maize varieties and improved rice seed respectively than relatively younger farmers.

Household size

Household size is the number of males, females, and children, and reflects household labour size as well as household food requirements or consumption. The results, β = -10.99, χ^2 = 6.56, $p < .05$, exp(β) =1.70e-05, indicate that household size is a negative significant predictor of adoption levels of irrigated rice technologies. The very high significance suggests that there is sufficient evidence not to accept the null hypothesis that the coefficients are zero or that household size does not influence respondents' adoption levels of irrigated rice technologies adoption. The results indicate that household size is a negative significant predictor of levels of irrigated rice technologies adoption. Therefore, moving a farmer from positive to negative perception of the influence of household size on adoption levels of irrigated rice technologies, has the potential of reducing the odds of farmer adoption levels 170000 times. Large household sizes reduced adoption levels therefore, the a priori hypothesis that household size is positively associated with adoption levels of irrigated rice technologies is not plausible.

The assertion that household size provides farm labour force did not apply at the Bontanga irrigation project area because irrigated rice production is a specialized set of activities. Field observations indicated that farmers at the Bontanga irrigation area relied on hired labour "for efficiency and speed" as remarked by some farmers.

The results are consistent with Akpan et al. (2012) that increase in farmer's family size decreases the fertilizer use intensity in the study area. The findings also compare with Baffoe-Asare et al. (2013) that household size was a positive significant determinant of CODAPEC and Cocoa High-Tech technology adoption in Ghana. The findings however, differ from (Bola, Aziz, & Aliou, 2016); and Kalineza et al. (1999) respectively that household size was a negative non-significant determinant of intensity of adoption of improved irrigated rice technology and household size was a positive non-significant determinant of soil conservation technology.

Marital status

Marital status was observed as a positive non-significant, $\beta = 2.51$, $\chi^2 = 1.72$, $p > .10$, $\exp\beta = 12.31$, predictor of adoption levels of irrigated rice technologies. The positive coefficient suggests that being married enhances innovation adoption levels. However, based on the p-value, the implication is that being married or not, does not predict farmers' irrigated rice technology adoption decisions at the Bontanga irrigation project area. In most communities in Sub-Saharan Africa, marrying increases the household labour force and expected to improve the capacity for family farm technology adoption options, especially for labour intensive technologies.

Cultural practices of the people of Bontanga irrigation area, indicate that women participate in few farming activities such as grain planting, harvesting, and marketing. This explains the non-prediction of adoption levels of irrigated rice technologies by being a married farmer (marital status). The results differ from Ayoola (2012) that marital status negatively influenced yam miniset technologies adoption though the result is non-significant. The results further conflict with Denkyirah et al. (2016) that marital status is a positive significant determinant of credit access in the Tolon District of Ghana.

Formal education

The outcome, $\beta = .47$, $\chi^2 = .12$, $p > .10$, infers that formal education is a positive non-significant predictor of adoption levels of irrigated rice technologies. Respondents who demonstrated a negative perception of the influence of formal education on adoption levels of irrigated rice technologies were more likely to be in the higher adoption levels of irrigated rice technology compared to those of positive perceptions of influence. The implication is that; formal education of farmers does not predict adoption levels of irrigated rice technologies at the Bontanga irrigation area.

The findings contradict the observations that farmers with high levels of formal education better access, process and use information and search for appropriate technologies to alleviate their production constraints compared with compatriots with low/no formal education, because formal education gives farmers the ability to perceive, interpret and respond to new information much faster than their colleagues who are with-out/-low education (Mensah, 2008; Kalineza et al. 1999). The positive prediction compares with literature that formal education has a positive association with technology adoption decisions (Akpan et al., 2012; Mensah, 2008; Saka et al., 2005). Saka et al. (2005) however, reported a p = .05 significant association which differs from the findings. The results, however, compare with Baete (2012) that education has no influence on rice technology adoption. The results, however, are not unexpected because majority of the farmers were without formal education. It is opined that the influencing factor regarding knowledge and skills formation, instead of formal education, for irrigated rice technologies adoption are extension education and irrigated farmers support.

Experience in irrigated rice cultivation

Experience of the farmer is human capital and farmer's knowledge, skills, and capacities acquired through years of practice, influence farmer's technology adoption decisions, depending on the contexts. The results, β = 13.85, χ^2 = 8.62, exp(β) 1.03e+6, $p < .005$, is an expression of positive significant prediction of experience over adoption levels of irrigated rice technologies at the Bontanga irrigation area. Farmers who disagree or have negative perception of the influence of experience on adoption levels of irrigated rice technologies are less likely to be in the higher adoption levels compared to lower levels of farmers with positive perceptions. The odds ratio, exp(β) 1.03e+6, demonstrates that moving a farmer from a positive to negative perception of the influence of experience on adoption levels would improve the odds of farmers being in higher levels of adoption by 1.03+6 times. The a priori hypothesis that experience has a positive influence on levels of irrigated rice technologies adoption is therefore plausible.

The experience and age of the farmer have been found to enhance the knowledge, capacity and skills in understanding and applying gained experiences in farming practices and technologies adoption (Baete, 2012; Rogers, 1983; Rogers, 2003; Mensah, 2008; Kalineza et al., 1999; Mamudu et al., 2012) and have been found to be controversial in their influence on technology adoption. The experience of the farmer in irrigated rice farming activities, is expected to increase human capital, knowledge and capacity to effect changes that enure to farmer's benefit and therefore expected to enhance technology adoption (Mensah, 2008).

Experience can allow the operator to gain better management skills to handle new technology as opposed to an inexperienced farmer. The findings compare with Baffoe-Asare et al. (2013); Mensah (2008); and Baete (2012) that experience of the farmer had a positively significant effect on agricultural technology adoption. The findings, however, differ from Baete (2012) that farmers failed to adopt rice technologies because of their experiences with earlier rice projects. For instance, Baffoe-Asare et al. (2013), reported a significant positive influence on Cocoa High Tech and CODAPEC technologies adoption in Ghana which is in tandem with results of this study. However, experience was found to be the most important farmer characteristic influencing rice technologies adoption in the Fiu area of the Malaita Province. Non-adoptors indicated their failure to adopt rice technologies stemed from their experiences with earlier rice projects (Baete, 2012).

Technologies Related Factors

Technology cost

The cost of technologies did not predict adoption levels of irrigated rice technologies, β = 1.09, χ^2 = 1.01, expβ = 2.98, p >.10, though the relationship was positive and therefore, failed to meet the a priori expectation of the coefficient. Technology cost relates to expenditure incurred by farmers in relation to the use of the specific technology. This includes, but not exclusively, cost of complementary inputs, cultural practices, labour expenses, and cost of credit. The quantity and price of inputs required to implement a technology play on the cost of the technology and exert an influence on technology adoption decisions. However, a higher expected or actual return from technology adoption would promote technology adoption.

The findings demonstrate that other factors other than technology cost predict adoption levels of irrigated rice technologies at the Bontanga irrigation area. For instance, perceptions of/or objective technology adoption outcome as postulated by the TPB and a high cost benefit ratio as stipulated by RCT, would spur farmer's adoption levels of irrigated rice technology. Farmers' knowledge or anticipation of high technology cost will allow them to prepare to meet related technology cost irrespective of the cost of technologies if they expect an advantage in technology adoption.

The results differ from Mensah (2008) that total cultivation cost negatively impacted on adoption of soybean technology at the 1% significance level. Respectively, Langintuo and Mekuria (2008) and Akpan et al. (2012) also observed that increases in price of improved seed has the tendency to reduce technology adoption rates/levels and high price of fertilizer had a negative influence on fertilizer use intensity.

Technology compatibility

Compatibility of a technology refers to the degree of harmony with farmers' knowledge, practices, and culture. The results, $\beta = -.88$, $\chi^2 = 1.37$, $p > .10$, indicate that perceptions on compatibility influence on adoption levels of irrigated rice technologies was negative and not significant. Whether technologies are compatible or not has no influence on farmers' adoption levels. Technologies compatibility therefore did not predict adoption levels of irrigated rice technologies at the Bontanga irrigation project area. Majority of the farmers have long years of experience in irrigated rice farming and have integrated or adapted the technologies into their farming systems, culture, and practices. It is also opined that training support offered by the farmer organisation has been effective in upscaling farmers' knowledge and skills on irrigated rice technologies and therefore rendering technology compatibility irrelevant at the Bontanga irrigation area. The findings are not unusual however, because some of the technologies namely levelling, flooding, seed nursing and transplanting are not usual rice cultivation practices in the Bontanga irrigation area and therefore incompatible with rice farming practices.

The findings compare with Baete (2012) that farmers failed to adopt irrigated rice technologies because the technologies were incompatible with their system of farming. The results differ from Rogers (2003) that compatible technologies positively influence farmers' technology adoption decisions. According to Rogers (2003), technologies that are compatible with farmers' culture and practices are easily adopted by farmers.

Complexity of technology

The complexity of technologies relates to the degree of difficulty in understanding and use of the technologies by the adopting unit. Technology complexity exerted a negative not significant prediction; $\beta = -1.65$, $\chi^2 = 1.69$, $p > .10$, on adoption levels of irrigated rice technologies at the Bontanga irrigation area. The implication is that more complex technologies reduce the odds of being in higher adoption levels of irrigated rice technologies at the Bontanga irrigation project area. Therefore, farmers who negatively perceived technologies complexity influenced adoption levels had reduced odds of being higher level adopters.

Participation in extension and farmer organisation training on irrigated rice technologies were offered to promote technology adoption options through removing the constraints of technologies attributes namely: compatibility, complexity, and risks. The findings indicate that the trainings had not been effective in rendering technology complexities irrelevant constraints to irrigated rice technology adoption at the Bontanga irrigation area. It is also opined that other factors are more relevant in influencing technology adoption compared to technology complexity.

The results compare to Rogers (2003) that the more complex an innovation is, the more negatively it influences adoption-decision of the adopting unit. The implication is that; technologies are complex enough to negatively influence adoption levels of irrigated rice technologies. Regarding complexities of technologies, Rogers, (2003) posits that complex agricultural technologies are less adopted by farmers.

Riskiness of technology

The risk associated with technology involves the farmers' objective and subjective/perceived threat associated with the use, yields, and marketing produce from use of technology which make farmers sceptical of the adoption of the technology. Risks and uncertainties usually emanate from inadequate information on the technologies (Ming-Horng & Chieh-Yu (2011), Rogers (2003).

The results; $\beta = -1.74$, Wald $\chi^2 = 1.71$, $p > .10$, reveal that risk of technology is a negative non-significant predicter of adoption levels of irrigated rice technologies. Thus associated risks of technologies did not influence farmers adoption of irrigated rice technologies at the Bontanga irrigation project area. The influence of risky technologies on adoption is a function of the individual farmer. Risk lovers/takers are likely to adopt technologies irrespective of the risks associated with technologies compared to risk-averse farmers. The very high proportion and adoption levels (Table 55) at the project area suggest that majority of farmers were certain of the benefits of the technologies, hence riskiness of the technologies was not a constraint.

Farmers at the Bontanga irrigation area were exposed to extension trainings from several sources namely; MoFA, NGOs and irrigated rice farmer organisation to remove associated technologies risks, and to spur irrigated rice technology adoption decisions. The findings suggest that extension training was effective in precluding technology related risk from constraining adoption levels. The findings compare to Ming-Horng and Chieh-Yu (2011), that farmers who were certain of the benefits of green innovation, adopted the technology. However, the results contradict Rogers (2003), that risky technologies negatively influence farmers' adoption decisions.

Relative advantage

Relative advantage connotes the degree to which a technology is observed or perceived to be better in performance than the technology it supersedes (Rogers, (2003). Some indicators of relative advantage include but not exclusively, social prestige, convenience, and yield (Langintuo & Mekuria, 2008).

The results; β = -.62, χ^2 = .44, p > .10, indicate technologies meeting needs was a negative non-significant predictor of adoption levels of irrigated rice technology. Farmers who perceived technologies were meeting needs did not influence adoption decisions are more associated with higher adoption levels of irrigated rice technology though not significant. The implication is; however, of practical relevance for innovation development because farmers with positive perception of the influence of technologies meeting needs are associated with higher adoption levels. The results differ from Baete (2012) and Langintou and Mekuria (2008) that relative advantage in the form of yield, improvement in income, early maturing and food security is the most important factor influencing farmers' technologies adoption decisions.

Disease resistance

For disease resistance, the results, β = 1.29, χ^2 = .90, p > .10, demonsrate that disease resistance positively but non-significantly predicted adoption levels of irrigated rice technology and that framers who disagree that disease resistance influences adoption decisions are associated with higher levels of technology adoption. It is relevant to note that disease resistance of improved seed varieties functions to improve crop yields and consequently improve food security, income and prestige of the adopting farmers and the results meet a priori expectation.

Pest resistance

The results on pest resistance; β = 1.60, χ^2 = 1.14, p > .10, show that pest resistance exerts a positive non-significant prediction on adoption levels of irrigated rice technologies. The sign of the coefficient meets a priori expectation that pest resistance had positive impact on technology adoption decisions. Pest resistance of crop varieties functions to mitigate uncertainties related to crop yields and losses attributable to disease and pests. An achievement of this function would improve yields, returns to investment as well as food security and subsequently offer motivation to farmers to adopt technologies.

To the extent that pest resistance improves yields, the results for pest resistance, based on the coefficient, compared with Langintuo and Mekuria(2008); and Baete (2012) that most important factors positively influencing farmers' adoption decisions is the yield of the improved seed crop over the traditional variety. Langintuo and Mekuria and Baete further assert that only relative advantage (perceived improvement in food security, high yielding and early maturing, perceived improvement in income, palatability and convenience (in cooking) to be the influencing factor of farmers' adoption decisions.

Resource Related Factors

Capital in the form of cash, assets, land, and savings is an important prerequisite for the establishment of enterprises especially so for farming. The capital-related factors included in the analysis were available capital, labour, and assets. Adequate availability or access to capital factors are envisaged to promote technology adoption decisions of farmers.

Available land

Land availability connotes access to/and affordability of land to the irrigated rice farmer. Observations on the project site indicated that farmers are allocated plots of land by the farmer organisation at the project area and charged a fee for the parcels of land allocated.

The results; $\beta = 1.52$, Wald $\chi^2 = 1.86$, $p > .10$, reveal a positive non-significant prediction of land availability on adoption levels of irrigated rice technologies at the Bontanga irrigation project area, affirming the a priori expectation of the sign of the coefficient. The findings indicate that farmers had access to land though land size was small. The small pieces of land allocated to farmers on the site would spur farmers' technology adoption (Kasirye (2013) and Pingali & Gerpacio (2008) because farmers would adopt technologies to achieve maximum yields from the small pieces of land, to meet farming needs. Indications are that small land holders are more likely to adopt technologies if even slowly, than large farm holders due to fixed costs, especially of learning.

The results compare with Ghimire, Huang, and Shrestha, (2015) and Cesar and John (2016) that land ownership or access to land was a positive significant (1%) determinant of new improved rice varieties' technologies in Central Nepal and land had a positive significant influence on technology adoption.

Capital to practice technology

Capital was observed as a negative non-significant predictor of adoption levels of irrigated rice technologies at the Bontanga irrigation area, β

= -1.87, χ^2 = 1.98, p > .10. The a priori expectation of the sign of the coefficient was not met. Farmers with positive perception of the influence of capital on adoption levels are negatively associated with lower adoption levels at the Bontanga irrigation area. The implication is that other factors other than capital predicts adoption levels.

The results respectively compare with Akpan et al. (2012) and Saka et al. (2005) that capital had a negative non-significant influence on fertilizer use intensity and improved rice varieties. The results however, differ from Cesar and John (2016) that capital had a positive significant impact on irrigation technology at 5% under the probit and ordered probit models respectively.

Labour availability

Irrigated rice technologies are relatively labour intensive therefore, inadequate access to labour limits the likelihood of adoption of the technologies, especially in combination with inadequate cash availability (Affholder et al., 2009). Availability of labour to practise technologies was a positive not significant predictor of adoption levels of irrigated rice technologies, β = .86, χ^2 =.33, p > .10. Respondents with positive perception of the influence of labour availability on adoption levels of irrigated rice technologies are more likely to be in higher adoption levels of irrigated rice technologies. The results demonstrate that labour is not a predictor of adoption of irrigated rice technologies at the Bontanga irrigation area. The a priori expectation is upheld plausible. Labour accessibility/availability is relevant to labour intensive technologies such as rice seed nursing, transplanting, and harvesting.

The outcome differs from Affholder et al. (2009) that labour requirement limits technology adoption through extra labour requirements in labour intensive agricultural systems.

Assets to practise technologies

Availability of assets was observed as a positive significant predictor of adoption levels of irrigated rice technologies at the Bontaga irrigation project area, β = -4.94, χ^2 =10.10, p < .001. Respondents with positive perception of the influence of assets on adoption levels of irrigated rice technologies are more likely to be in the lower adoption levels. The odds of being in the higher adoption level is decreased by 0.01 times. The significance of the association is confirmed by the 95% confidence interval, -7.99 to -1.89. The marginal effect is, however, very low. The results suggest that assets were not a constraint on technologies adoption at the Bontanga irrigation project area.

Social Related Factors

The selected social factors included status in community, ethnic group, member of social group, and position in social group. These factors enhance human capital and are expected to improve levels of irrigated rice technologies adoption options.

Status in community

Status in community was a positive not significant predictor of levels of adoption of irrigated rice technologies at the Bontanga irrigation project area; β = .92, χ^2 =.25, p > .05. The proportion of community leaders compared to the number of farmers was very low and therefore can influence only a small number of farmers, if the leadership has a social network with colleague farmers. Poorer social networks would result in poor contacts with farmers and therefore lower influence on levels of adoption of irrigated rice technologies. Another indicator of leaderships' influence also relates to the trust and confidence of farmers in the leadership knowledge and skills in irrigated rice farming. The findings imply that farmers have little confidence in the community leaders' knowledge and skills in irrigated rice farming.

The results, on the basis of direction of influence, differ from Adesina and Baidu-Forson (1995) that being a village head was a negative not significant determinant of modern sorghum varieties in Burkina Faso, otherwise results compare with Adesina and Baidu-Forson that status in community is not a significant predictor of modern sorghum varieties. Baete (2012) indicated that leadership in itself is not the determining factor but the trust in leaderships' knowledge and skills, are the important influencing determinants of technology adoption. According to Baete, farmers abandoned the because of mistrust in the knowledge and competence of the leadership in small machinery and prodcution management practices.

Ethnicity

Ethnicity of the farmer was observed as a negative not significant predictor; $\beta = -1.40$, $\chi^2 = 1.63$, $p > .05$, of adoption level of irrigated rice technologies at the Bontanga irrigation area. The non-significant relationship is confirmed by the 95% confidence interval, -2.69 – 4.53. Ethnicity or tribal affiliation of the farmer is thus not a statistically significant predictor of levels of adoption of irrigated rice technologies at the Bontanga irrigation project area. Ethnicity connotes tribal affiliations of the farmer and expresses human capital of the farmer. Farmers of similar ethnic groups communicate and interact better among themselves than dissimilar ethnic affiliations and improve human capital through social networks which are expected to affect levels of adoption of irrigated rice technology options. The results fail to meet a priori expectation because farmers of the Bontanga area are of the same ethnicity and therefore expected to positively influence levels of adoption of irrigated rice technology.

The findings indicate that because farmers are of similar ethnicity, technologies adoption fails to feature as an influencing predictor of levels of adoption of irrigated rice technologies. The findings compare to Khatri-Chhetri et al. (2017) that cast (ethnicity) had a negative non-significant influence on technologies adoption. The results differ from Khatri-Chhetri et al. (2017), in the same study, that ethnicity had a positive and significant influence on weather-based advisories technologies.

Membership in a group

The results, $\beta = -2.44$, $\chi^2 = 2.82$, $p > .05$, portrayed being a member in a group as a negative not significant predictor of adoption levels of irrigated rice technologies at the Bontanga irrigation project area. Respondents who conceded that being a member of a social group influences technology adoption are more associated with lower levels of adoption of irrigated rice technologies compared to those who disagree. Thus, those who agree that being a member of a social group influences adoption are less likely to belong to higher adoption levels though this assertion is not plausible since the 95% confidence interval contains zero (0). The a priori expectation of a positive perception of influence was not met. Being a member of a farming group or association serves as a source of information and knowledge about agriculture to the farmer through social networks. For instance, farmers who belong to an association or group learn from each other on how to grow and market new crop varieties (Nyanga, 2012), rendering the effect of social networks important in individual farmer's decision process through information sharing (Langintou & Mekuria, 2008, Nyanga, 2012).

The results differ from Langintou and Mekuria (2008) that membership in a farmers' group positively and significantly influence new maize varieties adoption. Langintou and Mekuria (2008) further asserted that the probability of a farmer adopting high yielding maize varieties increases by 10% if the farmer belongs to a farmer's group. Comparably, Saka et al. (2005) reports that being a member of a farmer's group/association had a positive significant influence on farmers' adoption level of improved rice varieties. Results compare to Asfaw et al. (2011) that being a member of a farmer's group exhibited a non-significant influence on fertilizer technologies adoption.

Status in farmers' group

Status in farmers' group was a negative and significant predictor; $\beta = -3.37$, $\chi^2 = 4.18$, $p < .05$, of adoption levels of irrigated rice technologies at the Bontanga irrigation project area. The negative association indicates that respondents with negative perception of the influence of status in farmers' group are more likely to be lower level adopters compared to higher levels. By extension, respondents with positive perceptions of the influence of status in farmers' group are more likely to be in higher adoption levels than the lower levels. The odds ratio, 0.04, implies a change from agree to disagree perceptions would decrease the odds of being in a higher adoption category by 0.04 times. The significance of the statistic has been confirmed by the 95% confidence interval, -6.59 to -.14, which does not contain a zero.

Comparable findings have been reported in Baete's (2012) study on irrigated rice farmers of the Malaita province of the Solomon Islands, that farmers discontinued the use of the rice technologies because the leadership of the farmers' cooperatives/groups lacked the requisite technical knowledge and skills in the areas of fertilizer management, pest and disease management as well as small machinery maintenance.

Land tenure arrangements

Land tenure was observed as a positive non-significant predictor, $\beta = .59$, $\chi^2 = .18$, $p > .10$, of adoption levels of irrigated rice technologies adoption at the Bontanga irrigation area. Land tenure arrangement offers the farmers land user rights and control over the land which allows the farmer control or otherwise of the amount of land being cultivated by the farmer which has implications for technology adoption.

Insecure land rights reduce farmer adoption options. For instance, in India, landowners do not permit technology adoption as it reduces the indebtedness of the tenants and reduce income earnings of landowners through reduced credits to farmer (Feder et al., 1982). The positive influence of land tenure on adoption levels, though not significant, is usual because farmers have secure tenureship, through land distribution by irrigation farmer organisation (Opoku, 2011), at the Bontanga irrigation project area.

This explains the non-prediction of land tenure on adoption levels of irrigated rice technologies. The outcome; however, compares to Ntege-Nanyeenya et al. (1997) that land tenure had a positive significant influence on adoption of maize production technologies in Iganga District of Uganda at 10% significance level. Contrary to the results, Cesar and John (2016), using the probit and ordered probit analytical models, found that secure land tenure significantly impacted on irrigation technology adoption at 5% and 1% for the respective models.

Institutional Support Factors

The institutional factors included in the study were NGOs, MoFA, farmer's group, bank/credit institutions, agrochemical dealers, radio/tv and market supports. Three of the included institutional factors namely: NGOs, agrichemical dealers and market support are negative predictors, while five are positive predictors of adoption levels of irrigated rice technologies.

NGO support

NGO support namely: extension education and training, credit, market, and inputs acquisition support, are offered with the objective to improve farmers irrigated rice technologies adoption. The outcome of the assessment of farmers' perceptions on the prediction of NGO support on irrigated rice technologies, $\beta = -2.69$, $\chi^2 = 3.08$, $\exp^{\beta} = 0.07$, $p < .10$, demonstrated that NGO support was a negative significant predictor of levels of adoption at the 10% significance level. The implication of the results is that the odds of moving a farmer with a positive perception of the influence of NGO support to a negative perception has the potential to reduce the odds of being in high adoption levels of irrigated rice technologies by 0.07 times.

The slight significance observed is however, unreliable; 95% confidence interval (-5.69 - .31) contains zero indicating no impact on levels of adoption of irrigated rice technologies at the Bontanga irrigation area. NGO support, therefore, is not a predictor of levels of adoption of irrigated rice technologies at the Bontanga irrigation area.

NGOs provided farmers with extension training, credit and input including produce market to mitigate constraints emanating from inadequacies of these services, which have been shown to exhibit varying influences on technology adoption. The influence of these support systems has been found to be variable. The findings compare to Akpan et al. (2012); and Ayoade and Akintonde (2012) that access to credit was a negative non-significant determinant of intensity of fertilizer use. Comparably, Affholder et al. (2009) also reported that extra inputs requirement constrained the use of direct-seeding mulch-based technology in Vietnam. The findings however, differ from Adesina and Baidu-Forson (1985); Baffoe-Asareet al. (2013); and Saka et al. (2005) that extension support was a significant positive determinant of technology adoption. The negative significant association of NGO support emanated from the inadequate provision of services which are unlikely to motivate farmers to improve technology adoption decisions.

MoFA support

This reflects support to farmers regarding extension services, and linkages to institutional services namely: credit institutions, input dealers by MoFA. The observed results, $\beta = .05$, $\chi^2 = .18$, $p > .10$, show there is no statistical evidence of the prediction of MoFA support on adoption levels of irrigated rice technologies. The 95% confidence interval, -1.84 – 2.85, confirmed the non-significance of the prediction of MoFA support on levels of adoption. The outcome suggests that MoFA support is not a predictor of levels of adoption of irrigated rice technologies at the Bontanga irrigation project area. This renders MoFA extension support irrelevant in the farmers' technologies adoption decision process. By extension, the main responsibilities of MoFA; extension service delivery, has no significant influence on adoption levels of irrigated rice technologies at the Bontanga irrigation area. This reflects the Irrigation Development Authority's (IDA) policy, mandating irrigation farmers' groups to provide extension services to farmers through the FAMPIM (JICA, 2006); (Opoku, 2011).

The findings differ from Baffoe-Asare et al. (2013; Langintou and Mekuria (2008); Michael et al. (1999); Nyanga (2012); Adesina and Baidu-Forson (1985); and Saka et al. (2005) that extension contact and training, had a positive and significant effect on technology adoption. None of these researchers however, used the ordinal regression models, rather analysis was done using the probit, tobit or the truncated variants of it; while focusing on single technologies.

Farmer group support

The results for farmers' group support indicated a significant positive predictor; $\beta = 2.45$, $\chi^2 = .4.33$, $\exp(\beta) = 11.55$, $p < .05$, of adoption levels of irrigated rice technologies at the Bontanga irrigation project area. The odds ratio, $\exp(\beta) = 11.55$, implies that a change in farmers' perception from agree to disagree has the potential to increase the odds of being in a higher adoption level by 11.55 times. Farmer group support in the form of extension education and training, input, credit, and market linkages have the potential to improve farmers' adoption levels of irrigated rice technologies. The existence of a vibrant farmers' group established by the IDA drives farmers' adoption of irrigated rice technologies.

Support from farmers' group comes in the form of networking to facilitate information, knowledge and skills acquisition and exchange between farmers. Especially for farmers at the Bontanga irrigation area, extension and irrigation services were delivered through the farmer organisation. Linkages to produce markets are done and achieved through the farmer groups. Farmers within a group learn from each other, how to grow and market new crop varieties (Nyanga, 2012), therefore the significant positive prediction of levels of irrigated rice technology adoption is expected. The evidence suggests that network effects are important for individual decisions, and that, in the context of agricultural innovations, farmers share information and learn from each other (Nyanga, 2012; and Langintou & Mekuria, 2008).

The findings compare with Langintuo and Mekuria (2008) that adoption rates will be enhanced if farmers belong to farmer organisation. Langintuo and Mekuria found that the probability of getting a farmer to adopt an improved, high yielding maize variety will increase by 10% if the farmer joins an association. This assertion conforms to the results of the study where the odds of farmers belonging to higher adoption categories are increased by more than 11 times.

One potential benefit farmer derives from joining associations is sharing of information. Farmers who have adopted the new varieties share their experiences with their colleagues, which allow non-adopters to better inform their decisions on whether to adopt. Comparable to the findings, Saka et al. (2005) also found that being a member of farmers' association had a positive and significant ($p = 0.05$) influence on farmers' level of adoption of improved rice varieties. However, the results differ from Asfaw et al. (2011) and Abdullah et al. (2017) that being a member of a farmers' association had no influence on fertilizer technology adoption. The expected sign on the coefficient on farmers group support was met.

Bank/credit institutions' support

The results indicate that bank/credit institutions' support was not a predictor; $\beta = 1.57$, $\chi^2 = 1.26$, $p > .05$, of adoption levels of irrigated rice technologies at the Bontanga irrigation project area. This finding is expected because farmers at the Bontanga irrigation area lacked bank/credit institutions' support and farmers experienced financial constraints which prevented them from adopting complementary input related technologies.

The findings differ from Akpan et al. (2012) that credit had a positive influence on technology adoption especially for small-hold farmers. The results however, respectively compare with Akpan et al. (2012), using the

OLS approach, and Abdullah et al. (2017) that credit support had a negative not significant influence on fertilizer use intensity and access to credit was a negative determinant of market participation in Malakan, Pakistan.

Agrochemical sellers' support

Farmers' perception on the influence of agrochemical sellers support on adoption levels of irrigated rice technologies was observed to be a negative not significant predictor of adoption; β = -2.78, χ^2, $p < .05$. The 95% confidence interval; -6.24 - .69, indicates the significant relationship is unreliable. Agrichemical sellers' support is therefore not a significant predictor of adoption levels of irrigated rice technologies.

Agrichemical sellers support farmers by rendering agrichemicals accessible, as well as providing chemicals on credit, to farmers and extension education on the agrichemical use, therefore solving the constraint of inadequate access to agrichemical inputs such as fertilizers, insecticides, and weedicides. The expectation is to motivate farmers' irrigated rice technologies adoption especially resource poor farmers. Improved access to chemical inputs is expected to improve irrigated rice yields. However, if the rice varieties are disease and pest resistant, farmers would not require these chemicals except for fertilizers.

Radio/TV support

Radio/tv support is offered in the form of extension information and knowledge to farmers. Radio/tv support was observed as a non-significant positive predictor; β = .76, Wald χ^2 =.45, $p > .05$, of adoption levels of irrigated rice technologies at the Bontanga irrigation project area.

Though radio and tv is an important source of irrigated rice technologies information (Tables 42) for the farmers of Bontanga irrigation project, it does not significantly influence their technology adoption decisions. On the national front, radio/tv does not broadcast agricultural technologies information especially for irrigated rice technologies and more so not in the language understood by farmers at the project area. Simli radio, an FM radio station, within the irrigation project catchment area, broadcasts general agricultural and rural development programmes in the local dialect. This was not situated in the irrigated rice cultivation context and thus not relevant to the irrigated farmers to influence their adoption decisions.

Market support

Market support was not a significant predictor of adoption levels of irrigated rice technologies at the Bontanga irrigation area; $\beta = -.05$, $\chi^2 = .00$, $p > .05$. The 95% confidence interval confirms the non-significance of the prediction adoption levels by market support. In Table 23, institutional market support to farmers at the project area was inadequate, and therefore reflects the non-significance of market support as a predictor of adoption levels at the Bontanga irrigation area. Institutional support is no guarantee of positive influence on technologies adoption.

The findings compare to Rogers (2003) that the quantity and quality of organisational support and human resources, government policy support and regulatory pressure as well as NGO support would only influence farmers' technologies adoption if support is perceived satisfactory.

Environmental Factors

Conducive weather

Conducive weather was found as a positive significant; $\beta = 2.77$, $\chi^2 = 5.06$, $\exp(\beta) = 16$, $p < .05$, predictor of adoption levels of irrigated rice technologies. The results indicate that a change of respondents' positive to negative perception of the influence of weather condition has the potential to increase the odds of being in a higher adoption level 16 times. Conducive weather therefore is an important predictor of adoption levels of irrigated rice technologies.

Conducive weather connotes favourable weather conditions such as temperatures, humidity, and sunshine among others. High temperatures promote water evaporation from dam and evapotranspiration from crop leaves and both conditions are unfavourable for irrigated rice cultivation and also influence crop maturity periods as well as crop pollination. Conducive weather conditions therefore have the potential to positively influence farmers' technologies adoption. The findings indicated that farmers experience good weather conditions at the Bontanga irrigation area.

The results compare to Feder et al. (1982) that a good physical farming environment increases the likelihood of technology adoption. They further posited that a more favourable environment (better soil and water availability) increases the expected utility of income from modern production and hence, increases the probability of a farmer adopting the new technology.

Good soil

The results: $\beta = 2.65$, $\chi^2 = 3.24$, $p > .05$, indicate a positive not significant prediction of adoption levels of irrigated rice technologies by good soil conditions. The observed $p < .10$ proves to be unreliable based on the confidence interval, -.24 – 5.55.

Good soil conditions reflect the physical and chemical characteristics of the soil to adequately support irrigated rice cultivation; heavy soils that can hold water and fertile soil for plant health and growth. The sign of the coefficient meets a priori expectation because good soil conditions are expected to promote technologies adoption, though not significant.

The results differ from Feder et al. (1982) that better soil conditions increase the probability that farmers would adopt new technologies. In a similar comparison, Abbas and Yuansheng (2018) reported that soil quality was a significant determinant of improved rice varieties adoption in the Northern Sindh of Pakistan.

Table 63 depicts the best predictors of adoption levels of irrigated rice technologies adoption at the Bontanga irrigation area.

Table 63- Summary of best predictors of levels of adoption of irrigated rice technologies

Parameter	Estimate (β)	p-value	Exp(β)
Experience of farmer	13.85	.00	1.03+006
Conducive weather condition	2.77	.03	15.88
Farmers' group support	2.45	.04	11.55
Household size	-10.99	.01	1.69e-05
Age of farmer	-4.79	.02	0.01
Have assets	-4.94	.00	0.01
Status in group	-3.37	.04	0.04

Source: Field survey, Seini (2013)

CHAPTER EIGHT

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This chapter presents the results, conclusions and recommendations of the study organised along the chapters as specific objecyives: description of farmer perceptions on effects of socio-demographic characteristics of farmers, rice technology characteristics and institutional support for adoption of irrigated rice technologies at Bontanga irrigation area; determination of levels of adoption of irrigated rice technologies introduced to farmers; establishing correlates of irrigated rice technologies adoption; and predict adoption levels of irrigated rice technologies, according studied variables.

Summary

This section presents key summary results based on the assessments of the stated objectives as indicated in the introductory paragraph. The assessments on objective one was conducted using frequencies and chi-square statistics by cross tabulations. The following are summaries thereof:

- Farmers at the Bontanga irrigation area were middle-aged, did not receive formal education, and highly experienced with large average household sizes.
- Farmers moderately and highly participated in extension education and irrigated technology training respectively, were members of social and farmer groups and held leadership. Farmers were commercially oriented with small average farm size and low yields less than potential per hectare yields.

- The age of the farmer had no association with some farmer characteristics, participation in extension training, and social characteristics.
- Age did not relate to participation in extension and irrigated rice technology trainings, membership in groups/organisations, position in irrigated rice farmers' organisation, and farm size.
- There was no relationship between household size and rice yield however, large household sizes (25-44) were positively associated with very high produce consumptions of 1001-1500 and more than 1500kg of rice produce.
- Formal education did not associate with participation in MoFA extension education training, irrigated rice technologies training, status in community, membership, and status in irrigated rice farmers' organisation, however, was highly and positively associated with being a household head.
- The level of formal education received was not associated with participation in MoFA extension education, membership in irrigated rice farmer organisation, position in irrigated rice technologies training.
- MoFA and NGO were the most important support in extension information delivery and training offered to farmers.
- Market and irrigation water supply were the most accessible services at the project area.
- Roads, inputs, extension services, mechanisation, land, and credit were constrained resources or services at the project area.
- Radio, friends, group meetings, family members, television and farmers' forum are the important major sources of irrigated rice technologies information for farmers.

- Technology characteristics positively associated with innovation use and the important technologies attributes associating with innovation adoption are complexity, riskiness, and relative advantage.
- Resource factors positively and significantly influence adoption levels of technologies.
- Ethnicity, membership in group, status in group and community were perceived to affect technology adoption behaviour.
- Institutional supports are associated with higher adoption levels and did affect innovation adoption decisions except produce market.
- Environmental factors positively influenced technologies adoption decision.
- High input prices ranked as number one constraint to adoption levels of irrigated rice innovations.
- Significant constraints included poor extension services, insect pest and disease prevalence, and high temperatures.

For farmer adoption levels and the applications of TPB, RCT, AND DIT theories in explaining innovation adoptions, the following were established:

- Though some technologies adoption were very high and complete, farmers did not adopt the full range of introduced innovations.
- Fertilizer technologies recorded the least levels of adoption with the lowest recorded for compound fertilizer.
- Though improved seed varieties recorded complete adoption, IPM Adoption very high.
- Two thirds of respondents recorded very high adoption levels.

- The three theories; TPB, RCT and DIT were found to explain; individually and mutually, adequately the innovations adoption or otherwise by irrigated rice farmers at the Bontanga irrigation area.
- RCT and DIT adequately offered individual and mutual explanations on pre-planting and planting innovations and therefore used in predicting farmer adoption of irrigated rice technologies at the Bontanga irrigation area. For fertilizer, improved seed, and IPM technologies, the three theories offered adequate explanations for farmers' decisions to adopt the irrigated rice technologies based on cost-benefit analysis, social pressures, perceived and actual controls as well as providing information on technology attributes and associated risks through appropriate communication channels. This section presents key findings on significant correlates of adoption levels of irrigated rice technologies at the Bontanga irrigation area conducted on the following thematic factors: The findings on the correlation of socio-economic factors, technology characteristics, and environmental factors on adoption levels established that:
- There was no relationship between adoption levels and farmer specific factors.
- Technology attributes positively but negligible to weak associated with adoption levels, with technology cost, complexity, riskiness, disease, and pest resistances highly significant.

    - There was no relationship between resource factors and adoption levels.
    - Social factors were weakly related to adoption levels with status in community and social group being significant and negatively associated with adoption levels.
    - Institutional factors exhibited negligible to moderate and positive significant relationships with adoption levels except available market which was nonsignificant.
- The relationship between adoption levels and environmental factors were weak, positive, and significant.

This section presents key findings of the prediction of best predictors of levels of irrigated rice technologies adoption using the log function of the ordered logistic regression model. The objective was to establish the best predictors of adoption levels from among the thematic areas using the ordinal logistic regression model.

- The dearth of literature on the use of ordinal regression model in analysing adoption as well as literature on institutional support on agricultural innovations was a challenge though there exists a plethora of literature on innovation diffusion and/or adoption using other models.
    - Among the farmer personal characteristics, farmers' experience, age, and household size were identified as best predictors of adoption levels of irrigated rice technologies. Age and household size on one hand and experience on the other, were negative and positive predictors of adoption levels of irrigated rice technologies respectively.

- Farmer group support, from the components of institutional support, was a positive predictor of adoption levels of irrigated rice technologies.
- Status in group also featured as a best predictor of adoption levels of rice technologies from the components of social factors.
- Among resource related factors, having assets to practised technologies positively predicted adoption levels. However, land, labour availability, positively influenced adoption levels whilst capital and assets availability negatively influenced adoption levels of irrigated rice technologies.
- Ironically, innovation attributes did not predict adoption levels of irrigated rice technologies.
- Except status in social group being a positive predictor, all social factors did not predict adoption levels of irrigated rice technologies.
- Institutional factors, except farmer group support, did not predict adoption levels of irrigated rice technologies. NGO, agrochemical companies, and market availability negatively predicted adoption levels, whilst MoFA, farmer's group, bank/credit companies, radio and tv supports negatively influenced adoption levels of irrigated rice technologies.
- Conducive weather and good soil were both positively related to adoption levels, but conducive weather was found the best predictor of adoption levels of irrigated rice technologies.

Conclusions

The fallout of the study is that:

Farmers of the Bontanga irrigation area were highly experienced, had large household sizes and did not receive formal education, commercial oriented, and participated in irrigated technology training. Age of the farmer does not relate with other socio-demographic attributes. Whilst experience enhances rice yields, it does not associate with participations in extension training and membership in social groups. Household size does not relate with rice yields and farmers' personal attributes, except marital status, do not relate with farmer adoption levels.

Radio is the most important and most frequently used source of irrigated rice technologies information for the irrigated rice farmers.

Except for cost and compatibility, technology factors highly related ether positively or negatively with farmer adoption levels.

Resource factors except labour availability, moderate farmer adoption levels. Social factors similarly relate with adoption level but for status in community.

Farmers did not consider institutional support, except market, relevant for improving adoption levels. Similarly, environmental factors were perceived to be important for enhancing adoption levels. However, poor extension, insect pests and diseases, low produce price, and high temperatures constrain adoption decisions.

Whilst farmers fully used improved seed varieties, land tillage, seedling preparation, IPM and transplanting innovations were highly used. Unaffordable fertilizer cost conditioned farmers' adaption of fertilizer technologies. Consequently, very high adoption levels were achieved through higher adoption of the pre-planting and planting technology.

The multiple theoretical approach offers better explanations than the tobit, probit, multinomial and some other methods, for farmers' multiple technologies adoption decisions at the Bontanga irrigation area and therefore offers best prediction of farmer adoption decision options. The finale from the results and summary findings regarding correlates of adoption levels is that:

While farmers' personal attributes, except experience, do not correlate with adoption levels, technology attributes related highly with farmer adoption levels but for compatibility and meeting farmer needs. Comparably, resource factors correlated moderately with adoption levels. Except for position in social group, social factors do not correlate with farmer adoption levels. Support from institutions related highly with farmer adoption levels but for available produce market. Without exception, environmental factors related highly and positively with adoption levels at the Bontanga area.

The inference from the model diagnostics for the use of the ordinal regression model in predicting adoption levels of irrigated rice technologies is justified and the model is a good-fitting model for the data used.

The ordinal regression model was a good fit for the data and adequately predicted 61% of adoption levels of irrigated rice technologies.

Farmers' personal attributes partially predict their adoption levels but with a conceptual challenge in one-shot survey study. Farmers' attributes are taken as given and the innovations could not be developed for specific characteristics therefore inclusion of these attributes proved irrelevant in a one-shot survey study. Comparably, having assets to practice irrigation technologies, technologies attributes and capital factors did not predict farmer's innovation adoption levels at the Bontanga irrigation area. Social factors, but for farmer's position in social group, do not predict farmers' adoption levels. Similarly, among institutional support factors, only farmer group support predicted adoption levels of irrigated farmers at Bontanga irrigation area while conducive weather conditions among environmental factors predicted farmers' adoption levels at the Bontanga irrigation area.

Recommendations

Following the results and conclusions drawn thereof the following recommendations are made to relevant stake holders:

- Complementary inputs should be made accessible and affordable by government/IDA to enhance technologies adoption and sustained use on the small farm sizes of farmers.
- For improved and sustained use of technology, governments need to implement minimum produce prices, buffer stock purchases, or arrange buyers for farm produce.
- To achieve synergy and prevent duplication of services, government should seek a collaboration between MoFA and NGOs for MoFA to perform their traditional specialised function of extension delivery and training.

- IDA should negotiate and arrange with Government to construct and maintain access roads to irrigation area to improve access to other complementary inputs and services at the project area.
- Government through IDA needs to provide mechanisation services for sustained adoption of pre-planting and harvesting technologies.
- Technology designers should ensure that technologies are easy to understand and practise, less risky, complex, and costly to facilitate adoption.
- Technology implementers should focus on extension education geared towards farmer's understanding of technology and removing risks and uncertainties associated with technology to improve adoption.
- Extension service providers, including MoFA and irrigated rice farmer organisations, should emphasise on delivering content and context relevant information, knowledge, skills, training, and group dynamics to farmers to encourage and sustain participation in extension training activities.
- Farmer personal characteristics need not receive any emphasis by researchers in assessing farm size, rice yield, participation in extension and irrigated rice technologies trainings, because they are not manipulable in its effects.
- Technology designers and implementers should include experienced farmers in extension and irrigated rice technologies training to improve knowledge and skills for sustained improved group participation and rice yields.

- Extension service providers should produce extension print materials targeted at the literate farmers for extension and irrigated rice technologies training to reach out to literate farmers.
- Content of print materials should target group dynamics and benefits of being a member of a social and farmer organisations/groups.
- For the purposes of introducing new ideas and sensitisation, radio, friends, group meetings, family members, television, and farmer's forum, should be relied on by extension providers to reach several farmers quickly.
- Extension service providers, in delivering content relevant information or training, radio and farmer social networks would be more resourceful and complemented with establishing farmer radio stations.
- Researchers should note that demographic characteristics are taken as given and cannot be manipulated, neither could innovations be developed for specific demographic attributes, therefore, the inclusion of farmer personal characteristics in data analysis is not realistic for planning purposes. Farmer's perceptions on the role or influence of the attributes are closer to realities.
- Extension providers (MoFA, NGOs and farmer organisations) should educate and/or train farmers on capital generation, and reduction of technologies complexity and riskiness to reduce real/perceived complexities and riskiness associated with technologies to promote farmer innovation adoption decisions.
- Extending the cultivable land area by government/IDA would preclude the land related constraints to adoption.

- Extension providers should educate farmers on resource creation to solve capital, credit, assets constraints.
- Extension and irrigated rice education should embody training farmers on implications of soil and conditions and how to take advantage of existing weather conditions and methods of mitigating harsh soil and weather conditions.
- IDA, through government, could import and/or secure complementary inputs for distribution to farmers on cash or credit basis or contract agrochemical companies to supply inputs on site.
- A consortium of NGOs and financial institutions through collaboration could be formed through government guidance to pool financial resources for disbursement to farmers at affordable interest rates and conditions at project site or an easily accessible rural bank.

- Importance need be attached to development of pest and disease resistant rice varieties by rice seed breeders, to improve and sustain adoption of irrigated rice innovations.
- Government and/or input dealers need to make complementary inputs affordable and accessible to farmers by either instituting price subsidies or providing credit accessibility to farmers to enhance and sustain the use of input related innovations.
- Based on the conclusions drawn, researchers should apply the multiple theoretical models in explaining and/or predicting adoption of multiple agricultural innovations.

On how selected variables correlate with adoption levels, the recommendations are that:

- Technologies implementers should identify farmers with good rice cultivation experience and include them at the innovation introduction and dissemination of technology training stages to enhance their personal technology adoption and influence colleague farmers' technology adoption.
- Technology implementers whilst encouraging the formation of CBOs and farmer groups/organisations, farmers who hold leadership positions in groups and/or organisations should be identified and included, in extension and technology training to enhance adoption.
- Researchers should use the ordinal logistic regression model as an important consideration in analysing multiple innovations use because multiple technologies fit well with the model, eliminate the overwhelming result tables with different statistics for the same variables, and yields high predictions of the model attributable to the included variables.
- Researchers should note technologies dynamism, for specific locations and activities especially for agricultural enterprises and activities whilst farmer demographic characteristics are static and in-manipulable. The inclusion of these factors in adoption studies lacks credence because they cannot be adjusted to suit innovations, neither can innovations be adjusted to suit specific farmer characteristic.

- Innovations trainers should identify and involve farmers of good experience in participating in training programmes as trainers of colleague farmers.
- Technology implementers should train farmers in assets acquisition and preservation to facilitate and/enhance technologies adoption through small business and financial management techniques capacity trainings to farmers.
- Innovators/technologies designers need to develop context and content relevant, compatible, less complex, and costly technologies to make innovations influence adoption levels of farmers, through farmer participation in technologies development phases.
- Farmers, through farmer organisation leadership, should be educated to fully understand the implications and influence of weather conditions on rice crop establishment, yields and crop maturity periods to facilitate enhanced irrigated rice technologies adoptions. Extension training should include methods to mitigate adverse weather effects on rice crop yields.

Recommendations for further studies

- The prediction of levels of adoption by technologies attributes should further be investigated at the Bontanga irrigation area.
- The relevance of inclusion of farmer demographic attributes in one shot survey adoption studies should further be investigated because they cannot be adjusted to suit innovations, neither can innovations be adjusted to suit specific farmer characteristic.

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APPENDIXES

Appendix A: Declaration of confidentiality

UNIVERSITY OF CAPE COAST

School of Agriculture

Department of Agricultural Economics and Extension

Adoption of Irrigated Rice Production Technologies among Farmers in Bontanga Irrigation Area in the Northern Region of Ghana

Questionnaire for Farmers

Dear Respondent,

You have been selected to participate in this study to assess Adoption of Irrigated Rice Production Technologies among Farmers in Bontanga Irrigation Area in the Northern Region of Ghana. The purpose is to understand the dynamics of technology development, dissemination and adoption as an academic endeavour and possible incorporation into future technology programmes. This study is conducted as a PhD study under the supervision of the Department of Agricultural Economics and Extension, School of Agriculture, University of Cape Coast, Ghana.

Information will be treated as confidential and will be bulked, analysed, and used for the stated purposes. Your co-operation and participation is of great need and highly appreciated. Please indicate your responses as suggested in questionnaire.

Thank you

Seini Abubakari

(Student)

Prof. Festus Annor-Frimpong

(Principal Supervisor)

Appendix B: Questionnaire

A. Background Characteristics

B. Demographic characteristics

1. What is your age (at last birthday)................?

2. Sex: female male

3. Have you received any formal education? No Yes

4. If yes, indicate the highest level attained: ....

5. How many years have you been cultivating rice..............?

6. Indicate your household size and composition: male female

children

7. Have you received any training on irrigated rice technologies? No

Yes

8. If yes, indicate: 1] duration..............2] 2 contents of training........................

9. What is your status in your community? Sub-chief Chief

10. Do you belong to any social group in your community? No Yes

11. If yes what position do you hold in the group? Member Leader

12. Marital status: Single Married Divorced

Socio-economic characteristics

13. Position in the household? Household head [1] household member [2]

14. Do you belong to any irrigation farmer organisation? No Yes

15. What is your position in the irrigation farmer organisation? Member

Leader

Receive information [A]	Media/Source	Preference level [B]

Institutional Support

16. How would you describe your access to the following services? Tick appropriate column

Services	Very poor	Poor	Fair	Good	Very good
Roads					
Inputs					
Land					
Extension					
Mechanisation					
Agricultural credit					
Produce market					
Irrigation water					
Specify others: 1. 2.					

17. Please indicate the type of support received from the listed institutions. Tick the column(s) that apply in your case.

Institution	Type of support				
	Information	Training	Credit	Market support	Input
MoFA					
NGOs					
Others (specify)					

18. Rank the listed information sources as your existing Sources of farming information. Use the scale below to rate your sources. 1 = cannot tell, 2 = not a source, 3 = minor source, 4 = source, 5 = major source [A].

Indicate your preference of the listed Media/Sources for receiving agricultural information. Tick the appropriate response column using the scale below in column [B]: 1= cannot tell. 2 = not preferred. 3 = Somehow preferred. 4 = Preferred. 5 = Most preferred.

1	2	3	4	5		1	2	3	4	5
					TV					
					Radio					
					Agric. Print material					
					Demonstrations					
					Group meetings					
					Family members					
					Friends					
					Research Institutions					
					Educational Institutions					
					Input Suppliers					
					Farmers forum					
					Internet					
					Agricultural print materials					
					Others					

Perceptions on factors affecting irrigated rice technologies adoption

Farmer Perceptions of Factors Affecting the Adoption of Irrigated Rice Technology

19. To what extent do you feel the following factors affect your adoption of irrigated rice technologies? Rate your perception using the scale of:

0 = cannot tell, 1 = strongly disagree, 2 = Disagree, 3 = somewhat disagree, 4 = somewhat agree, 5 = Agree, 6 = Strongly Agree

Statement: I use the Irrigated Rice Technology because:	Perception						
	0	1	2	3	4	5	6
The role I play being male or female							
My age							
The number of people living in my household							
My marital status							
The level of formal education I have attained							
The number of years I have worked as a farmer							
The cost of irrigation rice technology							
The technology is compatible with my cultural practices							
The technology is complex to use							
The technology is risky to use							
The technology meets my needs							
The technology is resistant to diseases							
The technology is resistant to pests							

The availability of land to practise the technology							
The arrangement for use of land (land tenure system)							
Capital is available to use the technology							
Labour is available to use the technology							
I have assets to use the technology: [the size of farms I have; I possess equipment; low interest rate received]							
My status in the community							
Ethnic group I belong							
Member of a social group							
I hold a position in the group							
I have support from NGOs							
I have support from MoFA extension services							
I have support from the farmers' group I belong to							
I have support from the Bank/Credit Companies							
I have support from agro-chemical sellers Companies							
Information received on the radio/TV							
Market is available for the rice							
The weather is conducive							
The soil is good							

B. Adoption of Technologies

19. Indicate whether you are using or not using any of the listed technologies by ticking the appropriate response column. Briefly indicate why, if you are not using any of the technologies.

Technology	Adoption Response		If 'No' why?
	No	Yes	
Transplanting			
Ploughing			
Harrowing			
Levelling			
Seed nursing			
Transplanting			
Flooding			
Seedling nursing			
Use of improved seed			
Any of: Afife, Bumbas, Thailand, Andii, IITA, Others			
Transplanting seedlings immediately after field preparation			
Recommended Fertilizer application			

4 bags of compound fertilizer/acre at/or immediately after planting			
2 bags of Nitrogen fertilizer/acre 3-4 weeks after planting			
Integrated Pest Management (IPM)			
Intermittent flooding of field			
Intermittent draining of field			
Fungicide application before transplanting			
Insecticide application at milky/booting stage			

D. Farm and produce information

22. Please indicate your farm size, crop yield/acre, quantity of produce consumed, and quantity of produce sold.

Farm size (acres)	Crop yield/acre (bags)	Quantity of produce consumed (bags)	Quantity of produce sold (bags)

E. Major Constrains to Adoption of Rice Technologies

23. To what extent do you perceive the under listed factors as constraining the adoption of irrigated rice technologies at Bontanga irrigation site. Use scale below to rate your perceptions.

Adoption: the continuous use of agricultural practices to improve crop performance and yields:

0 = cannot tell, 1 = Not a constraint, 2 = somewhat a constraint, 3 = a constraint, 4 = a major constraint

Constraints	Scale				
	0	1	2	3	4
Poor quality of roads					
Inadequate availability of inputs					
High price of inputs					
Inadequate access to credit					
Poor access to labour					
Low price of produce					
Non-availability of market for produce					
Inadequate land availability					
Poor soil fertility					

Poor soil quality					
Prevalence of insect pests					
Prevalence of rice diseases					
High temperatures					
Poor access to mechanisation					
Poor Extension services					
Others:					

Perceptions on technologies characteristics

24. Indicate your extent of agreement with the statement by ticking the corresponding column of response: 0 = cannot tell, 1 = strongly disagree, 2 = Disagree, 3 = somewhat agree, 4 = agree, 5 = strongly agree

I believe the introduced irrigated rice technologies are:

I believe the introduced irrigated rice technologies are:	Level of agreement					
Simple to understand and practice	0	1	2	3	4	5
Similar to local practices and culture						
Produces higher yields						
Requires less labour						
Less costly						
Meets rice production needs						