UNIVERSITY FOR DEVELOPMENT STUDIES, TAMALE

ADOPTION OF ECOSYSTEM-FRIENDLY FARMING PRACTICES AMONG RAIN-FED AND IRRIGATED SMALLHOLDER FARMERS IN NORTHERN REGION

IDDRISU, MOARI SULEMANA

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BY

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

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DECLARATION

Student

I, Moari Sulemana Iddrisu, author of this thesis, do hereby declare that except for various forms of related literature consulted and which have been appropriately acknowledged, the entire work was done by me in the Department of Agricultural and Resource Economics, University for Development Studies (UDS). This work has never been submitted either in whole or in part for any other degree in this University or elsewhere.

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Supervisors

We hereby declare that this thesis was carried out by Mr. Moari Sulemana Iddrisu in partial fulfilment of the requirements for the award of Master of Philosophy (MPhil) Degree in Agricultural Economics under our supervision in accordance with the guidelines on supervision of thesis laid down by the University for Development Studies.

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ABSTRACT

Environmentally friendly farming technologies play key roles in ensuring food safety and security, human health and in restoring and conserving the environment to safeguard the well-being of humans and animals. Therefore, future food security and economic independence of developing countries like Ghana would depend on ecosystems sustainability and agricultural productivity. This study explored the importance of farming practices on ecosystems sustainability for improved rural livelihoods. Specifically, the study was conducted to determine the factors influencing adoption of ecosystem-friendly farming practices (EFFPs) in the area. It was conducted in three districts (Kumbungu, Savelugu-Nanton and Tolon) in the Northern Region of Ghana. In all, 300 farmers participated in the study. Data were analysed both descriptively and appropriate econometric models. The study results revealed that farmers understand the importance of ecosystem-friendly farming practices, the adoptions of which are significantly influenced by social, economic, institutional, and ecological factors. Also, gender, household size, membership to Farmer-based Organizations/social groups, and extension contact negatively affects farmer's WTA decision, while the age, educational level, and cost of production positively affect farmers' willingness to accept payment before adopting EFFPs. It is concluded that farmer sensitization and capacity building through effective extension contact and service delivery especially on environmental conservation and climate smart agriculture practices can speed up the adoption of EFFPs. The development of strategies such as tradable pollution permits that offer farmers a market-based incentive to adopt EFFPs is recommended.

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DEDICATION

I dedicate this thesis to the Almighty Allah for His guidance and protection, my beloved late Mother (Hawah Musah – Peace be upon her), Father (Alhaj Moari Iddrisu), siblings (Alhaj Iddrisu Mohammed, Iddrisu Ayi, Iddrisu Ibrahim, Iddrisu Azaratu, and Iddrisu Abdul-Fataw), Moari family, and wife (Mrs. Ziba Mariama Wuni) for their priceless love and care.

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LIST OF ACRONYMS

Acronym	**Meaning**
CA	Conservation Agriculture
CAADP	Comprehensive African Agriculture Development Programme
CO_2	Carbon dioxide
CVM	Contingent Valuation Method
DoA	Department of Agriculture
EFFPs	Ecosystem-Friendly Farming Practices
ES	Ecosystem Services
FAO	Food and Agricultural Organization
FASDEP	Food and Agriculture Sector Development Programme
FBO	Farmer Based Organisation
GIDA	Ghana Irrigation Development Authority
GH₵	Ghana Cedis
GMOs	Genetically Modified Organisms
GoG	Government of Ghana
GSS	Ghana Statistical Service
IPM	Integrated Pest Management
IRM	Imazapyr-Resistant maize
JHS	Junior High School
MA	Millennium Assessment
MDGs	Millennium Development Goals

MEA	Millennium Ecosystem Assessment
MEC	Master of philosophy in Agricultural Economics
METASIP	Medium Term Agricultural Sector Investment Plan
MoFA	Ministry of Food and Agriculture
MRS	Marginal Rate of Substitution
MSLC	Middle School Leaving Certificate
NEPAD	New partnership for Africa's Development
NGOs	Non-Governmental Organisations
NPRS	National Poverty Reduction Strategies
NRC	Natural Resource Conservation
NSBC	Northern Savanna Biodiversity Conservation
SDGs	Sustainable Development Goals
SHS	Senior High School
SPSS	Statistical Package for Social Sciences
SSA	Sub-Saharan Africa
SSI	Smallholder Systems Innovations
SWC	Sustainable Water Conservation
UDS	University for Development Studies
UNEP	United Nations Environmental Policy
USA	United States of America
VIF	Variance Inflation Factor

WLE	Water, Land and Ecosystem
WTA	Willingness to Accept
WTP	Willingness to Pay

CHAPTER ONE

INTRODUCTION

1.0 Background of the study

Agriculture is the most important business enterprise in the world which is highly connected to ecosystem services (UNEP, 2011). Agriculture leads in landscape management globally, and covers nearly 40 per cent of the terrestrial surface of the Earth ecosystems (FAO, 2009). Agriculture landscapes must be managed not only for marketed products but also for socially valued ecosystem services (Antle & Capalbo, 2002; Robertson *et al*., 2004; Farber *et al*., 2006; Swinton *et al*., 2006, 2007; Swinton *et al*., 2015). Agriculture has the potential to provide beneficial ecosystem services to increase human wellbeing in society (Swinton *et al*., 2015). Increased food demand from a growing human population puts pressure on agriculture (both irrigated and rain-fed) to increase food production in order to meet the Sustainable Development Goal of eradicating hunger and poverty. This demand has so far been met through expansion of irrigated and rain-fed agricultural lands and intensification using new technologies (MA, 2005). However, almost half of the earth's irrigable and non-irrigable land area is already transformed (Steffen *et al*., 2004) and ecosystem degradation is likely to increase significantly during the first half of the 21st century (UNEP, 2011).

Global food production has increased significantly because of adoption of agricultural innovations and technologies (Tilman *et al*., 2002) with Sub-Saharan African Region experiencing steady rise in agricultural productivity for the same reason (Nin-Pratt & Yu, 2010; Fuglie & Rada, 2013). Despite the increases, there are still growing concerns about the ability of the existing traditional agricultural practices to feed the teeming population in the region. Agricultural production in Sub-Saharan Africa largely depends on rain-fed and irrigated ecosystems (Ehui & Pender, 2005). Smallholder agriculture is facing the largest soil infertility, pests and diseases, climate variability, food insecurity and water scarcity problems and these demands are met through expansion of cropped land (Rockstrom *et al.*, 2004). To overcome the degradation path that many Sub-Saharan Africa agro-ecosystems are going through and move towards a more resilient system capable of providing multiple ecosystem services, the adoption of ecosystem-friendly farming practices by farmers, especially smallholder farmers need to be implemented. Many projects such as conservation agriculture (CA) are implemented in response to the needs for sustainable food production by adopting sustainable farming practices in smallholder farming (FAO, 2010). The implementation of conservation agriculture (CA) practices aimed at conserving the ecosystem although, have been successful in some countries like Latin America (Bolliger, 2007), adoption rate among farmers is low in sub-Saharan Africa (Lamourdia & Meshack, 2009).

Agriculture remains the most important economic activity for rural Ghana and the growth of this sector is crucial for attaining the upper middle income status. This is because about 60 percent of Ghana's population is engaged in the agriculture sector (GSS, 2013a). It is known to contribute about 21 percent to Gross Domestic Product (GoG, 2013; Jasaw *et al*., 2014). However, agriculture in the country is heavily dependent on the natural ecosystem resource base for extensive crop and livestock production. The growth and sustainability of the agriculture sector over the years faced a lot of challenges such as socio-economic and environmental factors including poor infrastructure, low incomes, pests and diseases, infertile soils, irregular and unreliable rainfall patterns, incidence of perennial floods and droughts among others (Armah *et al*., 2011).

Also, land degradation has been a yearly issue and continues to be a major threat to the estimated 150,000km^2 agricultural lands, which is about 63 percent of the total land area of Ghana (METASIP, 2010). It has thus become a major developmental issue in terms of its impacts on poverty alleviation, food security and economic growth. As a result, ecosystem and ecosystem management practices are very important to the achievement of three of the Medium Term Agriculture Sector Investment Plan (METASIP II) of increased food security, growth in incomes, and sustainable management of land and environment through the Food and Agriculture Sector Development Policy (FASDEP II). However, agriculture sector can be sustained through the improvement of the performance of the existing irrigation sector and utilizing the country's significant ecological irrigation potential (IWMI, 2010). Also, improving farmers' access to improved technologies such as improved agronomic practices (mulching, crop rotation, cover cropping, organic manuring), and crop protection techniques can ensure sustainable growth in the agricultural sector.

Agriculture remains the mainstay of the economic growth of Northern Ghana. Over 70 percent of farmers in the Northern Region are engaged in rain-fed agriculture, where rainfall has become more erratic, resulting in prolonged drought periods (Armah *et al*., 2011). Consequently, the dominant vegetation (grasslands) suffers annual bushfires that deplete the biomass and expose the soils to erosion and loss of soil nutrients (Yahaya & Amoah, 2013). Additionally, biodiversity and ecosystems services that hitherto ensured that man lived in harmony with nature are being lost at an alarming rate (Jasaw *et al*., 2014). If recent trends continue, future agricultural supplies will not be enough to meet demand and to reduce poverty. Ghana agricultural policies are geared towards increasing crop yields such as intensive use of fertilizers, use of pesticides, and mechanization of farm lands but at the neglect of adopting ecosystem-friendly practices (Smith *et al*., 2005). Even projects with reported successful adoptions face major abandonments as project stops (Smith *et al*., 2005). It is against this backdrop that this study seeks to shed light on the factors that influence the adoption and retention of ecosystem-friendly farming practices in the Northern Region of Ghana.

1.1 Problem statement

The challenge facing agriculture globally is how to provide food for the increasing world population which is projected to reach nine billion people by the year 2050 and at the same time conserve the environment (World Bank, 2012). Improved farming practices promoted by technological advancement led to increased agricultural productivity which spared more than one billion people from famine but at the detriment of the ecosystems. Instead of striving for more "green revolutions" with emphasis on miracle seeds, genetically modified organism, synthetic and engineered pesticides, chemicals, and increased use of inorganic fertilizers, the future must look to natural ways and processes for supplementing agricultural productivity (Manimozhi *et al*., 2012). Thus, all development efforts and activities should be within well-defined ecological systems rather than within narrow economic gains. However, the adoption rate of ecosystem friendly agricultural practices among farmers varies across the globe (UNEP, 2011). Therefore, sustainable intensification of rain-fed and irrigated agriculture that are economically and environmentally sustainable would offer a useful approach to tackling food insecurity facing the world (Spore, 2012).

Despite the increasing awareness of the interrelationships between ecosystems and development, governments at the national and regional levels including development partners in Africa are still pursuing developmental policies that inadequately address the links between ecosystems health and development. Examples include National Poverty Reduction Strategies (NPRS) and the New Partnership for Africa's Development (NEPAD) that has been implemented but policies of ecosystems sustainability are not fully enforced. Therefore, it is not surprising that the regions facing the greatest developmental challenges tend to be those having the most trouble maintaining their ecosystems and the services they provide (UNEP, 2009). Also, the just ended Millennium Development Goals (MDGs) appeared not to have done very well towards ecosystem/environmental sustainability partly due to policy makers and implementers inadequately prioritizing the adoption of ecosystem-friendly farming practices. Hence, implementation of ecosystem-friendly farming practices is a prerequisite to achieving Sustainable Development Goal 1 (end poverty in all its forms everywhere) and Goal 2 (end hunger, achieve food security and improved nutrition, and promote sustainable agriculture).

Agricultural policies in most of Africa including Ghana emphasize on increasing food production but almost nothing is usually said in the statements about sustainable ecosystem management. For instance, the Comprehensive African Agriculture Development Programme (CAADP) and the Comprehensive Health Programme of the New Partnership for Africa's Development (NEPAD, 2003) have done very little about environmental sustainability. However, these targets cannot be achieved without proper existence of ecosystem and adoption of ecosystem-friendly farming practices among farmers.

Northern Region's ecosystem is gradually diminishing as the services provided by the ecosystem also getting extinct as a result of climate change and population pressure. Both rain-fed and irrigated agriculture have suffered losses over the years due to the degradation of ecosystems which results in soil infertility, poverty, food insecurity, and increasing scarcity of freshwater resources (Jasaw *et al.*, 2014). Meanwhile, Northern Region contributes greatly to Ghana's food basket and has the potential to even increase food productivity with its vast ecological landscape. However, the realization of this potential requires that ecosystem-friendly farming practices need to be adopted. Governmental and non-governmental organizations in Northern Ghana are engaged in promoting the adoption of sustainable agricultural practices that are ecosystem friendly. However, adoption rate of the practices among farmers appears to be very low and that problem has to be addressed. In the light of the above, the objective of this study is to analyze factors influencing the adoption of ecosystem-friendly farming practices in the Northern Region of Ghana.

1.2 Research questions and objectives

1.2.1 Research questions

The following are the research questions for the study:

1. What are the perceptions of farmers on ecosystem-friendly farming practices?
2. What factors influence the adoption of ecosystem-friendly farming practices by farmers in rain-fed and irrigated landscapes?
3. How much are farmers willing to be paid to adopt ecosystem-friendly farming practices?
4. What factors influence the willingness of farmers to accept payment to adopt ecosystem-friendly farming practices?

1.2.2 Research objectives

The main objective of the study is to analyze the adoption of ecosystem-friendly farming practices by farmers in rain-fed and irrigated landscapes.

Specifically, the study sought to:

1. Investigate the perceptions of farmers on ecosystem-friendly farming practices in rain-fed and irrigated landscapes.
2. Estimate the factors that influence the adoption of ecosystem-friendly farming practices by farmers in rain-fed and irrigated landscapes.
3. Evaluate the amount farmers are willing to be paid to adopt ecosystem-friendly farming practices.
4. Analyze factors that influence farmers' willingness to accept payment to adopt ecosystem-friendly farming practices.

1.3 Justification of the study

Global ecosystems have been transformed over the years as a result of human activities mainly to meet rapidly growing demands for food, fresh water, timber, fiber and fuel. These changes to the ecosystems have contributed to substantial net gains in human well-being and economic development, but the gains have been achieved at growing costs in the form of the degradation of many ecosystem services, increased risks of irreversible changes, and the exacerbation of poverty especially vulnerable group in society (MA, 2005). The challenges of reversing the degradation of ecosystems while meeting increasing demands for ecosystem services involve significant changes in policies, institutions and practices (MA, 2005).

Maintaining a healthy natural ecosystem resource base is vital for human survival, especially the rural poor farmers. Human-beings depend on ecosystem resources for their livelihoods and general well-being. This study looks at ecosystem-friendly farming practices in the Northern Region, especially districts that practice both rain-fed and irrigation farming to establish their perceptions, the determinants of ecosystem-friendly farming practices adoption and to examine the willingness of farmers to accept payment to adopt such practices.

Whilst there is increasing awareness of the degradation condition of the ecosystem, there is a major gap in understanding and adopting appropriate practices that will increase and sustain the services of the ecosystem. Identifying the factors that influence the adoption of ecosystem-friendly farming practices in Ghana will contribute to knowledge in terms of providing empirical feedback for research and policy decisions. Adopting ecosystem-friendly farming practices can therefore have significant positive impacts on the welfare of those living in poverty and the world at large. Thus, the findings of this study could be of interest to several development stakeholders, including relevant Government agencies (research, extension, policy and planning) and Non-Governmental Organizations (NGOs).

The findings from this study would be of benefits to many disciplines/institutions or organizations such as Government of Ghana (GoG) in achieving food security in the country through improved and sustainable agriculture, policy makers in designing and implementing proper environmental policies, Environmental Protection Agency (EPA) as their part of their mandate to protect the natural ecosystem, Non-Governmental Organizations (NGOs) involved in agriculture and environmental conservation to implement good agronomic practices and ecosystem conservation, agents of sustainable agricultural development as a first-hand information, students and other researchers with knowledge. Farmers are also potential beneficiaries of this research since the adoption of ecosystem-friendly farming practices will not only sustain the environment and productivity but also sustained increase in incomes and health ecosystem. Last but not the least, the researcher gains both academic improvement and practical field experience.

1.4 Scope and limitations of the study

This study concentrated on three districts in the Northern Region. However, according to 2010 Population and Housing Census, Northern Region has a total population of 2,479,461. Specifically, the study targeted three districts, namely Kumbungu District with a population of 39,341, Savelugu-Nanton District with a population of 139,283 and Tolon District with a population of 72,990. The total population of the three districts is

251,614 with approximately 80 percent engaged in agriculture. In particular, the study was conducted in Wuba, Kpalsogu, Vogg Kpalsogu, Kushibu, and Vogg Kushibu in the Kumbungu District; Libga, and Nyoglo in the Savelugu-Nanton District; and Golinga, Gbelahagu, and Galkpegu in the Tolon District. The study only focused on the adoption of ecosystems-friendly farming practices in these districts. Data were collected from 300 farmers across the selected districts.

The study was limited to farmers in Northern Region of Ghana. As a result, some factors influencing the adoption and willingness of farmers to accept payment may be unique due to differences in socio-economic characteristics, farming practices, and climatic conditions which across regions and the country at large. Secondly, the questionnaire for this study included some sensitive questions such as the total number of acres cultivated, total quantity of produce harvested, total quantity of produce consumed and sold as well as farm and off-farm income. Perhaps, some farmers considered this information to be secret and meant for private consumption, which they might not reveal the true figures or respond. Therefore, the research assured farmers of their confidentiality of information and make sure the farmer is not interviewed in the presence of colleague farmer(s).
The researcher selected the three districts because of time and resource constraints. There was a problem reaching most of the selected communities in the various districts because they are located in remote areas and the road networks to these communities were not motorable. Hence, a motorcycle was the only means used to reach them. Majority of farmers are not educated formally, which was a barrier to proper understanding of the concept of ecosystem, so enumerators who understand the local language were recruited and trained to carry out the data collection. The farmers were also not available for

interview during active working hours (7:00 am to 12:00 noon) especially, from Saturday to Thursday but usually available on Fridays for prayers. This made it difficult in the collection of data.

Another limitation was that respondents might not have revealed the true amount they would have accepted if they were faced with reality. Likewise, researchers might not also have revealed their true willingness to accept because they were also not faced with reality.

1.5 Organization of the study

This study is organized into five chapters. The first chapter covers the background of the study, problem statement, research questions and objectives, justification, scope and limitations and organization of the study. Chapter two captures the relevant existing literature. Chapter three explains the methodology of this research such as the study area, sampling procedure, method of data collection and analysis, theoretical framework and empirical model and specification. Chapter four discusses the major results and findings of the study. The final chapter is the summary, conclusions drawn from the study, policy recommendations and suggestions for future research.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter reviews relevant theoretical and empirical literature concerning the issue under study. This includes and among other related literatures on ecosystems and the adoption of ecosystem-friendly farming practices both locally and globally.

2.1 Ecosystem and ecosystem services: concepts and definitions

Ecosystem is the provider of various goods and services important for human well-being and regeneration of habitats, collectively called ecosystem services. Over the past decade, different efforts have been made to understand how ecosystems provide services and how service provision translates into economic value (MA, 2005; NRC, 2005). Yet, it is an established fact that, it is difficult to move from general pronouncements about the tremendous benefits nature provides to people to credible quantitative estimates of ecosystem service values. Spatially explicit estimates and values of services across landscapes (ecosystems) that might inform land-use and management decisions are still lacking (Balmford *et al*., 2002; MA, 2005). Without quantitative estimations, and some incentives for landowners to provide them, these services would be ignored by those making land-use and land-management decisions.

Ecological and economics literature provides several definitions of ecosystem services not all of which are compatible or equally useful from an economic perspective. The term ecosystem service was first propagated by ecologists pointing out the wide range of natural processes and products that support human existence and enhance human well-being (Daily, 1997; Daily *et al*., 1997). This early effort tended to define ecosystem services very broadly as the "biological underpinnings essential to economic prosperity and other aspects of our well-being" (Daily *et al*., 1997). The Millennium Ecosystem Assessment (2005a) further categorized ecosystem services into four namely; supportive service (leading to the maintenance of the conditions for life, such as nutrient cycling), provisioning services (providing direct inputs to human economy, such as food and water), regulating services (such as flood and disease control), and cultural services (such as provision of opportunities for recreation and spiritual or historical purposes). According to other researchers (see, De Groot *et al*., 2002; National Research Council, 2005;) who emphasize that, for valuation purposes one needs to differentiate clearly between ecosystem functions and services, the key distinction being that services require the explicit involvement of human beneficiaries.

By defining ecosystem services as things or characteristics of nature directly valued by humans, ecosystem functions and processes like nutrient cycling are not considered services because they are intermediate to the production of the final services or ecosystem components, such as surface water, oceans, vegetation types, and species. This definition of services as end-products avoids the problem of double-counting that would result from counting both intermediate inputs, such as hydrological cycling and water filtration by soils, and end products, such as drinking water. From a human welfare perspective, it is only the end-products that matter as humans do not care about hydrological cycling or water filtration per se, but about the resulting end-product (for example, the amount of available water of a certain quality).

The Millennium Ecosystem Assessment (2005) defines ecosystem services as ‘‘the benefits people obtain from ecosystems. For example, in the Millennium Ecosystem Assessment, nutrient cycling is a supporting service, water flow regulation is a regulating service, and recreation is a cultural service. However, the first two are seen as providing the same service, usable water, and the third (for example; recreation on a clean, passable river) turning the usable water into a human benefit (that is, the endpoint that has a direct impact on human welfare). If all the three services outlined by Millennium Ecosystem Assessment were to be individually valued and added to a cost-benefit analysis, an error of double counting would be committed, as the intermediate services are by default included in the value of the final service.

2.2 Ecosystem services and disservices to and from agriculture

Ecosystem services include pollination by insects, water provision and purification, healthy and productive soils and protection from pests. Agricultural production is heavily dependent on the services provided by natural ecosystems but only recently attempts have been made to estimate the impact of agricultural practices on the sustainable provision of ecosystem services (Akudugu *et al*., 2012; Afo-Loko *et al*., 2013; 2014; Swinton *et al*., 2015). Some ecosystem services can easily be quantified than others (Swinton *et al*., 2015). To some extent, most of the services are essential to crop production or could substitute directly for purchased inputs. Agro-ecosystems are vital sources of provisioning services and the practices involved to provide these services are influenced by the farmer and farm characteristics. Depending on agro-ecosystem structure and management system, they may also contribute a number of other ecosystem services (MEA, 2005). Ecosystem-friendly farming practices are capable of providing the same supporting services, provisioning services, regulatory services, and cultural services. In addition, agricultural systems and practices can be managed to support biodiversity and enhance carbon sequestration at global scale (Swinton *et al*., 2015).

A literature search concerning ecosystem services and agriculture yielded many publications that analysed the impacts of agricultural activities and practices on ecosystems (see, Swift *et al.*, 2004; Nelson *et al.*, 2009) that result in increased provisioning services such as food, fibre and fuel. However, this is achieved at the detriment of other ecosystem services, including loss of biodiversity, agrochemical contamination and sedimentation of waterways, pesticide poisoning of non-target organisms, and emissions of greenhouse gases and pollutants. Other publications assessed the ecosystem services that agricultural landscapes can provide (see, Swinton *et al.*, 2007a; Swinton *et al.*, 2007b) and concluded that farm management systems that emphasize crop diversity through the use of polycultures, cover crops, crop rotations, agroforestry, afforestation, reduced tillage, organic farming among others can enhance ecosystem functions and services. There is substantial research focus on possibilities to compensate farmers for the provision of ecosystem services through the creation of markets (see, Engel *et al.*, 2008; Wunder *et al.*, 2008; FAO, 2010; Pagiola *et al.*, 2010). They concluded that farmers are willing to receive payment before renouncing bad farming practices and engage in improved practices that generate multiples ecosystem services.

There is an increasing risk of ecosystem regime shifts that abruptly affect the stability of ecosystems from one relatively stable state to another, which might lead to disastrous changes in ecosystem services. According to UNEP (2011), changes in the quality and quantity of hydrological flows caused by agriculture can increase the risk of ecological regime shifts in aquatic systems, the soil and land-atmosphere interactions, which are often difficult to reverse and the decline in many ecosystem services caused by agriculture also affect the supply of those services, such as pollination, which are of high importance to agriculture itself. Hence, ecosystem services and dis-services to agriculture influence both where and how people choose to farm (Ackerman & Knox, 2006). Ecosystem services to agriculture affect not only the location and type of farming, but also farmland's economic value including crop price, values of agricultural land and production costs that are linked to soil fertility and depth, suitable climate.

2.2.1 Ecosystem services to agriculture

Ecosystems also offer important services to agricultural production (e.g. nutrient cycling, soil structure and fertility, etc.). Earlier literature employed qualitative approach to ecosystem processes and services on which agriculture productivity might depend (Zhang *et al.*, 2007). There are however, few studies (see, Ricketts *et al.*, 2004; Zhang *et al.*, 2007; Power, 2010) available that attempted to quantify the contribution and adoption of ecosystem-friendly farming (agricultural) practices to enhance the provision of one or more ecosystem services to agricultural production. According to Power (2010), ecosystem services contribute to agricultural yields by maintaining soil fertility and structure, nutrient cycling, crop pollination, biological pests and diseases control but provided limited value estimates.

2.2.2 Ecosystem services from agriculture

Proper farm management and for that matter ecosystem-friendly farming practices (EFFPs) can significantly enhance the ecosystem services provided by agriculture. Farmers regularly manage for greater provisioning services by using inputs and practices to increase yields, but adoption of good ecosystem-friendly farming practices (EFFPs) can also enhance other ecosystem services, such as pollination, biological pest control, soil fertility and structure, water regulation, and support for biodiversity. Many studies (see, Perfecto & Vandermeer, 2008) have identified the important role of perennial vegetation in supporting biodiversity in general and beneficial organisms in particular. Evidence suggests that management systems that emphasize crop diversity through polycultures, cover crops, crop rotations, agroforestry, afforestation, reduced tillage, organic farming among others can often reduce the abundance of insect pests that specialize on a particular crop, while providing refuge and alternative prey for natural enemies (Andow, 1991). Similar practices may benefit wild pollinators, including minimal use of pesticides, no-till systems and crop rotations with mass-flowering crops including, and mitigation of greenhouse gas emission. Agricultural practices can effectively reduce or counterbalance agricultural greenhouse gas emissions through a variety of processes (Drinkwater & Snapp, 2007; Lal 2008a; Smith *et al*., 2008). Effective manure management can significantly reduce emissions from animal waste. Replacing synthetic nitrogen fertilizers with biological nitrogen fixation by legumes can reduce carbon dioxide (CO_2) emissions from agricultural production by half (Drinkwater & Snapp, 2007). The process of legume intensification in agroecosystems modifies internal cycling processes and increases nitrogen (N) use efficiency within agroecosystems.

Agriculture can offset greenhouse gas emissions by increasing the capacity for carbon uptake and storage in soils in a form of carbon sequestration (Lal, 2008a). For example, soil conservation measures such as conservation tillage and no-till cultivation can conserve soil carbon, whiles crop rotations and cover crops can reduce the degradation of subsurface carbon. Finally, agricultural land can also be used to grow crops for bioenergy production which has the potential to replace a portion of fossil fuels and to lower greenhouse gas emissions (Smith *et al*., 2008).

2.2.3 Ecosystem disservices to agriculture

Organisms (living and non-living) such as herbivores, frugivores, seed-eaters, and pathogens (specifically, fungal, bacterial and viral diseases) within the ecosystem are pests and diseases which decrease agricultural productivity and sometimes can result in complete failure of crops and animals. Ironically, over-reliance on pesticides in recent decades has led certain species to develop genetic resistance to specific pesticide compounds, triggering pest outbreaks and recovery. This makes chemical control costlier and result in unintended negative health outcomes for non-target organisms, including humans (Thomas, 1999).

Ecological resources of value to agriculture are heavily competed for in many agriculture landscapes. Other ecological plants compete for water and reduce the water available to agricultural production. For example, trees can reduce the recharge of aquifers used for irrigation and an example is conifers in South Africa (van Wilgen *et al*., 1998).

2.2.4 Ecosystem disservice from agriculture

Good agricultural practice can contribute to ecosystem services, but can also be a source of disservices, including loss of biodiversity, agrochemical contamination and sedimentation of waterways, pesticide poisoning of non-target organisms, and emissions of greenhouse gases and pollutants (Zhang *et al*., 2007). These disservices increase cost of production to humans, and the benefits and costs accruing to the agricultural sector and society are not equitably distributed, from local communities impacted by pesticides in drinking water to the global commons affected by global warming. Ecosystem disservices are directly linked to agricultural activities (for example nutrient cycling, pollution and emission of greenhouse gases) through merging externalities into the costs of production has the potential to reduce these negative environmental consequences of agricultural practices. In fact, agriculture has been one of the major agents of global environmental change, including through changes in land use, land cover and irrigation that affect the global hydrological cycle in terms of water quality and quantity (UNEP, 2011).

Management practices also influence the potential for 'disservices' from agriculture such as habitat loss, soil erosion, pollution of water bodies and pesticides poisoning of humans and non-target species (Zhang *et al*., 2007). Since agricultural practices can harm biodiversity in many ways, agriculture is often considered threat to conservation. However, appropriate management (ecosystem friendly practices) can ameliorate many of the negative impacts of agriculture, while largely maintaining provisioning as well as other services. Agro-ecosystems can deliver a variety of other regulating and cultural services to human societies, and at the same time provisioning services and services in support of provisioning services.

2.3 Agro-ecological practices and ecosystem resilience

Resilience is a topical yet 'slippery' concept, which to some extent more difficult to explain (Morecroft *et al.*, 2012). Resilience means different things to those working in disaster management, climate change and ecosystems. The Millennium Ecosystem Assessment (2005) defines resilience as "the capacity of a system to tolerate impacts of drivers without irreversible change in its outputs or structure." Ecosystem resilience refers to the ability of an ecosystem to recover or regain from disturbance or withstand continuing pressures. It is a way to measure how well an ecosystem can tolerate disturbance without collapsing and changing into different undesirable ecological state. Resilience is about changing system of disturbance and recovery and not a single ecological state. Given enough time, a resilient ecosystem will be able to fully recover from such disturbances and become as bio-diverse and healthy as before the impact (Morecroft *et al.*, 2012). Similarly, a resilient ecosystem may be able to absorb the stresses caused by these disturbances with little or no sign of degradation. An ecosystem's ability to absorb or recover from impacts, and its rate of recovery, depend on the inherent biology and ecology of its component species or habitats; the condition of these individual components; the nature, severity and duration of the impacts and the degree to which potential impacts have been removed or reduced (Hall & Lamont, 2013).

2.4 Rain-fed and irrigated ecosystems

Intensified food production through agriculture is closely linked to ecosystem decline. The Millennium Ecosystem Assessment of 2005 highlighted trends of significant decline in many ecosystem services of high relevance to food security, such as those provided by cultivated ecosystems. The Assessment also reported that the quantity of provisioning ecosystem services (e.g., food, water and timber) used by humans increased rapidly during the second half of the twentieth century, and continues to grow (UNEP, 2011). Changes in one ecosystem service (for example, increased food and timber production) can lead to changes in others factors such as increased water use, degraded water quality, land-use change and greenhouse-gas emissions. key challenge in managing ecosystem services is that they are not independent of one another: individual ecosystem services should be regarded as various elements of an interrelated whole or what might be termed a "bundle". Efforts to optimize a single ecosystem service often lead to negative changes in others (MA, 2005).

Irrigation systems are made up of several components (for example, reservoir, supply canals and irrigated fields) which are artificial wetland ecosystems, often modifying or replacing earlier natural or semi-natural wetland ecosystems in the process of agricultural intensification and land conversion (Steffen *et al*., 2004). Due to a poor understanding of multi-functional uses of wetland ecosystems, these are often neglected in water management. A turn towards greater ecosystem consideration would seek to differentiate the benefit obtained from the natural resources from an ecosystem's components and processes, while sustaining an ecosystem's ability to perform its functions (Pirot *et al*. 2000).

2.5 Ecosystem friendly practices that enhance sustainable supply of ecosystem services

The claims of products and services provided by agroforestry practices are many. However, the agroforestry literature lacked evidence for many of these claims until recently. The last decade has seen an increase in scientific data that substantiate some of these claims. Increasingly agroforestry is viewed as providing ecosystem services, environmental benefits, and economic commodities as part of a multifunctional working landscape (Zhang *et al*., 2007). The multifunctional role of agro-ecosystems has also been emphasized by both the Millennium Ecosystem Assessment (2005) and the International Assessment of Agricultural Science and Technology for Development (2008). There is also a great deal of interest in providing financial benefits to landowners and farmers for land-use practices that maintain environmental services of value to the wider society (FAO, 2009).

Montagnini (2006) focused on carbon sequestration potential of agroforestry systems using various case studies from around the globe. The integration of trees, agricultural crops, and/or animals into an agroforestry system has the potential to enhance soil fertility, reduce erosion, improve water quality, enhance biodiversity, increase aesthetics, and sequester carbon (see, Garrett & McGraw, 2000; Nair *et al*., 2009). It has been well recognized that these services and benefits provided by agroforestry practices occur over a range of spatial and temporal scales (Izac, 2003). Many of these environmental externalities derived at the farm scale or landscape scale are enjoyed by society at larger regional or global scales.

2.6 The concept of technology adoption

Loevinsohn *et al*. (2013), define technology as the means and methods of producing goods and services, including methods of organization as well as physical technique. Thus, new technology is new to a place or group of farmers, or represents a new use of technology that is already in use within a particular place or amongst a group of farmers.

Technology is the knowledge/information that permits some tasks to be accomplished more easily, some service to be rendered or the manufacture of a product (Lavison, 2013). Technology itself is aimed at improving a given situation or changing the status quo to a more desirable level.

Adoption on the other hand is also defined in different ways by various authors. Rogers (2003) see adoption as the first or minimal level of behavioural utilization. Also, Loevinsohn *et al*. (2013) defines adoption as the integration of a new technology into existing practice and is usually proceeded by a period of 'trying' and some degree of adaptation.

Adoption process in agriculture is defined as a series of stages that the producers pass through, from first hearing about the technology (an awareness stage), to collecting information about the technology's expected benefits in terms of its profitability and ease of operation (the evaluation stage); if the information is found to be adequate and the evaluation is positive, the producer will experiment with the technology (the trial stage and the final full-scale adoption stage of the technology) (Rogers, 1962; Feder *et al*., 1985). Feder *et al*. (1985) distinguished between farm level and aggregate adoption of a technology per its coverage. They defined farm level adoption as the degree to which a new improved technology is incorporated into the production process in long-run equilibrium when the producer has complete information concerning the new technology and its potential and applies it on his farm. In the context of aggregate adoption, the definition transcends to the process of diffusion of a new technology within a given geographical area or within a given population. This definition of aggregate adoption also concords with that of Thirtle and Ruttan (1987) which states that aggregate adoption is the spread of a new technology within a population.

Defining technology adoption is a complicated task since it varies with the technology being adopted. For instance, a study by Doss (2003) showed that adoption of improved seed classified farmers as adopters if they were using seeds that had been recycled for several generations from hybrid ancestors. Adoption was identified with following the extension service recommendations of using only new certified seed (Doss, 2003). Therefore, in defining agricultural technology adoption by the farmers, the first thing to consider is whether adoption is a discrete state with binary response variables or not (Doss, 2003). That means definition depends on the fact that the farmer is an adopter of the technologies or non-adopter taking values zero and one or the response is continuous variable (Challa, 2013).

2.7 Measurement of adoption

Measuring adoption involves measuring choices. Feder *et al*. (1985) posit that adoption decision involves choice of how many resources, like land to be allocated to the new improved and old technologies if the technology is not divisible (e.g. mechanization, irrigation). Conversely, if the technology is divisible (e.g., improved seed, fertilizer, agronomic practices and herbicide), the decision process involves area allocations as well as levels of use or rate of application. Therefore, the process of adoption decision includes the simultaneous choice of whether to adopt a technology or not, and the rate and intensity of its use.

In measuring adoption, distinction must be made between technologies that are divisible and those that are not divisible with regards to the measurement of intensity of adoption. The intensity of adoption of divisible technologies can be measured at the individual level in a given period of time by the share of farm area utilizing the new technology or quantity of input used per hectare (Feder *et al.*, 1985). Likewise, this measure can be applied to the aggregate level of adoption in the same locality. Nevertheless, the intensity of adoption of non-divisible agricultural technologies such as tractors and combine harvesters at the farm level at a given period is dichotomous (use or no use), and the aggregate measure becomes continuous. In the latter case, aggregate adoption of a lumpy technology can be measured by calculating the percentage of producers using the new technology within a given area. Aggregate adoption is measured by the aggregate level of use of a specific new technology within a given geographical area or a given population.

2.8 Determinants of technology adoption

There exist vast literatures on factors that determine agricultural technology adoption. According to Loevinsohn *et al.* (2012), farmers' decisions about whether and how to adopt new technology are conditioned by the dynamic interaction between characteristics of the technology itself and the array of conditions and circumstances. Diffusion itself results from a series of individual decisions to begin using the new technology, decisions which are often the result of a comparison of the uncertain benefits of the invention with the uncertain costs of adopting it (Hall & Khan, 2002). An understanding of the factors influencing this choice is essential both for economists studying the determinants of growth and for the generators and disseminators of such technologies (Khanna *et al.*, 2002).

Traditionally, economic analysis of technology adoption has sought to explain adoption behavior in relation to personal characteristics and endowments, imperfect information, risk, uncertainty, institutional constraints, input availability, and infrastructure (Feder *et al*. 1985; Foster & Rosenzweig, 1996; Rogers, 2003; Uaiene, 2009). A more recent strand of literature has included social networks and learning in the categories of factors determining adoption of technology (Uaiene, 2009). Some studies classify these factors into different categories. For example, Akudugu *et al*. (2012) grouped the determinants of agricultural technology adoption into three categories namely; economic, social and institutional factors. Kebede *et al.* (1990) as cited by Lavison (2013) broadly categorized the factors that influence adoption of technologies into social, economic and physical categories. McNamara, Wetzstein and Douce (1991) categorized the factors into, farmer characteristics farm structure, institutional characteristics and managerial structure, while Nowak (1987) grouped them into informational, economic and ecological. Although there are many categories for grouping determinants of technology adoption, there is no clear distinguishing feature between variables in each category. This study will review the factors determining adoption of agricultural technology by categorizing them into technological factors, economic factors, institutional factors, ecological factors and household specific factors. This will enable a depth review of how each factor influences adoption.

2.8.1 Socio-demographic factors

Socio-economic/demographic factors refer to the personal background of the farm's main decision maker. Socio-economic factors found significant to our review are human capital, years of formal education, age, household size, gender, and farming experience.

Human capital of the farmer is assumed to have a significant influence on farmers' decision to adopt new technologies. This is because information-intensive technologies require a high level of human capital, the farmer's capacities and abilities clearly influence his/her adoptive decision towards improved farming technologies on their farm (Daberkow & McBride, 2008). Most adoption studies have attempted to measure human capital through the adopters' education, age, gender, and household size (Fernandez-Cornejo & Daberkow, 1994; Fernandez-Cornejo *et al*., 2007; Mignouna *et al.*, 2011).

Education of the farmer has been assumed to have a positive influence on farmers' decision to adopt new technology. Educational level of a farmer increases his ability to obtain and use information relevant to adoption of a new technology (*Mignouna et al*., 2011; Lavison, 2013). For instance, a study by Okunlola *et al.* (2011) on adoption of new technologies by fish farmers found that the level of education had a positive and significant influence on adoption of the technology. This is because higher education influences respondents' attitudes and thoughts making them more open, rational and able to analyze the benefits of the new technology (Waller *et al*., 1998). This eases the introduction of an innovation which ultimately affects the adoption process (Adebiyi & Okunlola, 2010). Other studies have reported a positive relationship between education and adoption as cited by Uematsu and Mishra (2010). On the other hand, some authors have reported insignificant or negative effect of education on the rate of technology adoption (Grieshop *et al*., 1988; Khanna, 2001; Samiee *et al*., 2009). Since the above empirical evidence have shown mixed results on the influence of education and adoption of new technology, therefore a study is needed in order to come up with a more consistent result.

Age is also assumed to be a determinant of adoption of new technology. Older farmers are assumed to have gained knowledge and experience over time and are better able to evaluate technology information than younger farmers (Mignouna *et al*., 2011; Kariyasa & Dewi, 2011). On the contrary, age has been found to have a negative relationship with adoption of technology. This relationship is explained by Mauceri *et al*. (2005) and Adesina and Zinnah (1993) that as farmers grow older, there is an increase in risk aversion and a decreased interest in long term investment in the farm. On the other hand, younger farmers are typically less risk-averse and are more willing to try new technologies. For instance, Alexander and Van Mellor (2005) found that adoption of genetically modified maize increased with age for younger farmers as they gain experience and increase their stock of human capital but declines with age for those farmers closer to retirement. Household size is simply used as a measure of labour availability. It determines adoption process in that, a larger household has the capacity to relax the labour constraints required during introduction of new technology (Mignouna *et al*., 2011).

Gender issues in agricultural technology adoption have been investigated for a long time and most studies have reported mixed evidence regarding the different roles men and women play in technology adoption. Gender may have a significant influence on some technologies. Gender affects technology adoption since the head of the household is the primary decision maker and men have more access to and control over vital production resources than women due to socio-cultural values and norms (Mignouna *et al*., 2011). For instance, a study by Obisesan (2014) on adoption of technology found that, gender had a significant and positive influence on adoption of improved cassava production in

Nigeria. His result conquered with that of Lavison (2013) which indicated male farmers were more likely to adopt organic fertilizer unlike their female counterparts.

Farming experience is used to measure how long farmers have been involved in agricultural production activities. This continuous variable has an uncertain impact on the adoption of EFFPs. Greater experience can lead to better knowledge of farming operations in the field (Khanna, 2001). More experienced farmers may feel less need for the supplementary information provided on EFFPs and, hence, eschew their adoption (Isgin *et al*., 2008).

2.8.2 Farmer perceptions

Farmer perception refers to their personal subjective evaluation of the attributes of an innovation/technology. Among the perceived attributes suggested by Rogers (2003), perceived relative advantage is used to assess how well an innovation is thought to offer increased benefits more than those technologies that one intends to replace. Among other relative advantages, profitability is a major concern when considering any capital-intensive agricultural technology, including ecosystem-friendly farming practices. Realistically and perceptually, rational farmers do not want to make losses on their investment. Hence, the probability of adopting EFFPs is expected to be higher if EFFPs are perceived to be profitable and this assertion is consistent with the findings of Walton *et al*. (2008).

2.8.3 Behavioural factors

‘‘Behavioral factors’’ are used to describe the mind of a farmer. These factors play a significant role in decision making, especially when an innovation does not offer direct benefits (Yeong & Mark, 2006). Notably, ecosystem-friendly farming practices offer a combination of economic and environmental benefits. Base on this, the “purpose” has been postulated as a precursor to the adoptive decision making process, particularly in leading to environmental-related behaviour (Lamba *et al*., 2009). This variable is conceptualized to capture the motivational factors that influence a behavior. Collectively, expression of higher likelihood or willingness to adopt EFFPs indicates that the farmer has control over the behaviour and is therefore more likely to realize it. As such, adoptive decisions emerge from intentionality. This factor is found to have a positive impact on the adoption of improved agricultural practices, especially when the cost of acquiring them is being subsidized (Khanna, 2001).

2.8.4 Technology factors

Technological factors embody many indicators in the use of technologies (EFFPs), including irrigation facilities. Characteristic of a technology is a precondition of adopting it. Trialability or a degree to which a potential adopter can try something out on a small scale first before adopting it completely is a major determinant of technology adoption (Doss, 2003). In studying determinants of adopting Imazapyr-Resistant maize (IRM) technology in Western Kenya, Mignouna *et al*. (2011) stated that, the characteristic of the technology play a critical role in adoption decision process. They argued that farmers who perceive the technology being consistent with their needs and compatible to their environment are likely to adopt since they find it as a positive investment. Farmers’ perception about the performance of the technologies significantly influences their decision to adopt them. A study by Adesina and Zinnah (1993) showed that farmers' perception of characteristic of modern rice variety significantly influenced their decision to adopt it. Their study indicated that perception of farmers towards fish farming facilitated its uptake. It is therefore important that for any new technology to be introduced to farmers, they should be involved in its evaluation to find its suitability to their circumstances (Karugia *et al*., 2004).

2.8.5 Economic factors

Farm size plays a critical role in adoption process of a new technology. Many authors have analyzed farm size as one of important determinant of technology adoption. Farm size can affect and in turn be affected by the other factors influencing adoption (Lavison, 2013). Some studies have reported a positive relation between farm size and adoption of agricultural technology (Uaiene *et al*., 2009; Mignouna *et al.*, 2011). Farmers with large farm size are likely to adopt a new technology as they can afford to devote part of their land to try new technology unlike those with less farm size (Uaiene *et al*., 2009).

A key determinant of the adoption of a new technology is the net gain to the farmer from adoption, inclusive of all costs of using the new technology (Foster & Rosenzweig, 2010). The cost of adopting agricultural technology has been found to be a constraint to technology adoption. For instance, the elimination of subsidies on prices of seed and fertilizers since the 1990s due to the World Bank-sponsored structural adjustment programs in sub-Saharan Africa has widened this constraint (Muzari *et al*., 2013). Previous studies on determinants of technology adoption have also reported high cost of technology as a hindrance to adoption. The study done by Makokha *et al*. (2001) on determinants of fertilizer and manure use in maize production in Kiambu county, Kenya reported high cost of labor and other inputs, unavailability of demanded packages and untimely delivery as the main constraints to fertilizer adoption.

Off farm income has been shown to have a positive impact on technology adoption. This is because off-farm income acts as an important strategy for overcoming credit constraints faced by the rural households in many developing countries (Reardon *et al*., 2007). Off-farm income is reported to act as a substitute for borrowed capital in rural economies where credit markets are either missing or dysfunctional (Ellis & Freeman, 2004; Diiro, 2013). According to Diiro (2013) off- farm income is expected to provide farmers with liquid capital for purchasing productivity enhancing inputs such as improved seed and fertilizers. According to Goodwin and Mishra (2004) the pursuit of off-farm income by farmers may undermine their adoption of modern technology by reducing the amount of household labor allocated to farming enterprises.

2.8.6 Institutional factors

Institutional factors are indicators that enable or disable a farmer's inclination towards behavioral change. Significant factors identified include farm location, belonging to a social group, acquisition of information about a new technology, access to extension services, and developmental pressure. Heterogeneity of farm locations and that matter natural resources (soil fertility, environmental and climatic conditions) influences performance and subsequent adoptive decision making process of farmers (D'Emden *et al*., 2006).

Belonging to a social group enhances social capital allowing trust, idea and information exchange (Mignouna *et al*., 2011). Farmers within a social group learn from each other the benefits and usage of a new technology. Uaiene *et al*. (2009) suggests that social network effects are important for individual decisions, and that, in the context of agricultural innovations; farmers share information and learn from each other. Studying the effect of community based organization in adoption of corm-paired banana technology in Uganda, Katungi and Akankwasa (2010) found that farmers who participated more in community-based organizations were likely to engage in social learning about the technology hence raising their likelihood to adopt the technologies. Although many researchers have reported a positive influence of social group on technology adoption, social groups may also have a negative impact on technology adoption especially where free-riding behavior exists.

Acquisition of information about a new technology is another factor that determines adoption of technology. It enables farmers to learn the existence as well as the effective use of technology and this facilitates its adoption. Farmers will only adopt the technology they are aware of or have heard about it. Access to information reduces the uncertainty about a technology's performance hence may change individual's assessment from purely subjective to objective over time (Caswell *et al*., 2001). However, access to information about a technology does not necessarily mean it will be adopted by all farmers. This simply implies that farmers may perceive the technology and subjectively evaluate it differently than scientists (Uaiene *et al*., 2009).

Access to extension services has also been found to be a key aspect in technology adoption. Farmers are usually informed about the existence as well as the effective use and benefit of new technology through extension agents. Extension agent acts as a link between the innovators (Researchers) of the technology and users of that technology. This helps to reduce transaction cost incurred when passing the information on the new technology to a large heterogeneous population of farmers (Genius *et al*., 2010). Extension agents usually target specific farmers who are recognized as peers (farmers with whom a particular farmer interacts) exerting a direct or indirect influence on the whole population of farmers in their respective areas (Genius *et al*., 2010).

Many authors have reported a positive relationship between extension services and technology adoption. A good example includes studies done by Akudugu *et al.* (2012) on the adoption of modern agricultural technologies in Ghana. This is because exposing farmers to information based upon innovation-diffusion theory is expected to stimulate adoption (Uaiene *et al*., 2009).

Access to credit has been reported to stimulate technology adoption (Mohamed & Temu, 2008). It is believed that access to credit promotes the adoption of risky technologies through relaxation of the liquidity constraint as well as through the boosting of household's-risk bearing ability (Simtowe & Zeller, 2006). This is because with an option of borrowing, a household can do away with risk reducing but inefficient income diversification strategies and concentrate on more risky but efficient investments (Simtowe & Zeller, 2006). However access to credit has been found to be gender biased in some countries where female-headed households are discriminated against by credit institutions, and as such they are unable to finance yield-raising technologies, leading to low adoption rates (Muzari *et al*., 2013).

Developmental pressure because of population pressure is a factor which a farmer is faced and considers whether to adopt or not with pressing urban growth surrounding his farm. Moreover, as arable and productive lands are increasingly given up for development, the pressure for change to more productive agricultural practices increases and investment in farms decreases. Farmers in such circumstance and pressure have to hypothesize before adopting EFFPs. This factor has been found particularly significant by Isgin *et al*. (2008).

2.8.7 Ecological factors

Ecological or agro-ecological factors are also known as ‘‘farm biophysical factors’’. These factors embody both on-farm natural endowments and operational factors to explain the adoption of EFFPs. Among natural endowments, soil quality including on-farm operational factors such as land tenure and farm size is significant factors influencing adoption of EFFPs. Soil quality is a factor represented by a ratio of an average yield per acre or maximum yield per acre. A relatively more productive parcel is offset by unproductive ones; the knowledge of spatial variability is more likely to induce the adoption of EFFPs. Farmers’ decision to adopt environmental management farming systems according to Golleao and Thomas (2007), and willingness to consider enrolling in a payment-for environmental-services program according to Swinton *et al*. (2014) determined by ecological/geographical location and their environmental attitudes, and the amount of land they would enroll depended more on the payment level and other income-related factors that would compensate the costs of participation (Ma *et al*., 2012).

2.9 Technology adoption-decision processes

One of the general findings of Rogers's literature review was what he termed the innovation-decision process (Rogers, 2003). Shown in **Figure 1**, the innovation-decision process describes the steps an entity goes through in deciding whether to adopt an innovation. The entity involved may be a solitary individual or a group such as a community or company. Note that for my research, I generally focus on the decision process of an individual. Thus, the following discussion on the process is conducted with that focus in mind.

2.9.1 Knowledge

The innovation-decision process begins with the knowledge Stage. One cannot begin the adoption process without knowing about the innovation. In this stage, a person first becomes aware of the technology, perhaps seeing someone using it. She may also see said technology advertised on television or read about it in a magazine or on the web. A peer or mentor may inform her about it as well.

2.9.2 Persuasion

A person moves into the next stage, the Persuasion Stage, when he or she moves beyond simple awareness of the technology. He or she begins to show interest in the technology and seeks out information about the technology: costs, features, user reviews, etc. It is at this point that she begins to consider herself as a potential user of the technology and begins to actively consider whether to adopt the technology into her regular activities or not.

2.9.3 Decision

At the Decision Stage, a person makes the choice to reject or adopt the technology. This personal process involves the weighing of advantages, disadvantages, costs, benefits, and trade-offs. The decision to not adopt, rejection, is an active choice to not acquire the technology or ever use it. Otherwise, the person begins to use and integrate the technology into her daily life. Although this stage is perhaps one of the most critical for understanding technology adoption, it is perhaps one of the most difficult to study. As Roger points out, the process of deciding occurs silently and invisibly to the outside researcher; one can rarely capture the exact moment of decision. Instead, the researcher can only access the adopter's reflections and retrospectives of the decision to adopt or not, sometimes months or years later. Such data is, of course, fraught with validity concerns.

2.9.4 Implementation

The task of integrating the innovation into regular use is called the Implementation Stage. This can be a slow, time-consuming process. For the person involved, changes to her usual habits and practices may be necessary. The technology is also being evaluated now to see if it meets expectations. Further information about the technology may also be sought to improve usability and usefulness of the technology. During this stage, re-invention may occur. Re-invention refers to the process by which a person adapts or modifies a technology to better meet her needs and improve its overall compatibility. This modification may also involve using the technology for a task different from the technology's original intent.

2.9.5 Confirmation

Once the processes of integration and re-invention have completed the final stage, Confirmation Stage, has been reached. At this point, the person finalizes their decision regarding the adoption of the technology. One option is exactly that—adoption. At this point, the person is committed to using the technology to its fullest potential it can serve in her life. Another option is a reversal of the original choice to use the technology. This is essentially a delayed rejection.

2.9.6 Discontinuance

After the adoption of a technology, the person does not always continue to use the technology, though. After an initial period in which the technology is used, the person may abandon the technology. Such discontinuance can occur in several ways. Some technologies face obsolescence in that they cease working or have a limited expectation for the duration of their use. For example, crutches given to a person with a sprained ankle are expected to be abandoned once healing has completed. Another form of discontinuance is replacement. If a broken technology is substituted with a new version, this is one form of replacement. A technology may be also abandoned to replace it with a newer or older version. Upgrading a computer with the latest software or purchasing a newer model cell phone is examples of this type of replacement discontinuance.

The final type of discontinuance is perhaps the most regrettable. Disenchantment rejection, also called abandonment, is when the user becomes dissatisfied with the technology and quits using it. Although the decision to stop using may be conscious, the user may instead just gradually use the technology less and less until it is forgotten. At the heart of it, disenchantment discontinuance means that the adopter's entire effort of learning, deciding, and implementing the innovation into her life has been ultimately for naught. She has wasted her time, resources, and efforts.

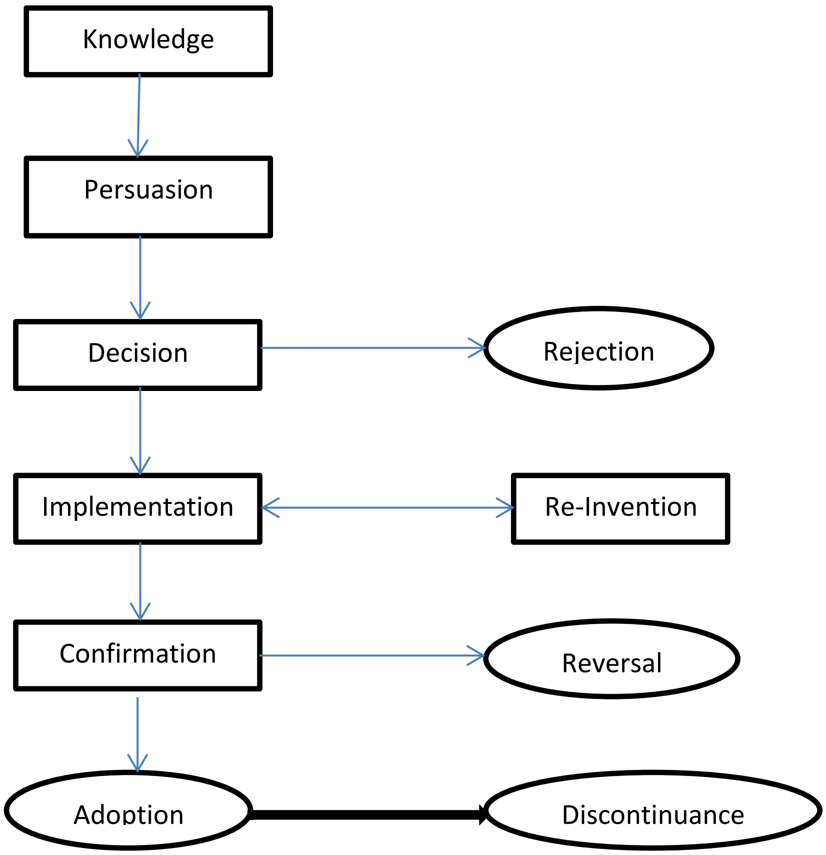

Figure 1: Technology adoption-decision process

Source: Adopted from Roger (2003).

2.10 Empirical models/applications of adoption

From the economic point of view, the farmer's decision to adopt EFFPs can be explored in the context of a discrete choice model, where the rational farmer endowed with sufficient information will weigh the benefits against the costs of adoption (Thomas, 2007). A farmer will adopt EFFPs if the expected utility derived from adopting is greater than the status quo utility. The empirical application shares several features with the previous empirical studies above. We consider a simple model of adoption for a representative farmer, focusing first on the potential gain from adopting EFFPs. Let π_0 and π_1 denote expected profit before and after adoption, respectively:

$$\pi_i = P_i Q - C_i(Q), \qquad i = 0, 1 \tag{1}$$

Where P_i and $C_i(Q)$, denote output price and supply cost function, respectively, and Q is output. Assuming that the cost function is linear, with $C_i(Q) = C_i Q \quad i = 0, 1$, the difference in expected profit levels between the two states "after adoption and before adoption" is simply $\pi_1 - \pi_0 = [(P_1 - P_0) - (C_1 - C_0)]Q$. This difference is positive if the change in supply price between the two states is greater than the change in marginal cost.

It is reasonable to consider that adoption may entail lower gains in early years because it requires investment in physical and human capital (Zhao *et al*., 2007). Furthermore, this lost in profit is usually not recovered by reverting to the preadoption situation. Also, uncertainty may be significant for the farmer regarding the precise value of expected profit after adoption. Hence, because of uncertainty and lost profits in earlier years, farmers may be willing to delay adoption until they have acquired enough information about its profitability. The value of delaying adoption is now standard in the literature on real option (Arrow & Fisher, 2010; Dixil & Pindyck, 2011). Hence, the decision rule for a farmer considering adoption can be written as:

Adopt if and only if $\pi_1 > \pi_0 + R$ (2)

Where, R is the adoption or option premium. Dividing both sides by output (Q) and rearranging, we have:

$$(P_1 - C_1) - (P_0 - C_0) - {}^{R}/_{Q} > 0 \tag{3}$$

This last rule can be confronted with the insight that either the expected profit rate under adoption or the difference in profit rates should be positive to trigger adoption. Although satisfying either of these conditions makes adoption move likely because the left-hand side of equation (3) moves away from 0, including the (positive) option value R makes the requirement a necessary but not sufficient condition for adoption. More precisely, the condition in equation (3) should be valid for any level of output Q.

Cleary, the option value R will depend on the variability of the return to adoption as well as on the farmer's characteristics. It is reasonable to assume that a more precise degree of knowledge about adoption profitability will have a negative impact on R because uncertainty is reduced. However, although a farmer may have a greater likelihood of adopting because he knows the degree of profitability with move precision, this is also true when adopting is not profitable. For this reason, one may need to evaluate the impact of knowledge jointly with farmer-specific individuals' characteristics.

As is usual in discrete choice models with a binary dependent variable, we specify a linear stochastic model for the underlying economic variable deriving adoption (a latent, unobserved variable). In the model, however, as profit rate before adoption $\left(P_{0_i} - C_{0_i}\right)$ and relative option value $^{R}/_{Q}$ are not observed directly, they are assumed to be (linearly) related to observed characteristics of the farmer. Consider the following latent variable:

$$y_i^* = \beta_0 + \beta_1\left(P_{0_i} - C_{0_i}\right) + \beta_2' X_{1i} + \beta_3' X_{2i} + \mu_i \qquad i = 1, 2 \ldots N \tag{4}$$

Where, y_i^* is the farmer index, X_{1i} is a vector of farmer $i's$ characteristics, X_{2i} contains observed components regarding information about EFFPs, μ_i is the residual term, and $\beta_0,\ \beta_1,\ \beta_2,\ and\ \beta_3$ are structural parameters. The adoption model can be stated as a discrete choice model with the dummy variable indicating adoption as the dependent variable: $\begin{Bmatrix} y_i = 1 \; if \; y_i^* > 0 \\ y_i = 0 \; otherwise \end{Bmatrix}$

2.11 Drivers of farmer adoption of ecosystem-friendly farming practices

The introduction of a new agricultural technology for which farmers are knowledgeable about, the determinants of its adoption fall into two basic categories: barriers and incentives. The barriers and incentives concept offers a convincing explanation for much of observed farmer behavior with respect to conserving the natural ecosystem. A national study in the United States from 2001–2003 revealed that when farmers realize a conservation technology is advantageous and not costly to adopt, adoption can proceed rapidly (Lambert *et al*., 2006). For example, adoption of seed-embodied conservation technologies like herbicide tolerance and transgenes that encode for the *Bacillus thuringiensis* (Bt) toxin reached high levels in just a few years. They rapidly signup because lease payments were a clear incentive for which there were no barriers other than knowledge and time of application. Technologies embodied in equipment and other capital goods, on the other hand, tend to face high cost to adopt. Therefore, attractive but capital-intensive technologies are adopted more slowly. They tend to be more quickly adopted by large-scale farmers who can spread fixed costs over more land and may be able to hire staff with the necessary skills.

Also, uncertainty can be another barrier to agricultural technology adoption. Farmers may be unwilling to invest when he/she is not certain about the possible outcome of the new technology. Organic farming technologies have been adopted slowly largely because of the time lag to certification and a degree of management difficulty that can make future earnings uncertain (Musshoff & Hirschauer, 2008). Another barrier to technology adoption is management of time, especially for small and part-time farmers (Lambert *et al*., 2006). In contrast, full-time farmers are more likely to invest the management time or hire a specialized employee who can help in the adoption process.

The willingness of farmers to adopt new management practices that provide additional services depends on awareness, attitudes, available resources, and incentives (Swinton *et al*., 2014a). The adoption of current practices also largely depends on the result of past experiences; cultural norms; including availability of technology, policies, and profitable markets support. Although environmental stewardship is a factor influencing many farmers' decisions, sustained profitability is usually the overriding concern. Particularly for those services related to reducing the environmental impact of agriculture, farmers are more likely to adopt practices that provide direct, local benefits. These benefits might be monetary, such as higher profits or greater future land values, or nonmonetary, such as safer groundwater for family use.

Literature on adoption of sustainable practices in general and ecosystem friendly practices (conservation agriculture) in particular is low among smallholder farmers in sub-Saharan Africa including Ghana (see, Bolliger, 2007; Minten & Barrett, 2008; Rockstrom *et al*., 2009). A vast number of case studies to find out the reasons for low adoption of different farming practices with the common purpose of sustainable management of the natural capital have been done with few common denominators found. The study conducted by Ostrom *et al*. (2007), revealed that there are manifold of social, economic and ecological factors interacting, which by nature vary from place to place and how the practices fit each setting or site influences the decision to adopt CA (ecosystem-friendly farming practices).

Farmer's participation in decision making and adaptation of introduced practices are stated as contributing to more adoptions (see, Erentein, 2003; Reij & Walters, 2001) which guarantees that practices introduced are actually practices of need for the farmers themselves.

The economic benefit in the form of income or yield for farmers is generally seen as the major factor influencing the adoption among farmers (see, Antle *et al*., 2006; Erentein, 2002, 2003). This is consistent with the view of conventional economics of humans as being "self-regarding individuals, maximizing their own well-being" (Janssen, 2002), which as all models of human behavior is an oversimplification (Janssen, 2002). Immediate costs and benefits greatly influenced farmer's adoption decision than long term benefits or benefits (see, Erentein, 2002, 2003; Giller *et al*., 2009, Hellin & Heigh, 2002; Minten & Barrett, 2006) which is seen as a problem for conservation agriculture where short term benefits are appearing erratically. This suggests that conservation agriculture need to be externally financed to compensate farmers for the societal benefits.

Earlier study done by Antle *et al*. (2006), related that farmers will not allow their soil to degrade more than what economically profitable considering the cost-benefit analyses is connected to the farmer's decision to adopt conservation practices. Antle *et al*. (2006), concluded that if there is a need for conservation practices to harvest societal benefits from the agricultural landscape there might be a need to add subsidies for using conservation practices until the state of the soil has recovered to a degree where soil conservation practices is economically viable for the farmer again, that is compensate for the hysteresis effects. It therefore seems important to analyse the three different economic alternatives state the system is in before subsidies are introduced or ended to evaluate (Antle *et al*., 2006).

2.12 Farmer adoption constraints and challenges

Market-based mechanisms for providing ES are not yet fully formed and, as such, are open to speculation. For example, ActionAid (2011) warns the international community about the dangers of entering soil carbon markets. The arguments are valid and revolve around challenges faced by small producers in other sectors. In the agricultural commodity sector, small farmers face geographical dispersion which results in high transaction costs, lack of market information, and limited access to affordable credit and inputs. Their share of the final price of their produce is low and declining, and their resource base is often threatened (Blackmore *et al.,* 2012).

2.13 Contingent Valuation Method (CVM)

The word "contingent" in the expression CVM means hypothetical. Contingent valuation method is a nonmarket-valuation method that is used to value specific changes from the status quo. CVM estimates total value (use and nonuse). CVM is a stated-preference technique, as in the individual "states" his preference. Specifically, in the CVM individuals are asked about the status quo versus some alternative state of the world, and information is elicited about how the individual feels about the alternative relative to the status quo, and their willingness to pay (WTP) or willingness to accept payment (WTA), if anything, to obtain the alternative (Morey, 2015).

The very nature contingent valuation method has been subject to criticism from both economic and psychological point of view, whose main research focus has been the problem of preference elicitation. This criticism further made the supporters of CVM to pay much more attention to a testing protocol in which questions of method reliability and validity are directly addressed. The respondents to a CVM questionnaire will be asked a variety of questions about how much they would be willing to pay (WTP) to ensure a welfare gain from a change in the provision of a nonmarket environmental commodity; or how much they would be willing to accept (WTA) in compensation for the improvement environmental quality or endure a welfare loss from a reduced level of provision. A basic question for the implementation of the CVM is therefore whether WTP or WTA is the most appropriate indicator of value in a given situation.

The CVM is used in this study to ask farmers about a current farm practice compared with an alternative one and their WTA more for the one they think will sustain their productivity or net social welfare. The farmers are allowed to indicate their value for the practices. It simulates a market for non-marketed goods and obtains a value for that good, contingent on a hypothetical market described during the survey. According to Owusu and Anifori (2013), consumers are allowed to value the product contingent on the market in order to solicit their WTP/WPA. The CVM estimates the premium that farmers are willing to accept before renouncing practices and adopting environmentally-friendly practice.

Several researchers have used CVM to estimate WTP and WTA in their studies. For example, Majumdar *et al.* (2011) estimated the monetary value of non-priced urban forest benefits to tourist by investigating the WTP for urban forest resources. Sumukwo *et al.*

(2012) assessed the economic value of improved solid waste management using CVM, while Anaman and Lellyet (1996) evaluated the economic and social benefits of public weather information using CVM. Both the single-bounded and double-bounded approaches of CVM have been employed by different researchers to undertake studies especially willingness to pay or accept for improved environmental quality. For instance, Haghiri *et al.* (2009) used the single-bounded approach. In this study, respondents were offered a single bid to pay or reject for the commodity under study. Owusu and Anifori (2013) used the doubled-bounded approach to value non-market goods.

2.14 Concept of Willingness to Accept (WTA) and Willingness to Pay (WTP)

WTA is also called subjective value, which is the marginal rate of substitution (MRS) between a given attribute and money (Daziano & Achtnicht, 2014). WTA refers to the lowest amount of money an individual is prepared to take to obtain less of a good or service. It is also the lowest amount an individual is willing to be compensated to forgo or provide a given good, service or practice. However, Kimenju and Groote (2005) stated that, WTP is the maximum amount of money a consumer is willing to pay for new or improved products. According to Mubyazi *et al*. (2004), WTP is the maximum price an individual is willing to dispose-off in order to obtain a product or service. The two are common approaches used by various economists to determine the value of resources. Assigning monetary value to goods and services has the basic objective of promoting the understanding of the two techniques (WTP and WTA) for goods and services people enjoy (Hecht, 1999).

In the context of this study, WTA is defined as the lowest amount an individual farmer is willing to be compensated to adopt ecosystem-friendly practices in order to increase and or provide ecosystem services. It measures the amount of money a farmer is willing to accept before adopting EFFPs. Several researchers have used various methods to measure WPA and WTP worldwide (see, Campbell *et al.*, 2014; Majumdar *et al.*, 2011; Krystallis & Chryssohoidis, 2005; Gil *et al.*, 2000; Boccaletti & Nardella 2000; Misra *et al.*, 1991), and hedonic pricing approach (Nouhoheflin *et al.*, 2004).

2.16 Summary and conclusion

Ecosystems provide valuable services which are categorized into four namely; provisioning services, supportive services, regulatory services, and cultural services. A wide range of ecosystem services and disservices confer benefits (for example, food, fibre, fresh air and water, fuel, spirituals among others) and costs (for example, reduce productivity or increase production costs among others) respectively to agriculture but are influenced by human activities. The flows of these services and dis-services directly depend on how agricultural ecosystems are managed and upon the functioning and composition of biodiversity of the remaining natural ecosystems in the landscape. However, a resilient ecosystem may be able to absorb the stresses caused by these disturbances with little or no sign of degradation.

Rain-fed and irrigation ecosystems landscapes have been transformed at an alarming rate with some wetlands ecosystems modified for agricultural intensification and land conversion. However, ecosystem-friendly farming practices such as agroforestry, afforestation, crop rotation, cover cropping, mulching, organic fertilization, minimum tillage, control burning and grazing can ensure sustainable supply of ecosystem services. Farmer adoption of these practices is driven by some basic determinants such as awareness, attitudes, barriers, and incentives. Adoption of ecosystem-friendly farming practices to provide sufficient supporting; provisioning, regulating, and cultural ecosystem services and fewer disservices will require research that is policy-relevant.

Adoption is a process that a farmer passes through from the awareness about the technology to the full stage of adoption. It is measured by estimating the rate of adoption, intensity of adoption, determinants of adoption, and factors influencing the willingness to accept payment for adoption. Adoption is influenced by various social, technical, economic, institutional, climatic and ecological factors. Where there are trade-offs that affect profitability, most farmers are lax to shoulder what they perceive as a private burden for the benefit of the public at large. Farmers generally believed they should be compensated to undertake practices that benefit the general public.

However, designing such a market for agricultural ecosystem services can be extremely difficult, even when external start-up funding is involved. Alternatively, government programs can offer payments, but with political limitations. Although funding payment for ecosystem service programs may be politically difficult farmers can be persuaded (For instance, tradable pollution permits) to adopt expensive practices that generate wider environmental benefits. Such programs potentially offer farmers a market-based incentive to adopt ecosystem-friendly farming practices in order to supply ecosystem services.

This study estimated the perception of famers about ecosystem-friendly farming practices in rain-fed and irrigated agricultural landscape. Factors influencing their adoption, how much they willing to accept before adoption as well as factors influencing their willingness to accept payment to adopt EFFPs were also estimated. However, Poisson regression model which is best suited is used to examine the factors that influence the adoption of EFFPs based on the assumption that there is no over-dispersion, and the Tobit model appropriates the analysis of factors influencing the amount willingness to accept before adopting these farming technologies. The adoption of environmental-friendly farming practices can also be made a qualification for farmers to gain access to desirable opportunities. Also, in the private sector, several large food companies have mandated certain management practices in the name of corporate social responsibility.

From the above, it is concluded that though a lot of studies have been conducted across the world on technology adoption, there is dearth of literature on the specific factors that influence the adoption of ecosystem-friendly farming practices, especially among smallholder farmers in Ghana. This is a serious gap that must be filled if the issue of low adoption of environmentally-friendly farming practices among farmers is to be addressed for sustainable agricultural productivity.

CHAPTER THREE

METHODOLOGY OF THE STUDY

3.0 Introduction

This chapter presents the methodology used to collect and analyse the data. This includes the conceptual and theoretical frameworks of the study, the description of study area, sampling and data collection, and variables used in the models as well as the methods of data analyses.

3.1 Research design

According to Creswell (2014), research design refers to the overall strategy that the researcher chooses to integrate the different components of the study in a coherent and logical way to effectively address the research problem. It constitutes the blueprint for the collecting data, measurement, and analysis of data. A research design or strategy identifies and describes the overall kind of study that will be done (see, Mouton, 2001; Creswell, 2014). Different research designs are best suited to answering certain types of questions (Mouton, 2001), and the decision of which design to use is usually guided by the research questions and the kind of information that the researcher requires (Hammond & Wellington, 2013; Wahyuni, 2012). Also, according to Polit *et al*. (2001), a research design refers to the "researcher's overall strategy for answering the research question(s) or testing the research hypothesis". Burns and Grove (2003) further defined research design as "a blueprint for conducting a study with maximum control over factors that may interfere with the validity of the findings". Brian (2012) also added that research design is the overall plan for connecting the conceptual research problems to the pertinent (and achievable) empirical research.

This study focuses on the farmers' perception, adoption decisions, and their willingness to accept payment to adopt ecosystem-friendly farming practices. The study employed non-experimental, qualitative (descriptive), quantitative and contextual approach. According to Polit *et al*. (2001), non-experimental research is used in studies for description and where it is unethical to manipulate the independent variable. Non-experimental research is suitable for the study of people in farming for several reasons. First, due to ethical considerations manipulation of the human variable is not acceptable because of the potential for physical or mental harm to the participants. Secondly, human characteristics are inherently not subject to experimental manipulation. Thirdly, research constraints such as time, personnel and the type of participants, make non-experimental research more feasible. Lastly, qualitative studies do not interfere with the natural behaviour of participants being studied; the type of research question would not be appropriate for an experimental research (Polit *et al*., 2001).

According to Burns and Grove (2003), a qualitative approach as "a systematic subjective approach used to describe life experiences and situations to give them meaning". But, Holloway and Wheeler (2002) refer to qualitative research as "a form of social enquiry that focuses on the way people interpret and make sense of their experience and the world in which they live". This study used the qualitative approach to explore the behaviour, perspectives, perception, experiences and feelings of farmers on adoption of ecosystem friendly farming practices. Also, according to Holloway and Wheeler (2002), complete objectivity is impossible and qualitative methodology is not completely precise because human beings do not always act logically or predictably. The researcher applies more than one research design at the same time in answering the research questions, and the study becomes what is known as mixed methods that integrates both qualitative and quantitative approaches (Creswell, 2014). The mixed methods are used as a deliberate effort to triangulate, and get a deeper understanding of the research topic (Hammond & Wellington, 2013).

The basis for using a qualitative approach in this study was to explore and describe the socioeconomic and demographic characteristics of the farmers, perception of farmers on ecosystem-friendly farming practices and among others. Also, the quantitative approach aimed at establishing the factors influencing the farmer adoption decision and the willingness to accept payment for adoption.

3.2 Study area

The study was conducted in three districts namely Kumbungu, Savelugu-Nanton and Tolon in the Northern Region of Ghana. The Northern Region has a total population of 2,479,461 (GSS, 2010), and lies between latitudes 8° and H10'N and has a land area of 97702 km². Northern Ghana's rainfall is characterized by a long dry period of about seven months from October/November to April/May called the Dry Season with no appreciable rainfall level, and a Rainy Season from May to October.

The Kumbungu District was carved out of the then Tolon/Kumbungu District with L. I. 2062 in 2011. The population of Kumbungu District, according to the 2010 population and housing census is 39,341 and about 95.4 percent of households are engaged in agriculture. It shares boundaries to the North with Mamprugu/Moagduri District, Tolon and North Gonja Districts to the west, Sagnerigu District to the South and Savelugu/Nanton Municipal to the East. The district has a total land area of 1,599sqkm being one of the smallest district in the Northern Region.

The Savelugu-Nanton District was carved out of the Western Dagomba District Council under the PNDC Law 207 in 1988. The population of Savelugu-Nanton District, according to the 2010 Population and Housing Census, is 139,283 representing 5.1 percent of the region's total population with about 94.3 percent of the households engaged in agriculture. The district is located at the Northern part of the Northern Region of Ghana. It shares boundaries with West Mamprusi to the North, Karaga to the East, Kumbungu to the West and Tamale Metropolitan Assembly to the South. The altitude of the district ranges between 400 and 800 feet above sea level. The district also has a total land area of about 2022.6 sq. km.

The Tolon District also came into existence in 2011 by LI. 2142 out from the then Tolon/Kumbungu District. The District was among the 42 inaugurated districts in 2012. The population of the Tolon District according to the 2010 Population and Housing Census is 72,990 representing about 2.9 percent of the region's total population with about 92.4 percent of the households engaged in agriculture. The district lies between latitudes 9° 15′` and 10°0 02` North and Longitudes 0° 53′and 1° 25′ West. It shares boundaries to the North with Kumbungu, North Gonja to the West, Central Gonja to the South, and Sagnarigu Districts to the East. The communities are mainly consisting of small holder farmers who among other smallholder farmers contribute greatly to Ghana's food security.

However, all the districts experience similar climatic conditions. The rainfall pattern is unimodal which begins in May and ends in the latter part of October. They experience some flood during the period. The rest of the year is dry. The average/mean annual rainfall is between 600mm – 1,200mm. The maximum temperature could rise to as high as 42^{0}C and minimum as low as 16^{0}C.

The study was conducted in selected irrigation sites namely; Bontanga, Golinga, and Libga. The construction of Bontanga Irrigation Scheme started in 1978 and completed in 1983. The project was funded by the Ghana Government. The project consists of an earthen dam that delivers water to the field by gravity and incorporated in the embankment are two (2) off-takes and a spillway, which is set to control the top water level in the reservoir. About 570ha of the total area is under irrigation (MoFA, 2013).

Figure 2: Map of Northern region showing the study area

Source: Northern Region, Ghana- Wikipedia, en.wikipedia.org.

The construction of Golinga Project was started in 1971 and completed in 1974 by the government of Ghana. The source of its water is the Kornin River. It has a potential area of about 100ha. The developed area covers about 40ha with the net irrigable area covering about 20ha. The main crops cultivated on the project are rice, okro, and onions (MoFA, 2013). The climate in the project area is the Guinea Savannah type.

The construction of the Libga project started in 1970 and completed in 1980. The project has a gross area of 20ha with all this area developed. The area under irrigation however is about 16ha. The major crops cultivated on the project are rice, cowpea and pepper. The project takes its source from the river Perusua. The climate is the Guinea Savannah type (MoFA, 2013).

3.3 Conceptual framework for the study

The farmer adoption of ecosystem-friendly farming practices is the main focus for which this research is conducted. Farmers make their own farming decisions in carrying out farming activities. These farmers are expected to face multi-faceted factors such as social, economic, institutional, ecological, and technical factors in the decision to adopt ecosystem-friendly farming practices. It is also expected that these farmers are affected differently in their quest to adopt ecosystem-friendly farming practices. Aryal *et al.* (2009), pointed out that farmers' willingness to adopt a given agricultural practice is a function of knowledge, attitude, resources and intention. Similarly, smallholder farmer is primary affected by social, economic, institutional, ecological, and technical factors (**Figure 3**).

Social factors such as sex, age, education, household size, and farming experience could have significant influence on the farmer's decision to adopt environmentally-friendly practices. Economic factors such as income level of the farmer, cost of inputs and technology, profitability of the technology, and general economic conditions of the country are perceived to influence the farmer adoption decision. Foster and Rosenzwerg (2010) pointed out that the key determinant of new technology and option is the net gains to the farmer from adoption, inclusive of all costs of using the new technology. Institutional factors such as farm location, social group, availability of farming information, access to extension services among others are perceived to significantly affect farmers' adoption decision. Mignouna et al. (2011), found out that farmer belonging to a social group enhances social capital allowing trust, idea and information exchange. Ecological factors include natural endowment, soil quality and on-farm operation (land tenure and farm size) that are perceived to influence the adoption EFFPs. Farmers' decision to adopt environmental management farming practices, according to Thomas *et al*. (2007), Ma *et al*. (2012), and Swinton *et al*. (2014) is determined by geographical location and environmental attitudes, and the amount of land they owned and other income-related factors that would compensate the costs of participation. The farmers' knowledge of the practices and compatibility of the practices to their environment are likely to be adopted. According to Wandji *et al*. (2012) farmers' knowledge and familiarity significantly facilitated its uptake. However, the successful adoption of ecosystem-friendly farming practices is expected to sustain the ecosystem, which will eventually leads to sustainable agricultural productivity over a period of time.

It is expected that, the sustained ecosystem and productivity will enhance the farmer livelihood activities and income at the macro level.

It is expected that farmers who adopt ecosystem-friendly farming practices will have a sustainable level of productivity/output than those who do not adopt the technologies. It is assumed that farmers who adopt the practices have positive attitude towards the environment and for that matter both present and future generations.

The concept of adoption is a behavioural choice at a particular time and space. This implies that some farmers may adopt despite being aware of the choices and some may not adopt despite being aware. However, farmers in the same geographical location are likely to adopt the ecosystem-friendly farming practices if they perceive their potential expected benefits (Swinton et al., 2015). The adoption literature shows that adoption of improved agricultural technologies is hypothesized to be affected by a host of social/demographic, economic, institutional, ecological/environmental, climatic, and technical factors (Feder *et al*., 1985; Kebede *et al*., 1990; Adesina & Baidu-Forson, 1995).

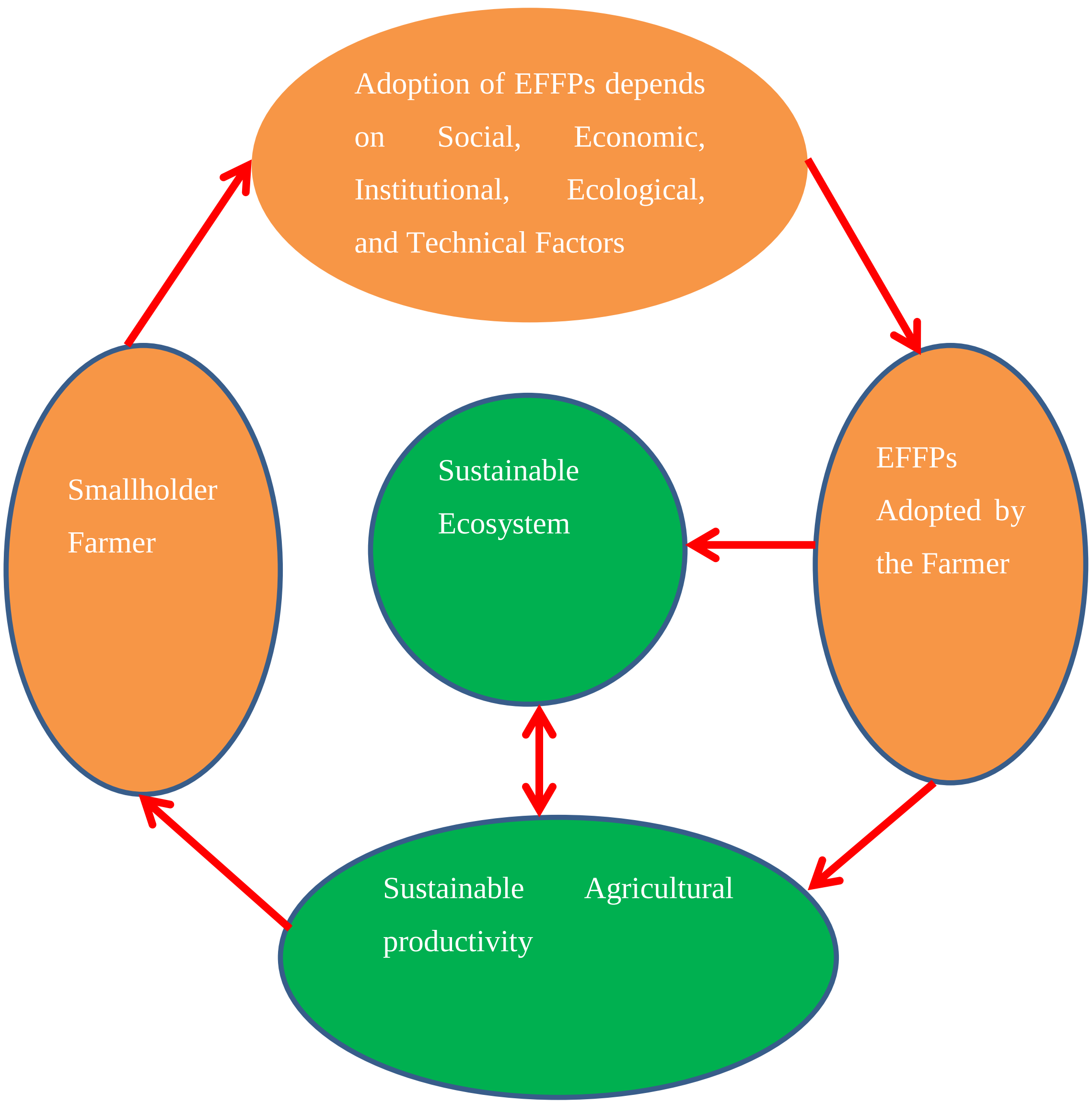

Figure 3: Conceptual framework for the study

Source: Researcher's conceptualisation, 2016.

3.4 Theoretical framework for the study

The adoption of improved practices/technologies has provided the basis for much research work on utility theory. Adoption theory suggests that the rate and intensity of adoption of a new technology is dependent upon characteristics of the new technology, the farmers' socio-economic characteristics and other factors including favorable agricultural policies (Rogers, 1983). This study is based on the theories of adoption and seeks to address the factors influencing their (farmers') choice of adoption, the effects of adoption among farmers, and the willingness to accept payment to adopt ecosystem-friendly farming practices.

Moreover, studies conducted by Feder *et al*. (1985) concluded that personal characteristics (age, family size, perception, experience); socio-economic characteristics (income, land tenure, farm size); demographic and institutional factors (credit, market, extension); environmental and climatic factors (pattern and amount of rainfall, soil type, topography, disease, pests); and technical factors (feasibility and availability of the technology) affect technology adoption. Therefore, a complete analytical framework for investigating adoption processes at the farm level should include models that address farmer's choice/decision and effects of adoption of new technology at each point throughout the adoption process. This study employed the Poisson regression and Tobit models to address this econometric issue. Similarly, earlier studies by Osgood (2000) and Slymen *et al*. (2006) used the Poisson regression to perform analysis on count data.

3.5 Source of data

Primary data used for the study were obtained from rain-fed and irrigated smallholder farmers in three districts namely Kumbungu, Savelugu-Nanton and Tolon in the Northern Region of Ghana. Information relating to farmers' socio-economic characteristics such as sex, age, educational level, marital status, household size, ethnic affiliation, major occupation, farming experience, farm size, cost of production, extension access and contact, belonging to farmer based organisation, and average income, among others were taken. These enabled the researcher examine the factors that influence farmer adoption of ecosystem-friendly farming practices. The data included the farmer level of awareness and acceptance to adopt ecosystem-friendly farming practices as well as the amount they were willing to be paid for adopting these practices. This helped determined factors that influence the willingness to accept payment.

3.6 Study population

The Kumbungu, Savelugu-Nanton, and Tolon Districts in the Northern Region were selected for the study due to their engagement in both irrigation and rain-fed agriculture (MoFA, 2013). Also, the districts are well-known for irrigating both crops and vegetables given their irrigation facilities such as Bontanga, Libga, and Golinga Irrigation Schemes. The target population for this study is farming households who engage in rain-fed and irrigation farming activities. However, a household for the purpose of this study is defined as a group of people living and eating from the same pot. About 80 percent of these farm households are engaged in agricultural production (GSS, 2010).

The adoption of improved farming technologies in Ghana, especially Northern Region is influenced by farmer's decisions making process. These decisions are based on socio-economic characteristics, technological factors, and environmental factors (Kassali *et al.*, 2010). Both male and female farmers are affected by these decision making process in carrying out their farming activity. Based on the above, the population for the field survey for this study targeted both male and female farmers.

3.7 Sampling techniques and sample size

The sample is a subset of the population selected for the research to represent the entire population. It is often impractical or impossible to cover the entire population considering time and resource. According to 2010 population and housing census Northern Region recorded a total population of 2,479,461 with Kumbungu, Savelugu-Nanton, and Tolon Districts recording a total population of 39,341; 139,283; and 72,990 respectively. The sample for study was drawn from the total population of 251,614 people. Hence multi-stage sampling technique was used to sample 300 respondents for the study. Specifically, a three-stage sampling technique was employed. The first stage involved purposive sampling of some major districts with irrigation facilities (Kumbungu, Savelugu-Nanton, and Tolon Districts). Then second stage employed simple random sampling technique to select ten (10) communities located around selected irrigation sites (Bontanga, Golinga, and Libga), and thirdly used accidental sampling procedure to select households.

A sample of 150 male farmers and 150 female farmers was selected from the population of the smallholder rain-fed and irrigated farmers in the districts. In Kumbungu District, communities such as Wuba, Kpalsogu, Vogg Kpalsogu, Kushibu, and Vogg Kushibu were selected. In Savelugu-Nanton District, communities such as Libga and Nyoglo were selected. Finally, in Tolon District, communities such as Golinga, Gbelahagu, and Galkpegu were selected. The researcher used accidental sampling procedure to select households from the ten (10) farming communities. This is due to scattered and unorganized nature of most houses in the communities. However, the enumerators made sure they randomly interviewed equal numbers of households (that is, 30) from each community totaling three hundred (300) households from three districts. This procedure was adopted to take into account the differences in adoption of ecosystem-friendly farming practice and their willingness to accept payment to adopt such practices across the two smallholder farms (rain-fed and irrigation) in the study area.

The **Table 1** below shows the composition of sample size sampled from each community within the three districts in the Northern Region of Ghana.

Table 1: Distribution of sampled respondents in the communities in three districts

District	Community	Irrigation facility	Number of respondents	
			Males	Females
Kumbungu	**Wuba**	**Bontanga**	**15**	**15**
	Kpalsogu	**Irrigation scheme**	**15**	**15**
	Vogg		**15**	**15**
	Kpalsogu		**15**	**15**
	Kushibu		**15**	**15**
	Vogg			
	Kushibu			
Savelugu-Nanton	**Libga**	**Libga**	**15**	**15**
	Noglo	**Irrigation scheme**	**15**	**15**
Tolon	**Golinga**	**Golinga**	**15**	**15**
	Gbelihagu	**Irrigation scheme**	**15**	**15**
	Galkpegu		**15**	**15**
Total			**300**	

Source: Field Survey, 2016.

3.8 Method of data collection

Data for the study were collected from a cross-section of farmers (irrigated and rain-fed) using semi-structured questionnaires. Focus group discussions were also carried out to complement the quantitative analysis that would carried out. A total of three hundred (300) personal interviews were conducted in January/February, 2016 by a team of well-trained enumerators including the researcher. The questionnaire contained both open and close ended questions to collect complete data required for the study. The questionnaire administration was done by randomly interviewing individual farm household heads through face-to-face contact. This is to ensure that enough, accurate, and needed information is captured to address the research objectives. This also increased the researcher's level of knowledge and experience with the data, interpersonal relationship with farmers and conversant with both qualitative and quantitative data since researcher was involved in both pre-test and main data collection team.

The farmers completed short questionnaires about their socioeconomic and demographic characteristics, farms, current farming practices, and their attitudes toward conservation. Farmers were asked about their views of these practices to reveal what it would cost them to adopt ecosystem-friendly farming practices. We used hypothetical questions to gather both qualitative and quantitative data on how farmers view various ecosystem-friendly farming practices and how much they are willing to accept payment in order to adopt them.

The focus group conducted with the participants using a discussion guide with semi-structured questions. Also, during the discussions farmers were asked grand/broad tour questions such as what is your understanding about the environment/ecosystem and the services it provides as well as mini/specific tour questions such as list the type of farming practices you commonly engaged to elicit information from participants. The interview techniques of probing using verbal and non- verbal communication were employed. For instance, phrases such as "Could you elaborate more on that point?" maintained eye contact to encourage farmers to continue speaking. During the interview and discussions, notes were taken by a non-participant. The rationale for carrying out the focus group discussions was to; obtain different and common or holistic views and perspectives of farmers on the ecosystem-friendly farming practices, clarify unclear questions during the questionnaire administration, and prevent researcher bias and without preconceived ideas.

3.9 Survey/research instrument

According to Holloway and Wheeler (2002), survey/research instrument is a tool developed by the researcher to collect data on or from participants in the context of the research problem. This approach allowed greater latitude in providing answers. Data were collected by means of cross-sectional survey using questionnaire and focus group discussions with some selected farmers. The questionnaire administration was done by incidentally or randomly interviewing individual farm household heads through face-to-face contact.

The rationale for carrying out the focus group discussions was to obtain different and common or holistic views; the study employed both questionnaire administration and focus group discussions. Also, to clarify unclear questions during the questionnaire administration because dialogue was used, observe non-verbal communication, and prevent researcher bias and without preconceived ideas. According to Polit *et al.* (2001), a focus group discussion allows the elicitation of research participants' own experience and flexibility in the collection of data. In this study, the participants (farmers) were also guided by a survey questionnaire to collect data on farmers' adoption of ecosystem-friendly farming practices through field survey conducted in January/February, 2016.

3.9.1 Structure of the instrument

The survey guide (questionnaire) used for this study comprised of two sections (qualitative and quantitative). The questionnaire was further divided into seven parts. Part I consists of identification of enumerator, district, community, and the farmer. Part II elicited information on socio-demographic data of the farmer. The sex, age, educational level, marital status, household size, income level, main economic occupation, among other important variables that influence the adoption decision and the amount they are willingness to accept as payment to adopt ecosystem-friendly farming practices were considered. Part III of the questionnaire contained questions on farmer and farm characteristics. These included production system, farming experience, belong to farmer base organizations and groups, extension access and contact, access to market, access to credit, access to land and land size, crop cultivated, and livestock and poultry production. These variables influence the adoption decision and willingness to accept payment for adoption of ecosystem-friendly farming practices. Part IV captured data on farmer perception about ecosystem, ecosystem services and disservices. Part V asked questions on farmer adoption decisions of ecosystem-friendly farming practices (EFFPs) whereas Part VI elicited factors influencing farmers willingness to accept payment for adoption of ecosystem-friendly farming practices. Finally, Part VII elicited the challenges or constraints farmers faced in adopting ecosystem-friendly farming practices (EFFPs). However, the final version of the survey questionnaire is provided at the **Appendix I**.

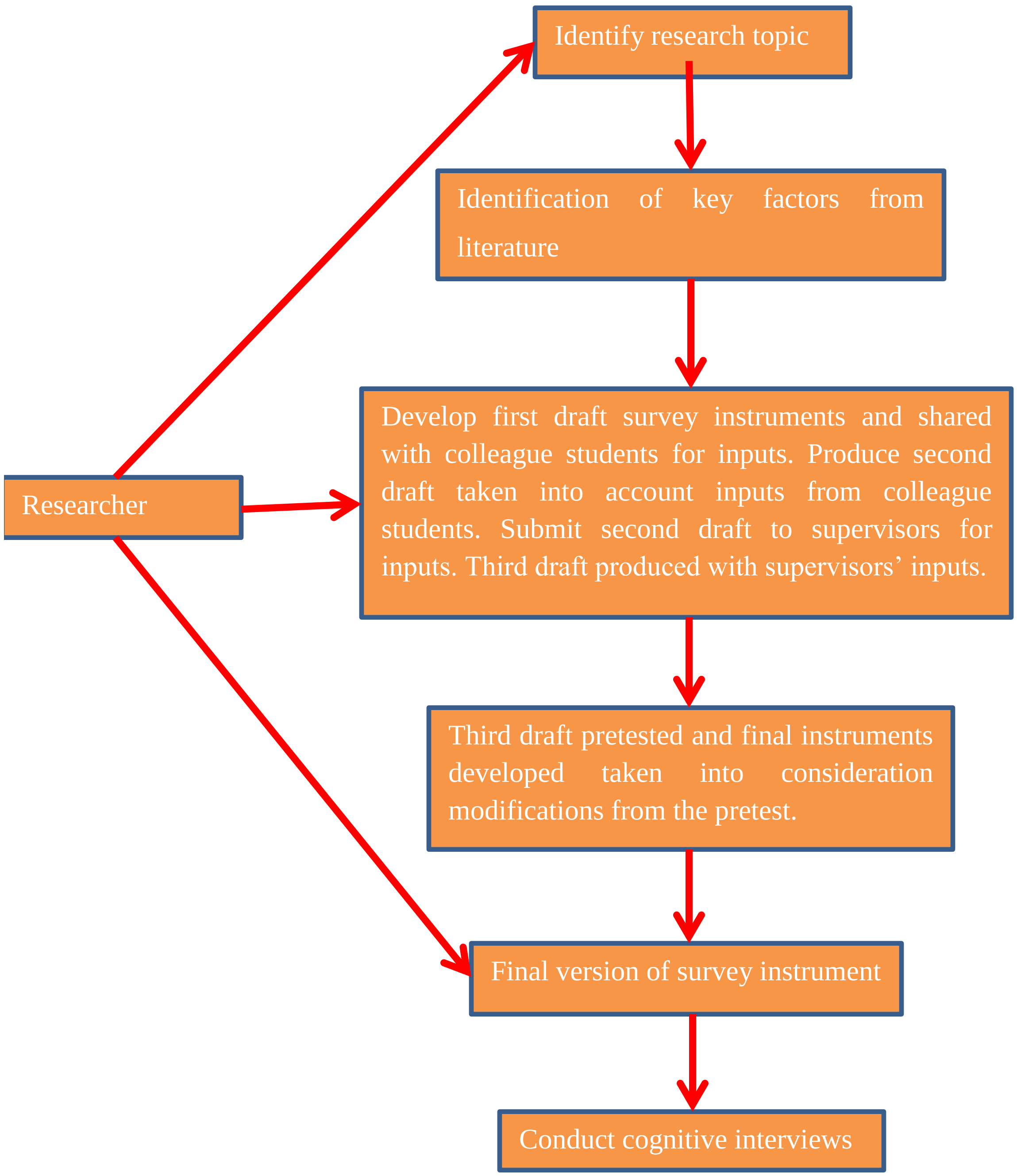

Figure 4: Methodology used to develop the survey/research instrument

Source: Author's Design, 2016.

3.10 Pilot survey

A pilot survey is a strategy used to test the questionnaire using a smaller sample compared to the planned sample size. In other words, it is a preliminary survey used to gather information prior to conducting a survey on a larger scale. It helps determine the time for the questionnaire while also helping researchers smooth out difficulties before administering the main survey. According to Holloway and Wheeler (2002), pilot surveys are not usually used in qualitative studies but new researchers could conduct interviews as a pre-exercise, to get used to the type of data collection.

Following this, a pilot survey was conducted at Golinga in the Tolon District of Northern Region with twenty participants who were both rain-fed and irrigated farmers by three enumerators including the researcher. This pre-exercise was done to orientate the researcher and the enumerators to the research questionnaire and provide them insight into the phenomenon and degree of respondents' understanding of the questions. This is also to ensure that errors can be rectified at little cost before the actual survey on the entire sample is carried out to address the research objectives. The responds were filled or recorded into the questionnaires. During the exercise attention was also given to the time taken to complete a questionnaire as well as the manner of asking questions. This enhanced the researcher's level of confidence, experience, interpersonal skills, and conversant with both qualitative and quantitative data since researcher was part of the pre-test and main data collection team.

3.11 Method of data analysis

Data were analyzed using Stata, Statistical Package for Social Sciences (SPSS) and Excel softwares. Stata was used to estimate the factors influencing the choice of adopting, effects of adoption, and willingness to accept payment to adopt and use ecosystem-friendly farming practices. Necessary checks and test such as the Variance Inflation Factor (VIF) and Breusch-Pagan/Cook-Weisberg test were carried out to check for the presence of multicollinearity and heteroskedasticity among the regressors before running the models and both proved to be absent. Statistical Package for Social Sciences (SPSS) and Excel were also used for qualitative data analysis (descriptive analysis). The results were presented in tables and graphs.

Specifically, several methods and approaches of data analysis were employed in this study to achieve the research objectives. First, the Kendall's Coefficient of Concordance (*W*) analysis was used to analyze farmers' perceptions about ecosystem-friendly farming practices from the most important to the least important, and then measures the degree of agreement/concordance between the respondents. Secondly, the Poison regression model was employed to determine the factors influencing the choice of adopting ecosystem friendly practices. Thirdly, the contingent valuation method using mean willingness to accept (WTA) was employed to compute how much farmers are willing to be paid. Finally, Tobit regression model was employed to estimate factors influencing their willingness to accept payment to adopt and use ecosystem-friendly farming practices.

3.11.1 The Concept of Kendall's Coefficient of Concordance (*W*)

The Kendall's Coefficient of Concordance (*W*) analysis as a statistical procedure was used to rank farmers' perceptions about ecosystem-friendly farming practices from the most important to the least important, and then measures the degree of agreement/concordance among the respondents. The formula for the coefficient of concordance (*W*) is given as:

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

Where;

W = index that measures the ratio of the observed variance of the sum of ranks and the maximum possible variance of the sum of ranks.

T= sum of ranks for the factors being ranked

m = number of respondents; and

n = number of factors being ranked

The maximum variance (T) is given by:

$$T = m^2(n^2-1)/12 \quad (2)$$

$$varT = [\sum T^2 - (\sum T)^2/n] \quad (3)$$

Where the variables are as defined above.

The idea behind this index is to find the sum of ranks given to each item (in this case farming practice) being ranked by respondents and then examine the variability of this sum. If the rankings are in perfect agreement, the variability among these sums will be a maximum.

The ecosystem-friendly farming practices were ranked according to the most important to the least important using numerals 1, 2,3, 4,.........*n* , in that order. The least score rank is the most important while the one with the highest score is ranked as the least important. The total rank score computed is then used to calculate for the Coefficient of

Concordance (W) to measure the degree of agreement in the rankings. The limits for W do not exceed 1.00 and cannot be negative. Thus, it can only be positive in sign and ranges from 0 to 1. It will be 1.00 when the ranks assigned by each respondent are the same as those assigned by other respondents and it will be 0.00 when there is a maximum disagreement among the respondents.

Farmers were asked to rank in order of importance. Ecosystem friendly practices were assigned numbers ranging, 1 to the most important and 7 to the least important. The Ecosystem-friendly farming practices are as follows: agroforestry, sustainable soil and water management, crop rotation and cover cropping, afforestation, organic farming, controlled bush burning, and controlled grazing.

The Coefficient of Concordance (W) may then be tested for significance in terms of the F distribution as follows:

$$F - ratio(F_c) = (m-1) \times W/1 - W \tag{4}$$

$$df\ for\ numerator = (n-1) - (2/m)$$

$$df\ for\ denominator = (m-1)[(n-1) - (2/m)]$$

3.11.2 The Poisson regression model

3.11.2.1 Theoretical model

The Poisson regression model according to Greene (1997) is given as:

$$P_r(Y = y) = \frac{e^{-\lambda}\lambda^y}{y_!}, \quad y = 0,1,2, \dots \dots \dots n \tag{5}$$

The parameter λ is assumed to be log-linearly related to regressors X_i. Hence,

$$ln(\lambda) = \beta' x_i \tag{6}$$

The log-likelihood function is specified as follows:

$$lnL = \Sigma_{i=1,2,\ldots n}[-\lambda_i + y_i\beta' x_i - lny_i!] \tag{7}$$

The expected number of ecosystem friendly practices per farm is given as:

$$E[y_i|x_i] = var[y_i|x_i] = exp(x_i\beta' + \mu_1) \tag{8}$$

Where,

β = 1 × k vector of parameters;

x = k × 1 vector with the values of k independent variables in the i^{th} observation

n = number of observations.

The equation can also be expressed as:

$$E(Y_i) = exp^{(\beta_i x_{1i})} exp^{(\beta_i x_{2i})}, \ldots \ldots \ldots exp^{(\beta_k x_{ki})} = exp(\beta_i x_{jn})C_i \qquad (i = 1,2,3, \ldots n) \tag{9}$$

Where, *j* can take any value from *1* to *k* and distinguishes a specific explanatory variable and C_i is a constant representing the product of the remaining exponential terms in Equation (4). For dichotomous explanatory variables, if $x_{ji} = 0, \quad E(Y_i) = C_i$, and when $x_{ji} = 1, \quad E(Y_i) = \beta_j C_i$

Therefore, $100 \times (exp^{\beta_j} - 1)$ calculates the percentage change on $E(Y)$ when x_j goes from zero to one, for all observations (i). In general, for independent variables that take several integer values, the percentage change in the expected level of adoption when x_j goes from x_{j1} to x_{j2} can be calculated as:

$$\frac{exp^{\beta_j x_{j2}} - exp^{\beta_j x_{j1}}}{exp^{\beta_j x_{j1}}} \times 100 \qquad (10)$$

3.12.2.2 Empirical model for estimating Poisson

The empirical model was estimated using characteristics reasonably assumed to influence farmer decision to adopt. The covariates include personal and household characteristics, farm and cropping characteristics, socio-economic and institutional variables, and attitudinal variables.

The empirical model for adoption is specified below:

$$logy = (\beta_0 + \beta_1 Sex + \beta_2 Age + \beta_3 Edulevel + \beta_4 HHsize + \beta_5 OffFarmincome + \beta_6 ProdSystem + \beta_7 BlgFBO + \beta_8 ExtAccess + \beta_9 CreditAccess + \beta_{10} Tincome + \beta_{11} MktAccess + \beta_{12} FarmerKnowledge + \beta_{13} ContractParticipt + \beta_{14} FarmerBenefits + \varepsilon_1) \qquad (11)$$

Where; y ranges from zero (0) to six (6) ecosystem-friendly farming practices.

3.11.3 Empirical model for estimating mean Willingness to Accept (WTA) payment

The dichotomous choice of Willingness to Accept Payment (WTA) approach is not directly observed yet assumptions about its distribution can be made which makes the estimations of the parameters of the distribution possible. According to Lusk and Hudson

(2004), the average WTA of a population can be estimated from a survey in monetary terms.

$$Mean\,WTA = \frac{\sum_{i=1}^{n} WTA}{n} \qquad (12)$$

where; *n* is the number of respondents.

3.11.4 Contingent valuation method

Contingent valuation methods (CVM) measure the amount of compensation paid (WTP) or received (WTA) that will restore the initial utility level of an individual who experiences an increment or decrement in the level of Utility. As indifference curves are not ordinarily observable, estimating these methods usually make the researcher design situations where survey respondents reveal relevant points on their indifference curves. The researcher creates hypothetical or experimental markets and the values recorded in these markets are treated as contingent values (Morey, 2015).

The main potential advantage of the CVM with respect to Revealed Preference valuation techniques, is its ability to provide estimates of both use and non-use values. One other advantage of the CVM is that, it establishes the value of many non-market benefits (Pearce & Turner, 1990), in particular the non-use values of environmental goods, which can be very significant. In fact, whilst Revealed Preference valuation techniques measures only the environmental services' use value which can be inferred by looking at other related marketed goods, CVM is potentially capable of determining the values derived from environmental attributes, which are not revealed by observable market behaviour (Mendelsohn & Olmstead, 2009). This is the main reason why the CVM is the technique adopted for this study.

The objective of estimating the econometric model in a CVM survey is to calculate the mean willingness to accept (WTA) payment in order to adopt ecosystem-friendly farming practices. This helps to increase the confidence in applying the results obtained from the CV empirical analyses and also estimate the determinants of respondents' willingness to accept a payment before adopting ecosystem friendly farming practices, which maintain ecosystem integrity and sustain agricultural productivity. Hence, the Tobit model was used to reach this goal.

3.11.4.1 The theory of discrete choice model

The discrete choice model has become the most common method for determining whether people are willing to pay or accept payment (compensation) for a non-market good. Since in this study the CVM responses are binary variables, a statistical model appropriate for a discrete dependent variable is required. In fact, when a household is confronted with a question to accept or reject an intervention that brings an environmental improvement from Z_0 to Z_1, hence the need to ask farmers about their WTA to obtain the proposed change. However, the "yes" or "no" responses obtained only provide qualitative information about WTA (Saz-Salazar *et al*., 2009). Therefore, in order to obtain a measure of farmer WTA we need a statistical model that relates the responses of the respondents to a monetary amount. Following Johansson (1993), an individual maximizes his utility subject to budget constraint. Then, the individual's indirect utility function can thus be written as:

$$V = \cup\ [x(p,y,z)z] = V(p,y,z) \tag{13}$$

where, x is an "n" vector of farmer's usual farm practices (private benefits) and z is a "m" vector ecosystem sustainability (public benefits). The quantity demanded for private benefits is a function of prices (p), income (y) and the provision or quality of environmental commodities (z). The indirect utility function is decreasing in prices, and increasing in income and the quality of the environment. Let us now introduce a change in the environmental quality. Then the change in utility is:

$$V = V(p, y, z^1) - V(p, y, z^0) \tag{14}$$

Where a superscript 0 and 1 denote initial and final levels values respectively for the ecosystem sustainability (public benefits). Since the utility function is not observable, we need a money measure to evaluate the change in utility. In this study, the individual farmer who produces crops and animals experiences an increase in his/her utility or well-being but at different consequence resulting from the use of environment. If the environmental quality deteriorates, then CV is the minimum amount of money that must be given to the farmer to compensate him/her to restore the loss of environmental quality. Therefore, we considered compensating variation (CV). Thus, CV measures the amount of money that farmers are willing to accept as compensation for undertaken ecosystem conservation:

$$V(p, y + CV, z^0) = V(p, y, z^1) \tag{15}$$

Now, following Hanemann (1984), if we assume that the utility function has some components which are latent to the researcher and are treated as stochastic, then the individual's utility function can be written as:

$$V(y, s, z) = \cup (y, s, z) + \varepsilon \tag{16}$$

where y is the farmer's income, s is a vector of his socio-economic characteristics, z is the quality of the environment and ε is a random disturbance term with an expected value of zero. When offered an amount of money A for a change in z ($z_0 \rightarrow z_1$), the individual will accept the offer if:

$$\cup\,(y + A, s, z_1) + \varepsilon_1 \geq \cup\,(y, s, z_0) + \varepsilon_0 \qquad (17)$$

Where, ε_0 and ε_1 are identically and independently distributed random variables with zero means and constant variance.

3.11.4.2 The Tobit model

The persistent setback linked with the use of open-ended questions in contingent valuation studies is that some respondents often state a zero WTA for an environmental improvement under analysis. Hence, no body states a negative WTA value, and majority of the responses are clustered around the zero value. The standard ordinary least-square regressions often ignore the censoring implied by zero values. The inability to recognize and address explicitly the censored or truncated distribution of bids in open-ended contingent valuation surveys results in biased and inconsistent estimates of the parameters (Maddala, 1983; Halstead *et al*., 1991). According to Greene (2003), this model is also known as censored normal regression model and assumes that many variables have a lower or upper limit called threshold value which takes on this limiting value for a considerable number of respondents. The remaining sample respondents' variable takes on a wide range of values above the limit. The explanatory variables in the model may influence both the probability of limit responses and the size of non-limit. The two parts agree to the classical regression for the non-limit (continuous) observations and the relevant probabilities for the limit (zero) observations, respectively. The Tobit model starts by defining a latent variable that is incompletely observed. Consider the decision of households to receive a payment for improved soil and environmental quality.

The theory states that the consumer makes marginal-benefit and marginal-cost analysis based on the satisfactions he/she received by paying for the improved supply (Mendelsohn & Olmstead, 2009). The analysis of open-ended bids has usually been addressed using standard ordinary least-square regressions ignore the censoring implied by zero values. Based on the above behavior of the model, the most appropriate method or way to addressing this challenge is the Tobit model (Tobin, 1958) that recognizes that WTA values are censored at zero.

3.11.4.3 Theoretical model of Tobit

The censored Tobit model is expressed in the form:

$$WTA_i^* = \beta x_i + \varepsilon_i \tag{18}$$

where WTA_i^* is an unobserved continuous dependent variable (income), x_i is a vector of exogenous variables, β is the associated vector of parameters and ε_i represent the error, independently and normally distributed with mean zero and constant variance σ^2, so the observed variable WTA takes the form:

$$WTA_i = WTA_i^* \; if \; WTA^* > 0 \; and \; WTA_i = 0 \; if \; WTA^* \leq 0 \tag{19}$$

This is censored at zero because all negative values of WTA_i^* are observed at zero. The estimation of the Tobit model was done according to the two methods described as follows. The maximum likelihood method relating to estimating farmers' willingness to accept before adopting ecosystem friendly farming practices and the determinants of WTA. The extent to which these factors affect farmers' willingness to accept payment before adopting ecosystem friendly farming practices is also determined. Therefore, applying the Tobit model with maximum likelihood method, gives estimators which are unbiased and consistent (Greene, 2003). Considering the above, a Tobit model was employed to determine the factors affecting farmers' willingness to accept payment to adopt ecosystem-friendly farming practices among smallholder farmers in Northern Region of Ghana.

3.11.4.4 Empirical model for estimating WTA

Following the theoretical model above, the empirical model for estimating the determinants of farmers' willingness to accept (WTA) payment for adoption of ecosystem-friendly farming practices among smallholder farmers in Northern Region of Ghana is indicated below. Assuming that censoring point is zero, then:

$$WTA = \beta_0 + \beta_1 Sex + \beta_2 Age + \beta_3 Maristat + \beta_4 Edulevel + \beta_5 HHsize + \beta_6 Prodsystem + \beta_7 BlgFBO + \beta_8 ExtAccess + \beta_9 ExtContact + \beta_{10} ProdCost + \varepsilon_1 \quad (20)$$

Where; WTA is the dependent variable indicating willingness amount to accept to adopt a given practice and β_0 to β_{10} be the parameters to be estimated. We also have the following independent variables chosen based on the literature. Thus we have sex (Sex) of the farmers, whether the farm owner is a woman or a man; age (Age) of the farmer, which is the age of the respondent or household head; marital status (Maristat) of the farmer, whether the farmer married or not married; Education level (Edulevel) which is equal to years of schooling; the household size (HHsize), which is the number of people eating from same pot; the production system (Prodsystem), whether the farmer is engaged in rain-fed and irrigated farmer; farmer belonging to a farmer based organization (BlgFBO); access to extension services (ExtAccess), that is extension services available to the farmer; extension contact (ExtContact), that is the number of times the farmer receives extension services and production cost (ProdCost), that is the cost the farmer incurs in production. ε_1 is stochastic/error term accounting for unexplained variations in the response variable and it is assumed to be normally distributed.

3.12 Statement of research hypothesis

Below are hypotheses tested to ascertain adequacy of the functional form adopted for the data analysis. Four hypotheses are tested following the objectives of this study. This will determine whether farmers perceived ecosystem-friendly farming practices or not and whether there are significant difference in farmers cost of production, average income, and the level of adoption or not. This will also determine whether or not farmers' socio-economic characteristics significantly influence the adoption and willingness to accept payment before adoption of ecosystem-friendly farming practices. The hypotheses are specified as below:

Table 2: Hypothesis tested and their descriptions

Hypothesis	Description
$H_0: \gamma = 0$	There are no differences in farmers' perception on ecosystem-friendly farming practices.
$H_1: \gamma \neq 0$	There are differences in farmers' perception on ecosystem-friendly farming practices
$H_0: \beta_{ij} = 0$	Farmer characteristics do not significantly influence the adoption of ecosystem-friendly farming practices.
$H_1: \beta_{ij} \neq 0$	Farmer characteristics significantly influence the adoption of ecosystem-friendly farming practices.
$H_0: \delta = 0$	There are no difference in the amount farmers will accept as payment to adopt ecosystem-friendly farming practices
$H_0: \delta \neq 0$	There are differences in the amount farmers will accept as payment to adopt ecosystem-friendly farming practices.
$H_0: \beta_{ij} = 0$	Farmer characteristics do not significantly influence willingness to accept payment.
$H_1: \beta_{ij} \neq 0$	Farmer characteristics significantly influence willingness to accept payment.

Source: Author's Design, 2016

3.13 Statistical testing technique for the hypotheses

The Generalized Likelihood Ratio Statistic (LR) was used to test the hypotheses. It is given as

$$LR = -2[ln\{L(H_0)\} - ln\{L(H_1)\}] \tag{21}$$

Where $L(H_0)$ and $L(H_1)$ are values of likelihood function under the null (H_0) and alternative (H_1) hypotheses (restricted and unrestricted models), respectively. LR has approximately a Chi-square (or mixed Chi-square) distribution if the given null hypothesis is true with degrees of freedom equal to the numbers of estimated parameters assumed to be zero for (H_0). ln is the natural logarithm of null hypothesis and alternative hypothesis.

3.14 Description of variables and a priori expectations

Below are discussions of variables determining the adoption of ecosystem-friendly farming practices? Also, these variables influence the amount farmers are willing to accept as payment before adopting those practices in the Northern Region of Ghana and their a priori expectations.

Sex: This variable was captured as the biological make-up of the respondent. During the data collection, respondents were asked to state their sex status (that is, whether male or female). This variable was dummied in the model as 0 if respondent is a female and 1 if respondent is a male. Male farmers are assumed to be more willing to adopt than their female counterparts. Men and women play different roles in technology adoption and that adoption decisions depend primarily on access to resources such as land, labor, and capital (Bonabana-Wabbi, 2002). Men tend to have better access to these resources than women. The males having ownership of the productive farm lands and resource-rich than females are more likely to adopt practices that will sustain them.

Age: This is a continuous variable and it was captured in the empirical model as the number of years of respondents. It was included in the model to know its influence on

EFFPs adoption since different age groups have different levels and willingness to adopt technology (Mignouna *et al*., 2011; Kariyasa & Dewi, 2011). Based on the above, this study hypothesizes that age will either have a positive or negative influence on EFFPs adoption. Older farmers are assumed to have gained knowledge and experience over time and are better able to evaluate technology information than younger farmers.

Educational level**:** This variable was hypothesized to determining the farmer decision to adopt EFFPs and was measured by the level of formal education. It was assumed that education affects the level of information and knowledge farmers have about ecosystem-friendly farming practices. Educational level of a farmer increases his ability to obtain process and use information relevant to adoption of a new technology (*Mignouna et al*., 2011; Lavison, 2013; Namara *et al*., 2013). Following this, educational level of respondents is hypothesized to have positive influence on the adoption of ecosystem-friendly farming practices and that farmers who obtained higher education are assumed to be willing to engage more in farming practices that will sustain the environment.

Marital status: This variable was dummied to indicate whether the respondent is married or otherwise. It was captured in the model as 1 if the respondent is married and 0 if otherwise. This study hypothesizes that marital status will either have a positive or negative influence on EFFPs adoption.

Household size**:** This is a continuous variable and defined as the number of people eating from same pot. It was hypothesized to have direct relationship with adoption of EFFPs. Larger households have higher labor force to carry out environmental sustainable practices than smaller ones since adoption of EFFPs are more tedious and expensive than usual practices. Therefore, it was postulated that, households with more members will be more willing to adopt more than smaller households.

Off-farm income: This was captured in the model as a continuous variable and measured as the amount of money obtained outside the farm. It postulated to have a positive impact on technology adoption. This is because off-farm income will be used to hire labor in order to carry out EFFPs and overcome credit challenges faced by the rural households. Off-farm income is reported to act as a substitute for borrowed capital in rural economies where credit markets are either missing or dysfunctional (Ellis & Freeman, 2004; Diiro, 2013). Based on this, it is assumed that households with higher off-farm income are more likely to adopt EFFPs than lower income earners.

Production system: This is the kind of farming activity (whether irrigator or rain-fed) the farmer engages. It was used as a dummy variable in the model in which irrigation was set as a benchmark. This study hypothesizes that production system will either have a positive or negative influence on EFFPs adoption.

Membership of FBOs: This is captured in the model as to whether the respondent belongs to any social group. This variable was dummied in the model as 1 if respondent belongs to FBO and 0 if otherwise. The study presumed that, this variable will have positive relationship with adoption of ecosystem-friendly farming practices. Belonging to a social group enhances social capital allowing trust, idea and information exchange (Mignouna *et al*., 2011). Thus, farmers who belong to FBO are exposed to agricultural information/practices and will be more willing to adopt appropriately.

Extension services: This was captured in the model as a dummy variable, indicating the accessibility of respondent to formal extension services or not. This study hypothesizes a positive relationship between extension services and technology (EFFPs) adoption. A good example includes studies done by Akudugu *et al.* (2012), reported a positive influence of extension services on the adoption of modern agricultural technologies in Ghana. Thus, it is assumed that farmer frequent access to extension services is likely to adopt more EFFPs than their counterparts without extension access since farmers are usually informed about the existence as well as the effective use and benefit of new technology through extension agents.

Access to credit: This variable was dummied to indicate whether the respondent have access to credit or not. It was captured in the model as 1 if the respondent obtains credit and 0 if otherwise. The study presumed that, this variable will have positive relationship with adoption of ecosystem-friendly farming practices.

Total income: It was captured as a continuous variable in the model. It is presumed that, farmers' adoption of ecosystem-friendly farming practices increases with household income level since adoption of some of the practices involves cost. According to Diiro (2013) total household income is expected to provide farmers with liquid capital for purchasing productivity enhancing inputs practices. As a result, income level is postulated to have positive or direct effect on adoption of ecosystem-friendly farming practices.

Access to market: This variable was described as the accessibility of respondent to profital markets. It was captured as dummied (1 = respondent access profitable markets, 0

= otherwise). The study presumed that, this variable will have positive relationship with adoption of ecosystem-friendly farming practices. Thus, farmers who have access to markets will be more likely to adoption of ecosystem-friendly farming practices.

Farmer knowledge: Farmer knowledge is used to measure how long farmers have been involved in agricultural production activities or engage in the practices. In other words, number of years of decisions making in farming. This continuous variable has an uncertain impact on the adoption of EFFPs. Greater experience can lead to better knowledge of farming operations and learn by doing in the field (Khanna, 2001). As a result, the level of knowledge of farmer on the technologies is postulated to have positive influence on adoption of ecosystem-friendly farming practices since higher knowledge and experience means higher adoption.

Contract participation: This variable was described as the respondent's willingness to participate contract farming. This variable was dummied in the model as 1 if respondent is willing to participate in contract farming and 0 if respondent is not willing to participate in contract farming. It was hypothesized to have direct and indirect relationship with adoption of EFFPs. It was expected that as the willingness to participate in contract farming in a household increases, adoption of EFFPs increases and vice versa.

Farmer benefits: This was captured as the net gains accruing to the farmer from adoption. That is, whether the farmer consider the net gain of technology before adopting. It was dummied in the model as 1 if respondent is considers the benefits of adoption and 0 if respondent does not considers the benefits before adoption. It was postulated to have positive influence on adoption of ecosystem-friendly farming practices since the cost of adopting agricultural technology is a constraint to technology adoption. Key determinant of the adoption of a new technology is the net gain to the farmer from adoption, inclusive of all costs of using the new technology (Foster & Rosenzweig, 2010). Based on the above, as the expected benefits is higher, the rate of adoption is likely to increase.

Cost of production: Amount farmers spend on crop production at the end of the season was captured as a continuous variable in the model. It is presumed that, farmers' adoption of EFFPs decreases with higher cost of production since the cost of production is a challenge to technology adoption. Hence, the expected sign of the coefficient of this variable is negative.

3.15 Summary and conclusion

Different strategies were adopted to best answer the research questions and the decision of which strategy to use was guided by the research questions and the kind of information that the researcher required. It focuses on the farmers' perception, adoption decisions, and their willingness to accept payment to adopt ecosystem-friendly farming practices. The study employed non-experimental approach. The study was conducted in three districts (Kumbungu, Savelugu-Nanton and Tolon) in the Northern Region of Ghana.

Conceptually, farmer adoption of ecosystem-friendly farming practices for sustainable ecosystem and agricultural productivity was the focus of the research. However, farmers are faced with social, economic, institutional, ecological, and technical factors that influence their decisions to adopt ecosystem-friendly farming practices. The theory of adoption of improved practices/technologies provided the basis for this research. The study employed the Poisson regression and Tobit models.

Primary data used for the study were obtained from rain-fed and irrigated smallholder farmers in three districts. The target population for this study was farm households that engage in rain-fed and irrigation farming activities. About 80 percent of these farm households are engaged in agricultural production.

Data were analyzed using Stata, Statistical Package for Social Sciences (SPSS) and Excel softwares and results were presented in tables and graphs. Specifically, several methods and approaches of data analysis such as the Kendall's Coefficient of Concordance (*W*), the Poisson regression model, and the contingent valuation method using Tobit regression model were employed in this study to achieve the research objectives.

In conclusion, the conceptual framework describes various factors that affect adoption of EFFPs. Moreover, if these factors affect adoption negatively, they reduce or threaten the sustainability of the ecosystem and agricultural productivity and vice versa. In the theoretical model, the Poisson model was used to analyse factors that influence the adoption of EFFPs. Also, the contingent valuation method was used to analyse the amount farmers are willing to accept as payment to adopt EFFPs and the factors influencing the willingness of farmers to accept payment to adopt ecosystem-friendly farming practices were estimated using Tobit regression model.

CHAPTER FOUR

PRESENTATION AND ANALYSIS OF RESULTS

4.0 Introduction

This section presents the combined socio-demographic characteristics of the respondents for all the three administrative districts (Kumbungu, Savelugu-Nanton and Tolon) in the Northern Region of Ghana. This includes differences in farmers' perceptions of ecosystem friendly practices, factors influencing the adoption of ecosystem-friendly farming practices, willingness to accept payment value to adopt ecosystem friendly practices; and factors influencing the amount farmers are willing to accept as payment to adopt ecosystem-friendly farming practices.

4.1 Socio-demographic characteristics of research participants

This section presents Socio-demographic characteristics of respondents. The examination of this is important to the extent that it provides a guide for policy makers regarding the adoption and preservation of the ecosystem. The results from research revealed that, out of 300 respondents, 50 percent (150) were men and 50 percent (150) were women (**Table 3**), representing overall respondents. The implication is that, the outcome of the research represents the collective views, concerns and opinions of both men and women. Further, majority (73%) of farm household heads are between 35 and 54 years with the mean age of about 44.5 years. This suggests that most of the smallholder farmers are energetic enough to undertake practices that are ecosystem (environmentally) friendly and are believed to be driving the households' decision-making processes on the adoption of ecosystem-friendly farming practices. Also, most farm households in the districts belong to the economically active age group and their adoption of environmentally friendly practices is crucial for the improvement of agricultural productivity and maintaining environmental integrity in the districts and the region at large. Older farmers are less likely to adopt improved natural resource management practices as their age, planning horizons shrink and so the incentives for them to invest in the future productivity of their farms diminish whilst younger farmers may incur lower switching costs in implementing and adjusting new practices (Paswel *et al*., 2007).

Majority of the respondents (73%) interviewed did not have any form of education. Only 10 percent of the respondents had basic/primary education, about 7 percent had JHS/MSLC education, 5 percent attained secondary education (SHS/VOC/TEC), about 4 percent had non-formal (Arabic, school for life) education and about 1 percent acquired tertiary education. The findings indicated that both literate and illiterate farmers were included in the study. Education plays a key role in the ability to accept and adopt modern agricultural technology (Seini, 2002; Kibaara, 2005). Also, education facilitates farmers understanding of the socio-economic conditions overriding their agricultural practices (Shamsudeen *et al.*, 2011). According to Barrett *et al*. (2002), improved natural resource management practices are knowledge-intensive and require considerable education.

The results from the study revealed that household sizes fall within the range of 1-10 representing 67 percent of respondents. The mean household size is about 5.5. This implies that most farm household heads have some labour to carry out labour intensive ecosystem-friendly farming practices and able to make collective farming decisions within the household. The adoption of ecosystem friendly practices can be influenced significantly by the total number of people operating in the farm since it is labor intensive. The data obtained also revealed that the mean farm size was 1.88 hectares per household head and majority (68%) of the smallholder farmers cultivated on a farm size ranging from 0.1 – 2.40 hectares. The implication is that most of the farmers in the districts are producing in smaller scale, besides few farmers who are operating on commercial scale. The amount of land farmers would enroll into environmentally friendly practices is dependent more on the cost and benefits that will compensate his/her participation (Ma *et al*., 2012).

The study results also revealed that the mean farming experience for rain-fed farmers and irrigated farmers was about 11 years and about 7 years respectively and maximum farming experience of 50 years and 47 years respectively. This implies that most of the farmers have had some level of knowledge in both rain-fed farming and irrigation. Farmers' willingness to enroll in and adopt a payment for environmental-services programme is determined by their farming experience, education, and environmental attitudes (Ma *et al*., 2012).

Table 3: Socio-demographic characteristics of research participants

Variable	District			Total Respondent
	Kumbungu	**Savelugu**	**Tolon**	
Sex				
Males	57	48	45	150
Females	56	47	47	150
Total	**113**	**95**	**92**	**300**
Age				
15 – 34	17	8	18	43
35 – 54	78	77	64	219
55 – 74	12	7	6	25
Above 75	6	3	4	13
Total	**113**	**95**	**92**	**300**
Educational Level				
None	76	61	81	218
Non-formal	5	6	2	13
Primary	14	13	3	30
JHS/MSLC	7	9	6	22
SHS/Voc.	9	6	0	15
Tertiary	2	0	0	2
Total	**113**	**95**	**92**	**300**
Marital Status				
Single	12	4	7	23
Married	100	87	84	271
Separated	1	1	0	2
Divorced	0	1	1	2
Widowed	0	2	0	2
Total	**113**	**95**	**92**	**300**
Household Size				
1 – 10	63	65	73	201
11 – 20	36	28	12	76
21 – 30	12	1	5	18
31 – 40	2	1	2	5
Total	**113**	**95**	**92**	**300**
Farm Size				
0.25 – 5.99	79	62	63	204
6 – 10.75	26	25	25	76
10.76 – 15.51	5	6	4	15
15.52 - 20.27	2	2	0	4
Above 20.28	1	0	0	1
Total	**113**	**95**	**92**	**300**

Source: Author's construct, 2016.

4.1.1 Households' production systems

This section indicates/presents the result based on the categories or production systems of farmers. The farmers were categorized into irrigators, rain-fed, and irrigation and rain-fed combined, indicated in **Figure 4** below. The result revealed that, equal numbers of respondents were engaged in irrigation and rain-fed activities at Savelugu/Nanton (66) and Tolon (66) District whiles 59 respondents were into irrigation and rain-fed farming at Kumbungu District. However, Kumbungu District dominated with farmers (50) engaged in only rain-fed activities, followed by Savelugu/Nanton District (23) and then Tolon District (16). Also, majority of the famers who engage in only irrigation emerged from Tolon District with 10 farmers, followed by farmers (5) from Savelugu/Nanton District and then farmers (4) from Kumbungu District.

Generally, majority of the farmers (191) out of the total (300) respondents sampled were doing both irrigation and rain-fed activities, representing 64 percent of the total respondents. These farmers diversified their farming activities in order to avoid total failure and ensure all-year round production. Some farmers (89) were also into rain-fed farming only representing 30 percent of the sampled population. It was revealed that most of these farmers do not have access to irrigable lands. Finally, the remaining 6 percent of the farmers (20) were engaged in only irrigation. This group of farmers had larger portion of land located at the catchments, midstream, and downstream.

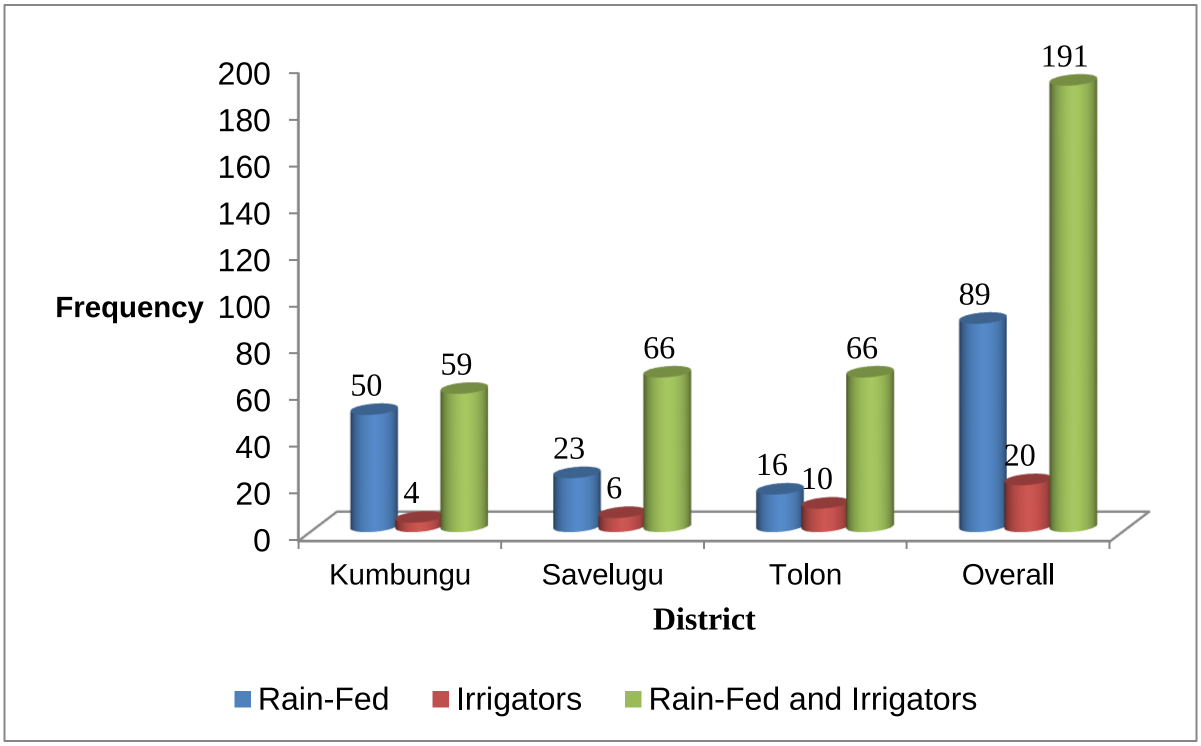

Figure 5: Households production system among districts

Source: Author's construct, 2016.

4.2 Farmers' perceptions of ecosystem-friendly farming practices

The study results revealed that farmers in both irrigated and rain-fed production landscapes perceived crop rotation with cover crops as the most important ecosystem-friendly farming practices in increasing and sustaining yields in their farm plots (**Table 4**). However, at the district level, Savelugu/Nanton District ranked it first with the mean rank of 1.74, followed by Kumbungu District with the mean rank of 2.01 and then Tolon District with the mean rank of 2.59. The implication is that farmers can increase and sustain both crops and animal production within smaller plots through proper rotational cropping and grazing regimes. Over the years there is progressive increase/expansion in area of farmland cultivated without considering the conservation of the environment for tomorrow and our children, grandchildren and those yet to be born to survive (Jasaw *et al*., 2014). Farmers realized the need to protect and maintain soil fertility/ecosystem for their own benefits. Consequently, farmers engaged themselves in rotating leguminous and cover crops such as cowpea, groundnuts, soybean among others with cereal crops such as maize, millet, and guinea corn among others. This helps prevent crop pests and diseases by disturbing the life cycles as part of integrated pest management (IPM) to maintain and sustain both yields and ecosystem. Rotation also improves nutrients cycling by use of legumes and non-legumes, and optimizes water use through difference in rooting depths (Smith *et al*., 2005).

Adoption of mulching was ranked as second most important practice. However, at the district level, Tolon District ranked mulching as the first most important among the districts with the mean rank of 2.56, followed by Savelugu/Nanton District with the mean rank of 2.59 and then Kumbungu District with the mean rank of 2.70. The adoption of mulching ranked second by the farmers in the three districts of the Northern Region also has important implications. First, it underlines their willingness to cultivate cover crops, leave residues after weeding and harvest, as they perceived to be good. Farmers emphasized that mulching is crucial to avoid delays in crop establishment and to enable decomposition of organic material, such as crop residues and weeds. Furthermore, mulching reduces weed germination, improves water management, and increases the fertility of the soil. According FAO (2010), residues form a mulch cover which reduces evaporation and creates a more stable temperature in the soil surface layer, increasing soil biodiversity. However, mulching is not commonly practiced because of excessive use of weedicides and burning of farms.

Agroforestry as part of afforestation was ranked third most important ecosystem-friendly farming practice. However, at the district level, Savelugu/Nanton District ranked organic farming as the first most important with the mean rank of 3.24, followed by Kumbungu District with the mean rank of 3.38 and then Tolon District with the mean rank of 3.63.The trees and shrubs planted are mostly leguminous and medicinal species such as neem, among others. The woody shrubs are planted along farm boundaries and in between crop rows. The main purpose of planting these woody shrubs is to provide green manure, to fix atmospheric nitrogen, control soil erosion, increase carbon capture and sequestration, and anthropogenically improve biodiversity in agricultural landscapes in mitigating climate change and sustaining ecosystem integrity for improved productivity. These species are either planted temporary or permanent in the field**.** However, these shrubs and trees are pruned prior to and periodically during cropping seasons to prevent shading of crops, leaves applied to the soil as green manure and act as mulch. This practice allows farmers to cultivate their fields for a long period of time following population pressure on land and small farm size that do not allow for long fallow periods for replenishing soil productivity (Paswel *et al*., 2007).

Organic farming was ranked as the fourth most important perceived ecosystem-friendly farming practice. However, at the district level, Savelugu/Nanton District ranked organic farming as the first most important with the mean rank of 3.27, followed by Kumbungu District with the mean rank of 3.53 and then Tolon District with the mean rank of 4.57. It came to light that most farmers were applying organic fertilizers by way of spreading these on the surface of the field or applying the manure directly in seed holes at the time of planting. This is vital in maintaining and sustaining organic matter content in the soil, a critical factor in soil health. The ability of manure to supply nutrients, such as nitrogen (N), phosphorus (P) and potassium (K), is high (Vanlauwe 2004). Other benefits include an increase living organisms and improved water holding capacity in the soil. Yet farmers expressed the difficulties such as inadequate animal and plant manure, bulkiness nature, expensive in carrying manure to farms/fields among others.

Soil bounding ranked the fifth most important practice that is capable of maintaining yields and ecosystem simultaneously. But at the district level, Tolon District ranked this practice as the first most important with the mean rank of 2.99, followed by Kumbungu District with the mean rank of 4.42 and then Savelugu/Nanton District with the mean rank of 4.78.This practice is often carried out by irrigated farmers and done at the boundaries of the field and within the field in case of multiple crops. This helps to control soil erosion, maintain soil fertility and moisture, increase the presence of soil micro and macro organisms necessary for crop establishment, and divide farm to avoid pest and disease attack and varietal mix-up as well as increase the effectiveness of applied inputs on the field.

Control burning was ranked the last. However, based on district level, Tolon District ranked organic farming as the first most important with the mean rank of 4.56, followed by Kumbungu District with the mean rank of 4.96 and then Savelugu/Nanton District with the mean rank of 5.38. Perhaps, the variable was ranked so low due to the fact that farmers do not realise the importance of controlling the burning of their farms and the general agro-ecological landscape. Also, because there are no strict rules and regulations regarding burning of the bush and farms, they tend to place little value to this practice.

Table 4: Sum of ranks of perception of ecosystem-friendly farming practices

	Kumbungu		Savelugu-Nanton		Tolon		Overall Districts	
	Mean score	**Rank**	**Mean score**	**Rank**	**Mean score**	**Rank**	**Mean score**	**Rank**
Crop [illegible] er crops	2.01	2	1.74	1	2.69	3	2.08	1
Mulc [illegible]	2.70	3	2.59	2	2.56	1	2.63	2
Agro [illegible]	3.38	2	3.24	1	3.63	3	3.28	3
Orga [illegible]	3.53	2	3.27	1	4.57	3	3.49	4
Soil [illegible]	4.42	2	4.78	3	2.99	1	4.57	5
Cont [illegible]	4.96	2	5.38	3	4.56	1	4.96	6

m = [illegible] **.365**, Chi-Square = **181.851**, df = **5**, Level of Significance = **0.000**

Sou [illegible] truct, 2016.

The value of the Kendall's Coefficient of Concordance (W=0.365) is greater than zero and therefore, confirming that there is some degree of agreement among both irrigated and rain-fed farmers' knowledge and perception about ecosystem-friendly farming practices. However, the extent to which this is significant is tested (that is F-test of 0.000) to be one percent significant levels. Hence, there is agreement or uniformity among irrigators and rain-fed farmers about ecosystem-friendly farming practices.

4.3 Factors influencing adoption of ecosystem-friendly farming practices by farmers

The second objective of the study was to estimate the factors that influence the adoption of ecosystem-friendly farming practices by farmers in rain-fed and irrigated landscapes in Northern Region. These factors are presented (**Table 5**) separately for Kumbungu District, Savelugu/Nanton District, and Tolon District for which their coefficients are discussed below. The dependent variable is a vector of ecosystem friendly practices such as crop rotation and cover cropping, mulching, agroforestry, organic farming, soil bonding, and control burning. The factors influencing farm households' adoption of ecosystem-friendly farming practices using the Poisson model were grouped into four main categories namely social, economic, institutional and ecological factors.

The social factors included the sex, age, educational level and household size of farmers. The economic factors included the off-farm income generation activities that household heads engage in, production system that the farm families involved in, farmer access to affordable credit facilities, total income of the farmer, access to market and expected benefits from the adoption by the farmer. The institutional factors included access to extension services, and membership to a Farmer-Based Organization (FBO). The ecological factors included farmer knowledge and attitude towards the environment (ecosystem), and willingness to participate in contract farming.

It was revealed from the Breusch-Pagan/Cook-Weisberg test for heteroskedasticity that, the Chi-square value is 57.29. This implies that the null hypothesis of constant variance is accepted and therefore, heteroskedasticity is absent and the variance of the error term is constant (homoscedastic). Also, the probability chi-squared for the entire three selected district was very significant at 1 percent (Prob > chi^2 = 0.000). However, the significant levels of the probability chi-squared varied for individual districts. The probability chi-squared is significant at 10 percent (Prob > chi^2 = 0.0535) for Kumbungu District, 10 percent (Prob > chi^2 = 0.0987) for Savelugu/Nanton District, and 5 percent (Prob > chi^2 = 0.0390) for Tolon District. This represents a Log Likelihood Ratio and indicates that, all the explanatory variables included in the model jointly contribute to explaining the variations in farmers' decisions or probability to adopt ecosystem-friendly farming practices. On the other hand, the Pseudo R^2 is reported to be 0.0623, 0.0648, and 0.0754 for Kumbungu District, Savelugu/Nanton District, and Tolon District respectively with the overall of 0.0551. The implication is that the explanatory variables included in the model are able to explain 6.23 percent, 6.48 percent and 7.54 percent for Kumbungu District, Savelugu/Nanton District, and Tolon District respectively but 5.51 percent for overall districts of farmers' adoption of EFFPs. These values also measure goodness of fit of the model. The remaining percentages of variation are explained by other factors. The goodness of fit parameters of the model indicated that, the Poisson model employed had the integrity and adequately predicted the determinants of the adoption of ecosystem-friendly farming practices, hence an appropriate measure.

Most of the variables were statistically significant both positively and negatively. Generally, out of the 14 explanatory variables hypothesized to influence the adoption of ecosystem-friendly farming practices, 5 were statistically significant. However, in the case of individual districts, four (4), three (3), and four (4) variables were statistically significant for Kumbungu, Savelugu/Nanton, and Tolon District respectively.

Table 5: Estimation of factors influencing adoption of ecosystem-friendly farming practices

Variable	ɡu District		Savelugu-Nanton District			Tolon District			Overall (All districts)		
	or	Marginal effect	Coef.	Std Error	Marginal effect	Coef.	Std Error	Marginal effect	Coef.	Std Error	Marginal effect
Sex	515	-0.2999	-0.0501	0.2018	-0.1523	0.0344	0.1822	0.0756	-0.0736	0.0733	-0.1904
Age	056	0.0131	0.0096**	0.0069	0.0289**	0.0129**	0.0066	0.0284**	0.0058*	0.0032	0.0150*
Education	534	0.2172*	0.0040	0.0537	0.0122	0.0735	0.1132	0.1618	0.0599**	0.0304	0.1549**
HH.Size	046	-0.0052	-0.004	0.0100	-0.0121	-0.0040	0.0098	-0.0088	-0.0056	0.0060	-0.0144
OF.Income	001	0.0001	0.0001	0.0002	0.0003	-0.0061	0.0004	-0.0013*	0.0004	0.0003	0.0010
Prdn.System	286	-0.1891	0.0084	0.1597	0.0253	0.0583	0.1274	0.1283	0.0432	0.0662	-0.1118
FBO	727	-0.1362	-0.0264	0.2252	-0.0798	0.1985	0.1686	0.4492	0.0987	0.0883	0.2561
Ext.Services	588	0.0320	-0.0326	0.2289	-0.0990	-0.3639**	0.1731	-0.8481**	-0.1528*	0.0830	-0.3983*
Credit	524	0.6652	-0.0708	0.1559	-0.2094	0.3056	0.2069	0.7388	0.0286	0.0738	0.0740
T.Income	000	-0.0000	0.0000	0.0001	0.0001	0.0000	0.0000	-0.0000	-0.0000	0.0000	-0.0000
Market	890	0.0732	0.1021	0.1925	0.2968	0.6993	0.4324	1.1419	0.1349	0.1394	0.3297
F.Knowledge	835	0.7257***	0.1328***	0.0841	0.4004***	0.2242***	0.0844	0.4936***	0.1984***	0.0404	0.5128***
C.Farming	548	0.2136	0.3235	0.5395	0.8393	0.1979	0.5626	0.3978	0.2282	0.2513	0.5315
F.Benefits	003	0.0010*	0.0004*	0.0003	0.0012*	0.0001	0.0003	0.0002	0.0003**	0.0002	0.0008**
Constant	107		-0.1304	0.6908		-1.1652	0.7515		-0.0780	0.3528	
Observations		113	95			92			300		
LR Chi^2 (14)		23.44	21.12			24.58			57.29		
Prob > Chi^2		0.0535	0.0987			0.0390			0.0000		
Pseudo R^2		0.0623	0.0648			0.0754			0.0551		
Log Likelihood		-176.4054	-152.4977			-150.5927			-491.1386		

Source: Author's construct, 2016.

However, the directions and magnitudes of parameter estimates (that is, coefficients) obtained from the Poisson regression model in **Table 5** above do not provide the best indications of the signs and effects of the explanatory power of the independent variables on adoption of ecosystem-friendly farming practices since the dependent variable is categorical. Thus, to ensure a more meaningful measure of the effect of explanatory variables and magnitude of change in the level of EFFPs adoption decision as a result of a unit change in any of the explanatory variables, marginal effects were estimated. Thus, the marginal effects (**Table 5**) indicate the influence of ecosystem-friendly farming practices adoption with their respective directions.

Marginal effects analyses were carried to better estimate the effects of the explanatory variables on farmers' adoption decision of EFFPs and was done separately for Kumbungu, Savelugu/Nanton, and Tolon District respectively. According to Greene (2002), other factors held constant for dummy variables for which marginal effects indicate the differences in the two predicted probabilities, as well as the change in the predicted probability of EFFPs adoption levels for a unit change in the explanatory variable for continuous variables. The results indicate that age of the farmer, educational level, access to extension service, farmer's knowledge about technology, and benefits of adoption to farmer are the main factors that significantly influenced the intensity of adoption of ecosystem-friendly farming practices.

Age was found to be significant at the 10 percent level and influences the adoption of ecosystem friendly practices positively for the entire districts (**Table 5**). A year increase in the farmer's age will increase his/her probability of adopting ecosystem-friendly farming practices by 0.0058 percent as indicated in the marginal effect result. However, this variable was not significant for Kumbungu District but statistically significant for Savelugu/Nanton District and Tolon District at 10 percent with positive influence on adoption. All other factors held constant, a unit increase in the farmer's age increases his/her probability of adopting EFFPs by 2.89 percent and 2.84 percent respectively for Savelugu/Nanton District and Tolon District. The implication is that, younger farmers may not be able to adopt ecosystem-friendly farming practices, especially capital intensive ones due to resource constraints. This confirms a study conducted by Akudugu *et al*. (2012), that farmers' rate of adoption of modern agricultural technologies is low at both the younger and older ages due to capital-intensive nature of some of the technologies. However, this result contradicts an earlier research by Paswell and Barrett (2007) that younger farmers are more likely to adopt the improved natural resource management practices and that, they are motivated to invest in the future productivity of their farms. This presents a serious challenge to extension policy issue. Extension systems must differentiate their targeted group on critical demographic characteristics such as age. If younger farmers are less likely to adopt new practices, may be extension information at the early stages of development and dissemination should be focused on younger farmers as the conservation of our natural ecosystem depends largely on growing youth. Also, it raises a serious challenge to policy makers and implementers in promoting the conservation of the environment for present and future generations to adopt ecosystem-friendly farming practices in the study area. This is because majority of the youth are engaged in agricultural activities in the districts.

The educational level of the farm household head was found to have a positive relationship with the probability of adoption and significant at 5 percent level (**Table 5**).

However, at the district level this variable was only significant for Kumbungu District at 10 percent with positive influence on adoption but not significant for Savelugu/Nanton District and Tolon District. This implies that well educated household heads are more likely to adopt ecosystem-friendly farming practices than the less educated ones. This is because when farm decision-maker is educated he/she shares the knowledge acquired to colleague farmers. This can enhance the adoption of ecosystem-friendly farming practices. This is consistent with the literature that education facilitates the acceptance of new practices especially of information-intensive and management-intensive practices (Waller *et al.*, 1998; Caswell *et al.*, 2001). Also, according to Barrett *et al*. (2002) improved natural resource management practices are knowledge-intensive and require considerable education for management input. The implication is that extension systems and agricultural development projects should seek not only to provide technological options to smallholder farmers, but also attempt to make up for low levels of educational attainment, perhaps through emphasis on management training and capacity building through sensitization of farmers.

Access to extension services (**Ext.Services**) negatively influenced farmer's decision or probability to adopt and which was found to be statistically significant at 10 percent level (**Table 5**). However, at the district level access to extension services only negatively influenced adoption and significant for Tolon District at 5 percent but not significant for Kumbungu District and Savelugu District. This implies that exposing farmer to extension services tend to reduce his/her probability to adopt ecosystem friendly practices by 15 percent. Also, the negative sign of the access to extension services variable means that those with no extension services tended to adopt the practices more than those with more access to extension services. Access to extensions services is supposed to create a platform for acquisition of relevant information that promotes ecosystem-friendly farming practices adoption and will help reduce the uncertainty about the relevance of the practices. However, this contradicts our a priori expectation of having a positive influence on adoption. This could be due to the fact that access to extension services does not necessarily mean access to relevant information. This contradicts the finding of study conducted by Akudugu *et al*. (2012) which indicated that, farm households' access to extension services promote agricultural technology adoption. This raises a serious alarm to extension policy makers to focus more on the content of their extension information package that is being disseminated to farmers and socio-demographic and ecological conditions of the area should be considered.

Farmer knowledge (**F.Knowledge**) about the practices had positive influence on his/her decision to adopt EFFPs and was found to be statistically significant at 1 percent for the entire districts (**Table 5**). Also, at the district level this variable was highly significant and positive for all the districts at 1 percent with positive influence on adoption (Kumbungu District, Savelugu/Nanton District, and Tolon District). The implication is that, as farmer knowledge increases by one unit his/her probability of adopting EFFPs across the districts increases by 72.57 percent, 40.04 percent and 49.36 percent for Kumbungu District, Savelugu/Nanton District and Tolon District respectively, all other factors constant. The positive sign of this variable suggests that as more farmers become aware and have some considerable knowledge about the practices, their probability and intensity of adoption increases. This confirms the earlier study by Swinton *et al*. (2015), that conservation tillage practices adoption is influenced by farmers' knowledge about the practice that offer private benefits at the same time provides beneficial environmental externalities. Hence, this emphasizes the need for agents of sustainable agricultural development to develop sensitization and capacity programs to create awareness and knowledge base of farmers to facilitate their adoption of EFFPs.

Off-farm income (**OF.Income**) was found to have a negative relationship with the probability of adoption and significant at 5 percent level for only Tolon District (**Table 5**). It was not significant for Kumbungu District, Savelugu/Nanton District as well as districts combined. This means that when the farmer's (from Tolon District) non-farm income increases by 1 cedi his/her probability of adopting EFFPs decreases. Off-farm income is reported to act as a substitute for borrowed capital in rural economies where credit markets are either missing or dysfunctional (Ellis & Freeman, 2004; Diiro, 2013), which contradicts this finding.

Access to credit (**Credit**) was found to have a positive influence on the probability of adopting EFFPs and significant at 5 percent level for only Kumbungu District (**Table 5**). Access to credit as expected increases the probability of adoption when the farmer access to credit increases. This finding highlights the importance of providing farmers with affordable credit to support their agricultural activities in securing productivity enhancing inputs. This is consistent with the finding by Mugusha et al. (2012) who reported that access to credit had a positive and significant influence on the rate of technology adoption. This is also consistent to the findings by Abdul-Hanan et al. (2013), that, credit is an important source of capital which facilitates the adoption of soil and water conservation technique and that farmers who have better access to credit stand a better chance of adopting technology faster than those who are capital-constrained.

Finally, the benefit (**F.Benefits**) the farmer expects to derive from adopting a given practice was found to have a positive relationship with the probability or decision to adopt ecosystem-friendly farming practices and exhibited five (5) percent level of significance (**Table 5**). However, at the district level this variable positively influenced adoption and significant for only Savelugu/Nanton District at 10 percent but not significant for Kumbungu District and Tolon District. This implies that if farmers anticipate benefits from adopting ecosystem-friendly farming practice to be higher than their current farming practices, they will be more motivated to adopt it than those without private benefits. As a result attractive but costly or capital-intensive environmental beneficial agricultural practices are less adopted. However, large-scale and rich farmers tend to adopt more quickly as they spread fixed costs over time and may be able to hire labour to do so. Lambert *et al.* (2006), concluded that if farmers see a conservation technology as beneficial and not costly to adopt, adoption becomes easy. Akudugu *et al*. (2012), reported that expected benefit to be derived from adopting a given technology had a positive and significant influence on the rate of modern agricultural technology adoption. Also, Farmers' decision to adopt environmentally beneficial practices is influenced by their perception of how much they would benefit directly (Swinton *et al*., 2015).

4.4 Maximum amount farmers are willing to accept to adopt EFFPs

This section summarizes the maximum amount participating farmers were willing to be paid to adopt ecosystem-friendly farming practices based on district level and farmer category. Results from the research indicated that majority of both rain-fed (83.15%) and irrigated (77.25%) farmers were willing to be paid between GH₵ 0 and GH₵ 500 to adopt ecosystem-friendly farming practices. Only a few rain-fed (16.85%) and irrigated (22.75%) farmers were willing to be paid above GH₵ 500 (**Figure 5**).

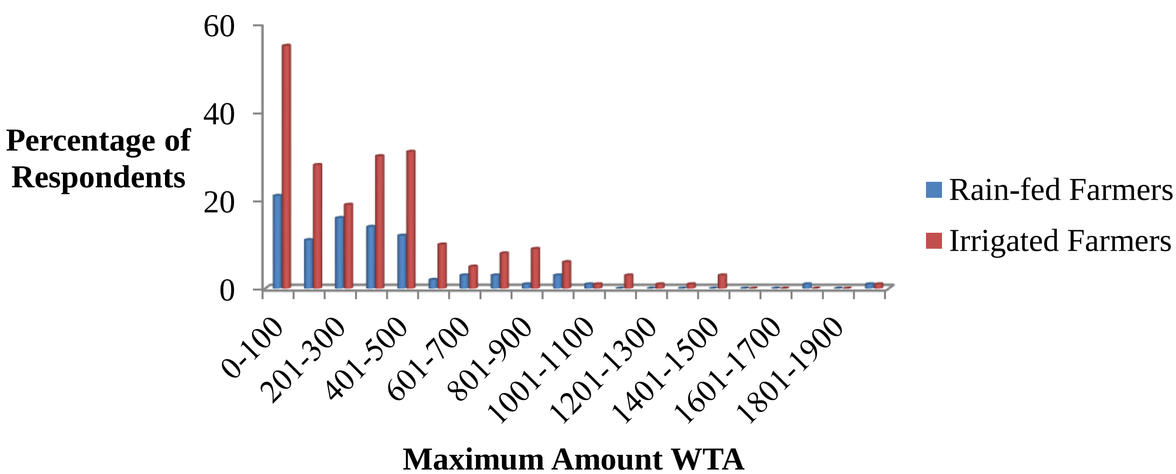

Figure 6: Percentage distribution of farmer maximum WTA

Source: Author's construct, 2016.

The results below indicated that the mean willingness to accept payment to adopt ecosystem friendly practices varied across the districts of the study area (**Table 6**). Tolon District had the highest mean (GH₵ 373.30) willingness to accept payment value with a standard deviation of 317.89. This is due to the fact that, some farmers in the district wish to be paid as high as GH₵ 2000. Savelugu/Nanton District followed with a mean willingness to accept payment value of GH₵ 346.74 and a standard deviation of 223.06. Some farmers in the district wish to be paid a maximum amount of GH₵ 1000. Lastly, Kumbungu District from which majority of the respondents (113) emerged had the lowest mean (GH₵ 338.90) willingness to accept payment value with a standard deviation of 244.76. The maximum WTA (GH₵ 954) in the district appeared the lowest across the districts. Generally, the reason for accepting payment was that, the adoption of some of the practices such as agroforestry, organic manuring (bulky), minimum tillage among others involve cost and the sacrifice of some yields as a result of adopting some practices in the short term. However, some farmers across the districts expressed their willingness to adopt and offer ecosystem services at a cost of GH₵ 0. Their view was that, the sustainability of the environment is of benefit to them in the long term.

However, farmers in general had a mean willingness to accept payment of GH₵ 463.23 with a standard deviation of 457.96. The mean WTA amount constitutes just about 23.16 percent of the maximum amount (GH₵ 2000) that farmers are willing to be paid before adopting ecosystem-friendly farming practices.

Table 6: Estimation of maximum willingness to accept payment among districts

Variable	**Mean**				**Standard Deviation**			
	Kum.	**Sav.**	**Tol.**	**Overall**	**Kum.**	**Sav.**	**Tol.**	**Overall**
WTA	338.90	346.74	373.30	463.23	244.76	223.06	317.89	457.96
	Kum.	**Sav.**	**Tol.**	**Overall**				
Observation	113	95	92	300				
Min. WTA	0	0	0	0				
Max. WTA	954	1000	2000	2000				

Note: Kum., Sav., and Tol., represent Kumbungu, Savelugu/Nanton, and Tolon Districts respectively.
Source: Author's construct, 2016.

The study also revealed the mean willingness to accept payment to adopt ecosystem-friendly farming practices based on farmer category (that is, the production system), which is indicated in **Table 7** below. It was found out that farmers who engaged in irrigation and rain-fed activities were more willing to accept payment with the mean of GH₵ 363.59 and standard deviation of 271.61. The reason is that, they need to be compensated to be able to carry out ecosystem-friendly farming practices both at irrigation and rain-fed landscapes since it is costly and labor intensive. Due to this, their maximum willingness to accept payment amount was GH₵ 2000. Rain-fed farmers followed with a mean willingness to accept payment value of GH₵ 335.89 and a standard deviation of 230.86. Their maximum willingness to accept payment amount was GH₵ 954. Rain-fed ecological landscapes are experiencing declining rate of ecosystem services' provision/supply and hence required some capital to engage in practices that could restore these important services. Irrigators also expressed their interest in accepting some payments before adopting EFFPs with mean of GH₵ 302.50 and standard deviation of 276.48.

Generally, the minimum willingness to accept payment is GH₵ 0 and the maximum willingness to accept payment is GH₵ 2000. From the results we can conclude that most of farmers prefer a payoff before adopting ecosystem-friendly farming practices. Results also indicate that some of these farmers are not willing to receive much money before accepting to adopt ecosystem-friendly farming practices since some are ready to adopt the practices even at GH₵ 0. Most of the farmers expressed positive attitude towards the environment and thus some other reasons more than money explain their adoption decision. For farmers whose willingness to accept is quiet closed to the maximum or equals the maximum willingness to accept payment amount, can be influence by their level of annual income and others socio economic factors. According to Swinton *et al*. (2015), farmers' decision to adopt environmentally beneficial practices is influenced by how much they would benefit directly.

Table 7: Estimation of maximum willingness to accept payment based on farmer category

Variable	Mean			Standard Deviation		
	Irrigators	**Rain-fed**	**Both**	**Irrigators**	**Rain-fed**	**Both**
WTA	335.89	302.50	363.59	230.86	276.48	271.61
	Irrigators	**Rain-fed**	**Both**			
servation	20	89	191			
ni. WTA	0	0	0			
x. WTA	954	1000	2000			

Source: Author's construct, 2016.

4.5 Factors influencing farmers' willingness to accept payment to adopt EFFPs

The dependent variable used in this model was a continuous variable that farm household responded as their maximum willingness to accept (WTA) payment measured in Ghana Cedis (GH₵). Most of the variables were statistically significant both positively and negatively. Generally, out of the nine (9) explanatory variables hypothesized to influence the willingness to accept payment to adopt ecosystem-friendly farming practices, seven (7) were statistically significant. However, in the case of individual districts, four (4), four (4), and two (2) variables were statistically significant for Kumbungu, Savelugu/Nanton, and Tolon District respectively. The results are presented in **Table 8** below.

The study results revealed that sex of the household head is an important factor that determines farmers' willingness to accept payment to adopt ecosystem-friendly farming practices. This variable was found to have negative influence and it is statistically significant at 10 percent level. This means that the amount female farmers are willing to accept as payment to adopt ecosystem-friendly farming practices is higher compared to those in male farmers. Perhaps, female farmers' access to larger and productive farm lands is very difficult and hence, need to conserve or protect the smaller portions given to them. However, the coefficients for individual districts are not significant.

Age of the household head is another important factor positively influencing farmers' willingness to accept payment to adopt ecosystem-friendly farming practice for the entire districts. It was found to be significant at the 10 percent level. The result indicates that when the household head age increases by one year, the maximum amount he/she will be willing to accept increases by 1.24 percent. In other words, as the age of a farmer increases by one year, the amount of money he/she is will to accept as payment to adopt ecosystem-friendly farming practice increases by GH₵ 0.0124. However, at the individual districts this variable was only highly significant for Savelugu/Nanton District at 1 percent with positive influence on WTA but not significant for Kumbungu District and Tolon District. As the age of household head increases, the amount he/she will be to accept increases significantly. Therefore, older household heads are more likely to be willing to accept payment before making adoption decision compared to younger household heads. This is consistent with study done by Swinton *et al*. (2015), that younger household heads have lower switching cost than elders.

Household size was found to have a negative relationship with the farmers' willingness to accept payment and it is statistically significant at 10 percent level for the entire districts. This means that the number of people in a household negatively affects farmers WTA adoption decision and decreases the WTA amount by GH₵ 0.0214 when a farm family household size increases by one person. However, at the individual districts this variable was only highly significant for Savelugu/Nanton District at 1 percent with negative influence on WTA but not significant for Kumbungu district and Tolon District. The reason for this is that, an increase in household size and for that matter its labour was supposed to lead to a great capacity to adopt ecosystem friendly practices since these practices are labour intensive and then reduce the desire of being paid before adopting them. This finding contradicts earlier study by Afo-Loko (2013) that reported that larger family size has great motivation to adopt conservation tillage and reduce the desire of being paid before adopting a new technology.

The maximum level of education the head of the household acquired determines farmer's willingness to accept payment before adopting ecosystem-friendly farming practices and was found to have a positive relationship with statistical significance at 1 percent level for the entire districts. The results showed that the more the farmer is educated the more he/she is willing to receive before adopting ecosystem-friendly farming practices. Meaning, a unit increase in the education level increases the probability of the farmer's willingness to accept payment amount by GH₵ 0.1658. In other words, when the education of a farmer increases by a level, the amount of money he/she will be willing to accept as payment to adopt ecosystem friendly practice increases by GH₵ 0.1658. However, at the individual districts this variable was only highly significant for

Kumbungu District at 5 percent with a positive influence on WTA but not significant for Savelugu/Nanton District and Tolon District. This means that education exposes an individual to have right information on the negative effect of ecosystem/environmental degradation which increases he/her decision to adopt ecosystem-friendly farming practices and thus increasing their desire to receive more payment than those without before renouncing to bad farming practices. This is consistent with the study conducted by Owodon (2014) that education creates a positive mental attitude towards the environment and increases the desire to receive more payment to adopt improved practices.

Farmer belonging to a farmer based organization (FBO) or group is another important factor which negatively influences farmer's willingness to accept payment. This variable is statistically significant at 1 percent (%) level. Information farmers obtain from group meetings enhances their ability to practically adopt improved environmental practices rather than demanding payment before adoption. Farmers that belong to farmer base organizations may get different information on environmental conservation methods, improved farming practices and other extension services than those farmers who do not belong to farmer base organization. This variable shows that farmers that belonging to farmer base organization have 50.47 percent less probability of accepting payment to adopt ecosystem-friendly farming practices than their counterparts and indicating that farmers belonging to farmer base organizations would accept GH₵ 0.5047 less than those farmers that do not belong to farmer base organizations or groups. However, at the individual districts this variable was only highly significant for Tolon District at 5 percent with a positive influence on WTA but not significant for Kumbungu District and Savelugu/Nanton District.

The number of extension agents' contacts or visits to the farmers during production season revealed to have a negative influence on the farmer willingness to accept payment before adopting ecosystem-friendly farming practices at 1 percent (%) level. The results show that an increase in the number of visits of agricultural extension agents to the farmer during the production will decrease the willingness to receive payment probability by 0.0851 percent. This implies that when a farmer is frequently exposed to extension training on improve practices he/she would not find it too useful to receive a payment before adopting technologies. The implication is that farmers who have regular contact with agricultural extension agents during their production season would accept GH₵ 0.0851 less than those farmers that have low extension contact. However, at the individual districts extension services negatively influence WTA by farmers in Kumbungu District and Tolon District at 5 percent but not significant for Savelugu/Nanton District.

Access to market was found to have a positive influence on WTA adopt EFFPs and significant at 10 percent level for Kumbungu District and significant at 5 percent level for Savelugu/Nanton District with negative influence but not significant for Tolon District as well as the entire districts (**Table 8**). Access to market increases the amount farmers are willing to accept for Kumbungu District and decreases the amount farmers are willing to accept for Savelugu/Nanton District.

The farmer's production system (that is, farmer category) negatively influences willingness to accept payment at 5 percent (%) significant level for farmers in Kumbungu District. The implication is that, rain-fed farmers are more willing to accept payment than irrigators since irrigators were used as a bench mark. However, this variable was only highly significant for Kumbungu District but not significant for Savelugu/Nanton District and Tolon District as well as the overall analysis.

Finally, the farmer's production cost positively influences his/her willingness to accept payment at 1 percent (%) significant level. The implication is that, a unit or one Ghana cedi increase in the farmer's cost of production per acre will increase the amount he/she will be willing to accept payment (WTA) by GH₵ 0.0005. However, at the individual districts this variable was only highly significant for Savelugu/Nanton District at 1 percent with a positive influence on WTA but not significant for Kumbungu District and Tolon District. It can be concluded that the higher the cost of production borne by the farmer the more he/she feels compensated before adopting ecosystem-friendly farming practices. Hence, farmers will demand higher amount of payment before adopting. This is consistent with the literature that farmers' willingness to adopt environmentally beneficial practices is influenced by their perception of how much it would cost to do so (Swinton et al., 2015).

Table 8: Maximum likelihood estimates of Tobit model of factors influencing the amount farmers are willing to accept as payment to adopt ecosystem-friendly farming practices by farm households in Northern Region of Ghana

Vari	**Kumbungu**		**Savelugu-Nanton**		**Tolon**		**Overall (All districts)**	
	Coefficient	Std Error	Coefficient	Std Error	Coefficient	Std Error	Coefficient	Std Error
Sex	-0.2528	0.2789	-0.3304	0.3231	-0.5628	0.4125	-0.2881*	0.1525
Age	0.0055	0.0093	0.0350***	0.0115	0.0111	0.0124	0.0124*	0.0065
Mari	0.8595*	0.3728	-0.5083**	0.2182	-0.7192	0.5005	-0.1437	0.1937
Hou	-0.0059	0.0073	-0.0359**	0.0151	-0.0157	0.2114	-0.0214*	0.0119
Edu	0.1843**	0.0888	0.0084	0.0807	0.3814	0.2462	0.1658***	0.0620
Prod	-0.5227**	0.2167	-0.2344	0.2275	-0.0368	0.2495	-0.1056	0.1332
Men	0.3976	0.2606	0.2605	0.3077	0.8192**	0.3749	-0.5047***	0.1804
Exte	-0.0959**	0.0414	-0.0279	0.0704	-0.0948**	0.0534	-0.0851***	0.0294
Cost	0.0001	0.0003	0.0005***	0.0001	0.0005	0.0003	0.0005***	0.0001
Con	1.9038	0.9586	2.1800	0.7408	2.8162	1.1963	2.4192	0.5590
No.	113	95	92	300				
LR	19.49	41.76	12.34	48.45				
Prol	0.0299	0.0000	0.1946	0.0000				
Pseu	0.0504	0.1378	0.0371	0.0470				
Log Likelihood	-174.1303	-130.6254	-159.9824	-491.1809				

Note: ***, **, and * indicate significance levels at **1%**, **5%**, and **10%** respectively.
Source: Author’s construct, 2016.

CHAPTER FIVE

SUMMARY, CONCLUSIONS, AND POLICY RECOMMENDATIONS

5.0 Introduction

This chapter summarizes the main findings of the study and draws major conclusions from the results and analysis of the study. Based on the major findings, recommendations are also made to inform policy formulation and for future research in the area of ecosystem conservation, adoption of ecosystem friendly farming practices for sustainable productivity by smallholder farmers.

5.1 Summary of key findings

This study was carried out in the Northern Region of Ghana to assess farmers' adoption of ecosystem-friendly farming practices in rain-fed and irrigated landscapes. The study addressed the following objectives; (1) the differences in farmers' perceptions of ecosystem-friendly farming practices, (2) the factors that influence the adoption of ecosystem-friendly farming practices, (3) the amount farmers are willing to accept as payment to adopt ecosystem friendly farming practices, and (4) estimate the factors influencing the amount farmers are willing to accept as payment to adopt ecosystem-friendly farming practices among farmers in rain-fed and irrigated landscapes.

The socio-demographic characteristics were analyzed using descriptive statistics presented in relative frequencies. The first objective was analyzed using Kendall's Coefficient of Concordance. The Poisson regression model was used to achieve the second objective. Contingent valuation using mean willingness to accept payment amount was employed to address the third objective. Finally, the fourth objective was analyzed using the Tobit regression model.

The data used for the study were collected for 2015/2016 farming season. A sample of 300 smallholder farmers (both rain-fed and irrigated) was selected. This comprised equal distribution of male and female farmers across three administrative districts (Kumbungu, Savelugu-Nanton, and Tolon) in the Northern Region of Ghana. The multi-stage sampling technique was used to sample the 300 respondents. A semi-structured questionnaire was administered via face-to-face interview to collect data for analysis. Focus group discussions and key informant interviews were carried out to augment the data collected using semi-structured questionnaires.

The results showed that smallholder farmers (rain-fed and irrigated) strongly agreed that crop rotation with cover crops, mulching, agroforestry, organic farming, soil bunding, and control burning are eco-friendly. As a result smallholder farmers had already adopted some of the practices unintentionally. However, farmers decision to adopt EFFPs were found to be influenced either negatively or positively by the farmer's age, educational level, household size, off-farm income, extension services, credit access, knowledge level/experience, and benefits. Also, majority of the farmers interviewed expressed their willingness to accept payment (payoff) before carrying out EFFPs. Only a few were willing to adopt at zero charge (amount). The study revealed that sex, household size, educational level, membership of FBO, extension services, and cost of production are the most important factors determining farmers' willingness to accept payment before adopting EFFPs.

5.2 Conclusions

The mean age of respondents was found to be 37 years and so it can be concluded that the adoption of ecosystem-friendly farming practices largely depends on this age group since they are energetic enough to undertake these practices effectively. Also, most farm households in the districts belong to the economically active age group and their adoption of environmentally friendly practices are crucial for the improvement of agricultural productivity and climate change resilience at the same time maintaining environmental integrity in the districts and the region at large. There is high illiteracy (72%) among farmers. This concludes that education plays a key role in the ability to accept and adopt environmental-friendly farming practices. The mean household size was 10.49, which concludes that the adoption of ecosystem-friendly farming practices is influenced significantly by the total number of people operating in the farm since the adoption of some of the practices is labour intensive. Since the mean farming experience for rain-fed farmer and irrigated farmers 10.88 and 6.71 respectively concluded that most of the farmers go into rain-fed farming before irrigation and not all of them have access to irrigable lands. Also, their willingness to enroll in and adopt a payment-for environmental-services program is determined by the farming experience.

Meanwhile, the coefficient of concordance analysis revealed that smallholder farmers (rain-fed and irrigated) strongly perceived that crop rotation with cover crops, mulching, agroforestry, organic farming, soil bunding, and control burning are environmentally-friendly and are capable of maintaining yields and ecosystem integrity simultaneously. This can be concluded that farmers were already aware of the practices and adoption would be easier if proper education, extension training through farm demonstration and motivation to farmers are implemented. Though farmers were facing challenges of full adoption due to certain socio-economic, demographic, technical, institutional, and ecological factors, each farmer adopted at least one practice.

The outcome of Poisson regression analysis suggested that farmers' decision to adopt EFFPs was influenced by many determinants such as the farmer's age, educational level, household size, off-farm income, extension services, credit access, knowledge level/experience, and benefits. The positive influence of age concludes that, younger farmers may not be able to adopt ecosystem-friendly farming practices as compared to the older and more experienced ones. Therefore, young farmers should be empowered since the future of the ecosystem also depends largely on the youth today. However, the sex of the farmer does not show any significant impact or influence on adoption behaviour, which concludes that both men and women farmers tend to behave with equal responsibility and the accountability in the decision making of his/her farm. Since educational level of farmer had a positive relationship with the EFFPs' adoption, it can be concluded that education plays a key role in the adoption of agricultural technology. Also, the benefits the farmer expected from the adoption of EFFPs positively influenced and increased the chance of adoption. It is concluded that, farmers adopt easily to practices that yield higher private benefits. However, access to extension services negatively influenced the farmer decision to adopt EFFPs, concluding that access to extension services alone is not good enough to enhance the adoption but the number of contact and on-farm practical demonstration the farmer gets might be important. Finally, farmer knowledge and attitude towards the environment (ecosystem) had a positive influence on the probability of EFFPs' adoption, suggesting that farmers' awareness and understanding about improved farming practices increases their chance of adoption.

Though few farmers expressed their willingness to adopt and offer ecosystem services at a cost of GH₵ 0, majority of the farmers were willingness to accept payment before adoption with a mean willingness to accept payment of GH₵ 463.23. In conclusion, farmers proposed they should be compensated to adopt EFFPs.

The determinants such as sex, age, household size, membership of FBO, extension services, and cost of production were found to positively or negatively influenced the amount farmers are willing to accept payment. Since sex of the household head (for which female was a bench mark) had a negative influence on WTA, it is concluded that female farmers can contribute to environmental conservation. The age of the household head had a positive effect on WTA decision and it can be suggested that older farmers have the exigency to demand for payment as compared to younger farmers. Also, household size of the farmer negatively affects farmers WTA for adopting concluding that, larger households are likely to demand lesser amount as compared smaller households before adopting EFFPs. Since educational level of the farmer had a positive influence on WTA, it can be concluded literacy is very important for making agriculture a business and not a way of life. It was also revealed that when the farmer belongs to a FBO/group his/her willingness to accept payment reduces. Similarly, the extension service the farmer gets or receives in a production season decreases the amount he/she be willing to demand payment. Finally, farmers' cost of production compelled them to consider payment before adopting ecosystem-friendly farming practices, since this variable was positive.

5.4 Policy recommendations

Generally, four main empirical findings emerged from this study. Firstly, there is a strong agreement or perception of smallholder farmers across the various districts or agricultural landscapes about EFFPs (crop rotation with cover crops, mulching, agroforestry, organic farming, soil bounding, and control burning of farms). Indicating that, the ecosystem/environment and crop productivity can be sustained if these are fully adopted by farmers. Therefore it is recommended that a major seasonal sensitization/awareness programmes (farm demonstration and seminars) by agriculture extension agents (AEAs) from the various departments of agriculture (DoA) and other agriculture related non-governmental organizations (NGOs) to ensure full implementation/adoption of EFFPs. These will provide a platform for the exchange of information on environmentally-friendly and climate smart agriculture practices among districts/communities and other stakeholders across agricultural landscapes particularly Northern Region. These farmer sensitization and capacity building programs are also capable of reducing the exigencies of farmers to receive a payment before adopting EFFPs that have both public and private benefits (win-win affair).

Secondly, the results from the Poisson regression revealed that age of the farmer, educational level of the farmer, farmer knowledge/experience, and farmer benefits positively influenced the probability of adopting ecosystem-friendly farming practices. The study recommends that extension service delivery or programs should differentiate their targeted group on critical demographic characteristics such as age since the conservation of our natural ecosystem depends largely on growing youth and elderly. Also, the government should ensure that every citizen have access to at least basic education since the future sustainability of the ecosystem/environment depends on the children today. In addition, extension systems and agricultural developmental projects should seek not only to provide technological options to farmers, but also attempt to make up for low levels of educational attainment, perhaps through emphasis on management training and capacity building through sensitization of farmers. As more farmers become aware and have considerable knowledge about the practices, their probability adoption increases; hence, the need for agents of sustainable agricultural development to develop sensitization and capacity programs to create more awareness and develop the knowledge base of farmers to facilitate their adoption of EFFPs. Since the expectation of certain benefits from adoption increases the farmer's probability of adoption, it is therefore recommended that, there should be alternative policies such as tradable pollution permits that offer farmers a market-based incentive to adopt environmentally friendly practices for public and private benefits. The adoption of environmental-friendly practices can also be made a precondition for farmers to gain access to desirable opportunities such as government agricultural subsidy programs and corporate social responsibilities.

Thirdly, since majority of the farmers were willing to accept payment before adoption, there should be deliberate programmes, like carbon trading, Pigovian tax system, among others, design by government and other stakeholders to compensate farmers who engage in environmentally friendly agricultural practices to enhance their adoption.

Finally, the results from the Tobit regression revealed that age of the farmer, educational level of the farmer, and cost of production positively influenced the willingness to accept payment before adopting ecosystem-friendly farming practices. It is therefore recommended that, the youth should be encouraged to go into agriculture since they are energetic to carry out EFFPs without necessarily demanding payment. It is also recommended that both public and private agencies should educate farmers on the negative effect of environmental degradation through bad farming practices. The government should also ensure that farmers' cost of production is reduced through agricultural subsidy programmes to create an incentive for free adoption and allow the farmers some extra income to undertake long term farm investments.

Variables such as sex of the farmer, household size, membership of farmer base organisation, and extension services negatively influenced the willingness to accept payment before adopting EFFPs. It is further recommended that female farmers should be empowered to have access to productive farm lands to be financially independent and make appropriate farming decisions. Farmer should be supported and advised to substitute household labour (children at school growing age) with hired labour to carry out labour intensive practices. Since farmers' group meetings enhances their ability to practically adopt ecosystem-friendly farming practices reduces the demand for payment before adoption, government and other development agencies should promote farmer groups (FBOs) and cooperatives. It is also highly recommended that the extension agent to farmer ratio should be improved and extension agents should endeavour to provide knowledge, skills and information to farmers on the adoption of the technologies to boost ecosystem biodiversity and productivity.

5.5 Suggestions for further research

The main purpose of the study was to determine the adoption of ecosystem-friendly farming practices among rain-fed and irrigated smallholder farmers in the study area.

However, the following research gaps were identified and need to be addressed by further research:

1. Since most farmers in the study area had perceived/agreed that crop rotation with cover crops, mulching, agroforestry, organic farming, soil bounding, and control burning of farms are ecosystem-friendly technologies, future studies should be done on the extent to which each of the practice contributes to ecosystem sustainability.

2. This study employed a hypothetical market **(**contingent valuation method**)** to estimate the amount farmers are willing to accept before adoption, future research should be conducted on the actual willingness amount since EFFPs are tangible and can be measured.

3. There should be further research on quantitative analysis of trade-off/opportunity cost/farm level benefit cost analysis to smallholder farmers resulting from ecosystem-friendly farming practices adoption and not only the amount they are willing to receive as compensation.

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APPENDICES

Appendix I: Survey Questionnaire

WATER, LAND AND ECOSYSTEM (WLE)/UNIVERSITY FOR DEVELOPMENT STUDIES (UDS), TAMALE, GHANA
DEPARTMENT OF AGRICULTURAL AND RESOURCE ECONOMICS (ARE)

SURVEY QUESTIONNAIRE ON ADOPTION OF ECOSYSTEM FRIENDLY FARMING PRACTICES AMONG IRRIGATED AND RAIN-FED SMALLHOLDER FARMERS IN NORTHERN REGION

Disclaimer and Consent:

Dear Research Participant(s),

The aim of this survey is to assess the **adoption of ecosystem-friendly farming practices among irrigated and rain-fed smallholder farmers in northern region**. It is a study in partial fulfillment for the award of Master of Philosophy (M.Phil.) Degree in Agricultural Economics at the University for Development Studies (UDS), Tamale. Thus, the information obtained through this interview is for academic purposes only and will be accorded the highest degree of confidentiality. Your consent is therefore sought to provide frank responses to the questions contained in this questionnaire. Thank you for your cooperation and understanding.

NOTE: All open-ended questions must be given a verbatim comment from the respondents (farmers) and tick [√] appropriately for close-ended questions.

PART I

QUESTIONNAIRE IDENTITY

1. Name of enumerator:…………… Contact details:……………………………

2. Date of interview:…………… Region:……………District: ……………………

3. Name of community: …………Questionnaire number: …………………………

4. Name of respondent: …………………Contact details: …………………………

PART II

SOCIO-DEMOGRAPHIC DATA

5. Sex of respondent: **1. Male [ ]** **2. Female [ ]**

6. Are you the household head? **1. Yes [ ]** **2. No [ ]**

7. Relationship of respondent with household head ***(if respondent is not household head)*…………………………………………………………………………………**

8. Age …………… **years old**.

9. What is your highest educational level completed?

1. None **[ ]** 2. Non-formal education **[ ]** 3. Primary **(class 1 – 6) [ ]** ……….years

4. JHS/MSLC **[ ]** ……….years 5. SHS/Vocational/Technical School **[ ]** ……….years

6. Tertiary **(Training college, university, polytechnic) [ ]** ……….years

10. Marital status of respondent?

1. Single **[ ]** 2. Married **[ ]** 3. Separated **[ ]** 4. Divorced **[ ]** 5. Widowed **[ ]**

11. How many people live in your household (including yourself and wife(s)) and eat from the same pot? ………………**people**

12. How many of the household members are engaged actively in farming activities? ……………**people**

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

Household Category	**Total Number of Household Members**	
Age	Males	Females
0 –14 years		
15 – 34 years		
35 – 54 years		

55 – 74 years		
Above 75 years		
Sex		
0 –14 years		
15 – 24 years		
25 – 54 years		
55 – 64 years		
Above 65 years		
Level of Education		
None		
Primary		
JHS		
SHS		
Tertiary		

14. Are you a native of this community? **1. Yes [ ]** **2. No [ ]**

15. What is your ethnic affiliation? **1. Dagomba [ ]** **2. Gonja [ ]** **3. Mamprusi [ ]** **4. Frafra [ ] 5. Akan Kasena/Nankana [ ] 6. Other (*Please specify*)…………………**

16. What is your religious affiliation? **1. Muslim [ ] 2. Christian [ ]** **3. Traditional [ ]** **4. None [ ]**

17. What is your main occupation? **1. Farming [ ] 2. Daily wage labour (farming or non-farm activities) [ ] 3. Salaried worker [ ] 4. Petty trading [ ] 5. Craftsman (example, bricklayer, carpenter, tailor, among others) [ ] 6. Other (*Please specify*) [ ]………..**

18. Indicate the average annual income last year (**2014**)

Source of income		**Amount (GH₵)**
m income	Income from crops and vegetables	
	Income from livestock, including poultry birds	
-farm ome	Farm labor (by-day)	
	Non-farm (e.g. trading, salary)	
er (specify, e.g. pension, remittance, grants, gift etc)		

19. How would you rate the level of satisfaction for your household on the following livelihood outcomes?

Livelihood Outcome	**Rating of Satisfaction**			
	1. ***High***	2. ***Moderate***	3. ***Low***	4. ***Not Satisfactory***
Health				
Education				

Cash security				
Food security				
Housing security				
General security				

PART III
FARMER AND FARM CHARACTERISTICS

20. Indicate the production system: **1. Irrigation** [ ] **2. Rain-fed** [ ] **3. Both** [ ]

21. If irrigation, what is your source of water for production? **1. Dam** [ ] **2. River** [ ] **3. Dug-out** [ ] **4. Bucket-kit** [ ] **5. Others……………………**

22. Number of years in farming and average annual income obtain from each system last year (**2014**)

Production system	Farming experience (**years**)	Average annual income(**GH₵**)
Irrigation		
Rain-fed		

23. Do you belong to any farmer base organization (**FBO**)/association/NGO? **1. Yes [ ] 2. No [ ]**

24. Do you have access to extension services? **1. Yes [ ] 2. No [ ]**

25. If **yes**, number of extension contact in a year ………………….**time(s)**

26. What is nearest distance from home to the inputs shop? ……………………….(**mile/km**)

27. Do you have access to market for your farm produce? **1. Yes [ ] 2. No [ ]**

28. If **yes**, what is the distance from your home to accessible market? ………………….. (**mile/km**)

29. Do you have access to credit? **1. Yes [ ] 2. No [ ]**

30. If **yes**, source of the credit? **1. Banks [ ] 2. Credit unions [ ] 3. Co-operative [ ] 4. Susu [ ] 5. Family and friends [ ] 6. Other(s), please specify……………………**

31. What is the amount you obtained from the credit facility last year **(2014)**? ………**GH₵**

32. If **no** to question **28**, why? ……………………………………

33. Do you have access to land? **1. Yes [ ]** **2. No [ ]**

34. Indicate how much land you had access last year **(2014)** and its characteristics in the table below: **Total land……………………acres**

	Size of land (acre)	**Area cultivated(acre)**	**Own land/Share cropping/Rented/Gift (O-0, S-1, R-2, G-3)**	**Distance of farm from home (kg/mile)**	**Irrigated/Rain-fed (I-0, R-1)**
t 1					
t 2					
t 3					
t 4					

Note: use the codes

35. Please, fill-in the table about the crops and vegetables grown last year **(2014)** (**kg/bags/crates/bowls**)

Crops	**Total land(acre)**	**Area cultivated**	**Output (kg or bags)**	**Quantity of bags sold**	**Unit price (GH₵)**	**No. of bags consumed**
Vegetables						

Example of crops and vegetables; *maize, millet, guinea corn, yam, cowpea, groundnut, soybean, cassava, sweet potato, bambara groundnut, rice, watermelon, okro, pepper, aleafu, onion, carrot, cabbage, tomato, bra, etc.*

36. Please, fill-in the table about the livestock and poultry kept from last year to this year (**2014-2015**)

Livestock	**Number last year (2014)**	**Number this year (2015)**	**Number sold**	**Unit price (GH₵)**	**Number consumed**
Poultry					

ample of livestock and poultry: *cattle, sheep, goat, pig, donkey, fowl, guinea fowl, duck, key etc.*

PART IV

FARMER PERCEPTION ABOUT ECOSYSTEM, ECOSYSTEM SERVICES AND DISSERVICES

37. What do you understand by environment (ecosystem)?..

38. Identify the environmental/ecosystem services provided by nature (**Please, use the codes where appropriate**)

ecosystem services	Place of collection	Distance travel(**mile/km**)	Importance: **1=very important 2= important 3=somewhat important 4= least important 5=not important 6=don't know**	Reason for collection: **1=household consumption 2=selling 3=both 4=others…… ……**
a. Harvestable services				
l wood				
h meat				
dicinal plants				
ber/grass for housing				
ey				
ı				
d fruits				
mal feeds				
er………………..				
a. Non-harvestable services				
you know that the ecosystem/natural environment provides other services that you cannot see or touch? **1. Yes [ ]** **2. No [ ]** If **yes**, specify 1…………… 2……………… 3…………… 4…………… 5……………				

39. What are the human use and dependency on these services based on the following listed below

Ecosystem service	**Local level**	**Regional levels**	**Global scales**
Provisioning services			

Regulatory services			
Cultural services			
Supporting services			
Who benefits	**Local level**	**Regional levels**	**Global level**
Provisioning services			
Regulatory services			
Cultural services			
Supporting services			

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

40. What is your perceptions about the ecosystem services functioning in irrigated and rain-fed landscapes/site **10-20** years ago

Ecosystem service	Observed changes: 1-**increasing** 2-**decreasing** 3-**same**		Effects: 1-**positive** 2-**negative** 3-**don't know**	
	Irrigated farm	Rain-fed farm	Irrigated farm	Rain-fed farm
visioning services				
Regulatory services				
Cultural services				
Supporting services				

Note: use the codes

41. How important are the following benefits provided by the ecosystem in your community? **Please tick [√] appropriately in the table below**

Ecosystem services/Functions	**Very important**	**important**	**Somewhat Important**	**least important**	**Not important**	**Don't know**

Crops/vegetable							
Animals(domestic)							
Animals(wild)							
Firewood							
Honey							
Tourist attraction							
se of place							
ıber							
ter							
od control							
ı							
dicinal							
ritual values							
lination							
t and disease control							
ılthy soil							

le: 1=very important **2**= important **3**=somewhat important **4**= least important **5**=not ortant **6**=don’t know

42. Are these services in question **41** at risk or in decline? **1. Yes [ ]** **2. No [ ]**

43. If **yes**, what is the cause?

…………………………………………………………………………………………….

44. What is the impact of agricultural intensification/practices on ecosystem services? ……………………………………………………………….

45. How can we prevent environmental (ecosystem service) degradation?

....

46. List some of the ecosystem disservices that affect irrigated and rain-fed agriculture in the table below

Ecosystem Disservices	
Irrigated farm	**Rain-fed farm**

:e: E***cosystem disservices*** *(pest damage, disease damage, competition for water and nutrients weeds and trees, habitat loss, nutrients run-off, pesticides poisoning, herbicides poisoning, ilizer pollution, flooding, bush burning, among others)*

PART V

FARMER ADOPTION OF ECOSYSTEM FRIENDLY PRACTICES (EFPs)

47. Please, list the current farming practices that you are engaged in your farming

	Irrigated farm	Rain-fed farm
Farming activities or practices		

:e: *mulching, crop rotation, intercropping, minimal/no-tillage, maximum/mechanized tillage, organic manuring, application of chemical fertilizers, application of herbicides and pesticides, burning of farm, burning of bush, clearing of trees in the field, agroforestry, cover cropping, afforestation, etc.*

48. Do you think these activities or practices are ecosystem friendly? **1. Yes [ ] 2. No [ ]**

49. If yes, why? ………………………………………………………….…………..

50. If no, why? ……………………………………………………………………

51. Which of the following practices are you engaged (**tick [√]** ***as many as applicable***): 1. **Agroforestry** [ ] **2. Mulching** [ ] **3. Crop rotation with cover crops** [ ]

4. Soil bonding [ ] **5. Organic farming** [ ] **6. Control burning** [ ]

52. Indicate your perception about these ecosystem friendly practices using **ranking** in the table below

Ecosystem friendly practice (EFP)	**1**	**2**	**3**	**4**	**5**	**6**
Agroforestry						
lching and						
p rotation with cover crops						
l bonding						
;anic farming						
ıtrol burning						

le: 1=very important **2**= important **3**=somewhat important **4**= least important **5**=not ıortant **6**= not important at all.

53. Have you adopted to any of the ecosystem friendly practices (**EFFPs**) in question **51** above? **1. Yes [ ]** **2. No [ ]**

54. If **yes** adopted, mention them ……………………………………………………………………………………………

55. If **no**, why? ……………………………………………………………………………

56. What are some of the benefits for adopting the ecosystem friendly practices (**EFPs**) base on the following?

Category	**Associated benefits**
Human	
Environment	
Crops	
Animals	
Soil and Water	

57. What are some of the negative effects for not adopting the ecosystem friendly practices (**EFPs**) base on the following?

Category	Associated negative effects
Human	
Environment	
Crops	
Animals	
Soil and Water	

PART VI

FARMER WILLINGNESS TO ADOPT ECOSYSTEM FRIENDLY

58. What is your attitude towards conservation of the environment (ecosystem)?

1. P**ositive** [ ] **2. Negative [ ]**

59. Which of the following farm practices can or has caused a change in soil fertility, crop yields, animal rearing, vegetation cover, tree population, rainfall patterns, temperatures, and human health?

1. Use of chemical fertilizers [ ] 2. Use of herbicides [ ] 3. Use of pesticides/insecticides [ ] 4. Bush burning [ ] 5. Cutting of trees for fuel wood [ ] 6. Over tillage [ ] 7. Others…………………………………………………

60. Indicate your cost of production in the last year (**2014**) cropping season in the table below

Item/activity	**Production system**					
	Rain-fed agriculture			Irrigated agriculture		
		Unit cost (GH₵)	**Total cost (GH₵)**		**Unit cost (GH₵)**	**Total cost (GH₵)**
Land preparation (tractor, animal, manual)						
Seeding planting (seeds & planting						

cost)						
Weeding						
Watering (irrigation charges)						
Fertilizers (NPK, Urea, 23-10, NH_3, organic)						
Herbicides (litres)						
ticides/insecticides (litres)						
vesting						
cessing and storage						
nsportation (from farm & to ket)						
d (if rented)						
ers ………………						

61. Do you agree that the activities and use of these inputs in question **59** cannot result in the sustainability of the environment (ecosystem) for both current and future generations? **1. Yes [ ]** **2. No [ ]**

62. **If yes,** how many of these ecosystem friendly practices can you and be willing to adopt to ensure the sustainability of the environment and yield? **(Tick [√] as many as appropriate).** 1. **Agroforestry** [ ] **2. Mulching** [ ] **3. Crop rotation with cover crops** [ ] **4. Soil bonding** [ ] **5. Organic farming** [ ] **6. Control burning** [ ] 7. **Others (specify)…………………………………………**

63. What are the likely changes in environmental sustainability (ecosystem services provision) as a result of changing/improving good farm practices?

1. **Increasing [ ]** **2. Decreasing [ ]** **3. Remain the same [ ]** **4. Don't know [ ]**

64. Would you accept payment to adopt all the above practices? **1. Yes [ ]** **2. No [ ]**

65. If yes, what is highest amount would accept as payment? (*please*, **tick** [√] ***ONLY ONE*** *as the highest amount per acre per year*)

1- GH₵ **0** **[ ]** 2- GH₵ **50[ ]** 3- GH₵ **100 [ ]** 4- GH₵ **150 [ ]** 5- GH₵ **200 [ ]**

6- GH₵ **250 [ ]** 7- GH₵ **300 [ ]** 8- GH₵ **350 [ ]** 9- GH₵ **400 [ ]** 10- GH₵ **450 [ ]**

11- GH₵ **500 [ ]** 12- above GH₵**500 [ ] 13- if above** GH₵**500, state amount………**

66. What kind of ecosystem services will you supply/provide?

1. Provisioning [ ] **2. Regulatory [ ]** **3. Cultural [ ]** **4. Supporting [ ]**

5. All the both [ ]

67. How much will you be paid for the supply of these services? ………………………**GH₵**

68. Considering the cost you incurred on inputs and farm activities in question **60**, if a program is run by the government or a nongovernmental organization would pay you to adopt all the ecosystem friendly practices in question **62** above, will you participate in the program/contract? **1. Yes [ ]** **2. No [ ]**

69. If **yes**, how many acres of land would you enroll in this program?..........................**acre(s)**

70. **If yes,** how much would you be willing to accept as payment to adopt each of the ecosystem friendly practices in question **62? (please, probe for maximum amount)**

Ecosystem friendly practices	**Amount**	**No. of Acres**
roforestry	1- GH₵ **0 [ ]** 2- GH₵ **1-50 [ ]** 3- GH₵ **51-100 [ ]** 4- GH₵ **101-150 [ ]** 5- GH₵ **151-200 [ ]** 6- GH₵ **201-250 [ ]** 7- above GH₵ **250 [ ]**	
lching	1- GH₵ **0 [ ]** 2- GH₵ **1-50 [ ]** 3- GH₵ **51-100 [ ]** 4- GH₵ **101-150 [ ]** 5- GH₵ **151-200 [ ]** 6- GH₵ **201-250 [ ]** 7- above GH₵ **250 [ ]**	
Crop rotation with cover crops	1- GH₵ **0 [ ]** 2- GH₵ **1-50 [ ]** 3- GH₵ **51-100 [ ]** 4- GH₵ **101-150 [ ]** 5- GH₵ **151-200 [ ]** 6- GH₵ **201-250 [ ]** 7- above GH₵ **250 [ ]**	
Soil bonding	1- GH₵ **0 [ ]** 2- GH₵ **1-50 [ ]** 3- GH₵ **51-100 [ ]** 4- GH₵ **101-150 [ ]**	

	5- GH₵ **151-200** [ ] 6- GH₵ **201-250** [ ] 7- above GH₵ **250** [ ]	
Organic farming	1- GH₵ **0** [ ] 2- GH₵ **1-50** [ ] 3- GH₵ **51-100** [ ] 4- GH₵ **101-150** [ ] 5- GH₵ **151-200** [ ] 6- GH₵ **201-250** [ ] 7- above GH₵ **250** [ ]	
ıtrol burning	1- GH₵ **0** [ ] 2- GH₵ **1-50** [ ] 3- GH₵ **51-100** [ ] 4- GH₵ **101-150** [ ] 5- GH₵ **151-200** [ ] 6- GH₵ **201-250** [ ] 7- above GH₵ **250** [ ]	
al willingness to adopt ΓA) value		

Note: avoid double counting of acres in each practice (do not count same plot twice)

71. If no to question **62, why?……………………………………………………………**

PART VII
CONSTRAINTS FARMERS FACED IN ADOPTING ECOSYSTEM FRIENDLY PRACTICES (EFPs)

72. Do you face any challenges/constraints when adopting ecosystem friendly practices? **1. Yes [ ]** **2. No [ ]**

73. If **yes**, mention them using the table below

challenges/constraints(both irrigated and rain-fed farm) for men	**rank**	challenges/constraints(both irrigated and rain-fed farm) for women	**rank**

NB: **Ranging** f**rom 1to 5 (1**=very important **2**= important **3**=somewhat important **4**= least important **5**=not important)

74. If **no**, why? ....

75. Identify your strengths, weakness, opportunities, and threats in adopting ecosystem friendly practices in the table below

Strengths	**Weakness**	**Opportunities**	**Threats**

76. Please, rank the constraints you face in adopting ecosystem friendly practices in question **72** above in the table below

Constraint	**Rank**

77. Do you have any suggestion about what needs to be done to help farmers increase the adoption of ecosystem friendly practices**?**

...

...

...

THANKS FOR PARTICIPATION AND GOD BLESS YOU

Appendix II: Focus group and key informant discussions guide

SECTION A

Agricultural issues

1. Mention the farming practices that are commonly employed in the farming
2. Can all the practices help sustain yield and environment? **1. Yes [ ] 2. No [ ]**

a. If **no**, which of them can and which of them cannot sustain yield and environment?

3. Who is the owner of farm lands in this community?

a. How do people get access to farm land (**e.g. inheritance, sharecropping, borrowing, purchasing, renting etc.**)?

b. Where do these farm plots found (e.g. bush, forest, backyard, dams, and river)?

c. Does the accessibility of land changes seasonally? **1. Yes [ ] 2. No [ ]**

4. Mention the farm inputs applied on your farms?

SECTION B

FARMERS UNDERSTANDING AND PERCEPTION ABOUT ECOSYSTEM, ECOSYSTEM SERVICES AND DISSERVICES

5. What do you understand by environment (ecosystem)?...

6. What is your perceptions about the ecosystem services functioning in irrigated and rain-fed landscapes/site **10-20** years ago

Ecosystem service	Observed changes: 1-**increasing** 2-**decreasing** 3-**same**		Effects: 1-**positive** 2-**negative** 3-**don't know**	
	Irrigated farm	Rain-fed farm	Irrigated farm	Rain-fed farm
Provisioning services				
Regulatory services				
Cultural services				
Supporting services				

Note: use the codes

7. How important are the following benefits provided by the ecosystem in your community? **Please tick [√] appropriately in the table below**

Ecosystem services/Functions	**Very important**	**important**	**Somewhat Important**	**least important**	**Not important**	**Don't know**
Crops/vegetable						
mals(domestic)						
mals(wild)						
ewood						
ney						
urist attraction						
se of place						
nber						
ter						
od control						
n						
dicinal						
ritual values						
lination						
t and disease control						
lthy soil						

de: 1=very important **2**= important **3**=somewhat important **4**= least important **5**=not important **6**=don't know

a. Are these services in question **3** at risk or in decline? **1. Yes [ ] 2. No [ ]**

b. If **yes**, what is the cause?…………………………………………..

c. If no, why? ……………………………………………………….

d. How can we prevent environmental (ecosystem service) degradation?

……

……

8. List some of the ecosystem disservices that affect irrigated and rain-fed agriculture in the table below

Ecosystem Disservices	
Irrigated farm	**Rain-fed farm**

:e: E***cosystem disservices*** *(pest damage, disease damage, competition for water and nutrients weeds and trees, habitat loss, nutrients run-off, pesticides poisoning, herbicides poisoning, ilizer pollution, flooding, bush burning, among others)*

SECTION C

FARMER ADOPTION OF ECOSYSTEM FRIENDLY PRACTICES (EFPs)

9. Please, list the current farming practices that you are engaged in your farming

	Irrigated farm	**Rain-fed farm**
ming activities ..ıractices		

Note: *mulching, crop rotation, intercropping, minimal/no-tillage, maximum/mechanized tillage, organic manuring, application of chemical fertilizers, application of herbicides and pesticides, burning of farm, burning of bush, clearing of trees in the field, agroforestry, cover cropping, afforestation, etc.*

a. Classify among the practices, those that are friendly to the environment and those that are not friendly

b. Which of the following practices will you adopt (**tick [√]** ***as many as applicable***):

1. **Agroforestry** [ ] **2. Mulching** [ ] **3. Crop rotation with cover crops** [ ] **4. Soil bonding** [ ] **5. Organic farming** [ ] **6. Control burning** [ ]

c. Indicate your perception about these ecosystem friendly practices by **ranking** in the table below

Ecosystem friendly practice (EFP)	1	2	3	4	5	6
:oforestry						
lching and						
p rotation with cover crops						
l bonding						
;anic farming						
ıtrol burning						

ıle: 1=very important **2**= important **3**=somewhat important **4**= least important **5**=not ›ortant **6**= not important at all.

SECTION D

FARMER WILLINGNESS TO ADOPT ECOSYSTEM FRIENDLY PRACTICES (EFPs)

10. What is your attitude towards conservation of the environment (ecosystem)? **1. P**ositive[] **2. Negative [ ]**

11. Which of the following farm practices can or has caused a change in soil fertility, crop yields, animal rearing, vegetation cover, tree population, rainfall patterns, temperatures, and human health?

1. Use of chemical fertilizers [ ] 2. Use of herbicides [ ] 3. Use of pesticides/insecticides [ ] 4. Bush burning [ ] 5. Cutting of trees for fuel wood [ ]
6. Over tillage [ ] 7. Others………………………………………………………………

a. Do you all agree that the activities and use of these inputs in question **11** cannot result in the sustainability of the environment (ecosystem) for both current and future generations? **1. Yes [ ] 2. No [ ]**

b. **If yes,** which of the following ecosystem friendly practices can or will you adopt to ensure the sustainability of the environment and yield? **(Tick [√] as many as appropriate).**

1. **Agroforestry** [ ] **2. Mulching** [ ] **3. Crop rotation with cover crops** [ ] **4. Soil bonding** [ ] **5. Organic farming** [ ] **6. Control burning** [ ] 7. **Others (specify)……**

c. Would you accept payment to adopt all the above practices? **1. Yes [ ] 2. No [ ]**

d. If yes, what is highest amount would this community accept as payment? (*please,* **tick [√]** ***ONLY ONE*** *as the highest amount per acre per year*)

1- GH₵ **0 [ ]** 2- GH₵ **50[ ]** 3- GH₵ **100 [ ]** 4- GH₵ **150 [ ]** 5- GH₵ **200 [ ]** 6- GH₵ **250 [ ]** 7- GH₵ **300 [ ]** 8- GH₵ **350 [ ]** 9- GH₵ **400 [ ]** 10- GH₵ **450 [ ]** 11- GH₵ **500 [ ]** 12- above GH₵**500 [ ] 13- if above** GH₵**500, state amount……….**

SECTION E

CONSTRAINTS FARMERS FACED IN ADOPTING ECOSYSTEM-FRIENDLY FARMING PRACTICES (EFFPs)

12. Do you face any challenges/constraints when adopting ecosystem friendly practices in this community? **1. Yes [ ] 2. No [ ]**

a. If **yes**, mention and rank them in the table below

challenges/constraints(both irrigated and rain-fed farm) for men	**rank**	challenges/constraints(both irrigated and rain-fed farm) for women	**rank**

NB: **Ranging from 1to 5 (1**=very important **2**= important **3**=somewhat important **4**= least important **5**=not important)

b. If **no**, why? ....

13. Identify your strengths, weakness, opportunities, and threats in adopting ecosystem friendly practices in the table below

Strengths	**Weakness**	**Opportunities**	**Threats**

14. General suggestions about what needs to be done to help farmers in this community increase the adoption of ecosystem friendly practices**?**

..

..

..

..

..

THANKS AND GOD BLESS YOU ALL

Appendix III: STATA Output of Poisson Regression for Overall/General Analysis

```
Poisson regression                            Number of obs   =        300
                                              LR chi2(14)     =      57.23
                                              Prob > chi2     =     0.0000
Log likelihood = -491.13864                   Pseudo R2       =     0.0551
```

Ifyes_Ecofriendly_Practice_Adopt	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Sex_respondent	-.0736299	.0733294	-1.00	0.315	-.2173528	.070093
Age	.0057893	.0031935	1.81	0.070	-.0004699	.0120485
Educational_level	.0599316	.0303571	1.97	0.048	.0004327	.1194305
HH_size	-.0055793	.0060238	-0.93	0.354	-.0173856	.0062271
Income_Others	.0003937	.0002735	1.44	0.150	-.0001424	.0009297
Production_System	-.0432348	.0661546	-0.65	0.513	-.1728955	.0864259
Belong_FBO	.0986806	.0882849	1.12	0.264	-.0743547	.2717158
Access_Extension_Services	-.1528317	.0830421	-1.84	0.066	-.3155912	.0099278
Access_Credit	.0285827	.0737598	0.39	0.698	-.1159839	.1731492
Total_Income	-.0000171	.0000114	-1.50	0.134	-.0000396	5.26e-06
Access_Market	.1348862	.139426	0.97	0.333	-.1383838	.4081561
Farming_Practices_Adopted	.1983798	.0404488	4.90	0.000	.1191016	.2776579
Willingness_Participate_Contract	.2281972	.2513423	0.91	0.364	-.2644246	.7208191
WTA_Amount	.0003238	.0001548	2.09	0.036	.0000204	.0006272
_cons	-.0780186	.3527508	-0.22	0.825	-.7693974	.6133603

```
Marginal effects after poisson
      y  = Predicted number of events (predict)
         =  2.5850654
```

variable	dy/dx	Std. Err.	z	P>|z|	[95%	C.I.]	X
Sex_re~t*	-.1903811	.18956	-1.00	0.315	-.561905	.181143	.5
Age	.0149657	.00824	1.82	0.069	-.001179	.03111	37.02
Educat~l	.1549272	.0783	1.98	0.048	.00146	.308395	1.69667
HH_size	-.0144228	.01557	-0.93	0.354	-.04493	.016084	10.4933
Income~s	.0010176	.00071	1.44	0.150	-.000368	.002403	23.3667
Produc~m	-.1117647	.17096	-0.65	0.513	-.446845	.223316	2.57
Belong~O*	.2561243	.23	1.11	0.265	-.194664	.706912	.463333
Access~s*	-.3982952	.21788	-1.83	0.068	-.825341	.02875	.546667
Acces~it*	.0740315	.19139	0.39	0.699	-.301086	.449149	.433333
Total_~e	-.0000443	.00003	-1.50	0.133	-.000102	.000014	1983.92
Acces~et*	.3297345	.32187	1.02	0.306	-.301125	.960594	.92
Farm~ted	.5128247	.10321	4.97	0.000	.310536	.715113	2.57667
Willin~t*	.5314653	.52512	1.01	0.311	-.497745	1.56068	.966667
WTA_Am~t	.000837	.0004	2.10	0.036	.000055	.001619	347.933

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

Appendix IV: STATA Output of Poisson Regression for Kumbungu District

Poisson regression	Number of obs	=	113
	LR chi2(14)	=	23.44
	Prob > chi2	=	0.0535
Log likelihood = -176.40538	Pseudo R2	=	0.0623

Ifyes_Ecofriendly_Practice_Adopt	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Sex_respondent	-.1177866	.1514601	-0.78	0.437	-.4146429	.1790698
Age	.0053166	.0055887	0.95	0.341	-.005637	.0162703
Educational_level	.0878633	.0534454	1.64	0.100	-.0168878	.1926144
HH_size	-.002116	.0045614	-0.46	0.643	-.0110563	.0068242
Income_Offfarm	.0000214	.0001107	0.19	0.847	-.0001955	.0002383
Total_Income	-.000012	.0000264	-0.46	0.649	-.0000638	.0000398
Production_System	-.0764869	.1285919	-0.59	0.552	-.3285223	.1755486
Belong_FBO	-.0553724	.1727127	-0.32	0.749	-.3938831	.2831383
Access_Extension_Services	.0129583	.1588328	0.08	0.935	-.2983482	.3242649
Access_Market	.0298889	.1889783	0.16	0.874	-.3405018	.4002796
Access_Credit	.2550452	.1524064	1.67	0.094	-.0436659	.5537562
Farming_Practices_Adopted	.2935185	.08352	3.51	0.000	.1298223	.4572147
ingness_Participate_Contract	.0899793	.3547888	0.25	0.800	-.605394	.7853526
WTA_Amount	.0003979	.0002674	1.49	0.137	-.0001261	.0009219
_cons	-.1865136	.7107271	-0.26	0.793	-1.579513	1.206486

x

inal effects after poisson
  y = Predicted number of events (predict)
     = 2.4723758

able	dy/dx	Std. Err.	z	P>|z|	[	95% C.I.]	X
re~t*	-.2998543	.39672	-0.76	0.450	-1.0774	.477695	.743363
Age	.0131447	.0138	0.95	0.341	-.013908	.040198	36.6726
at~l	.217231	.13152	1.65	0.099	-.040544	.475006	1.88496
size	-.0052316	.01127	-0.46	0.643	-.027327	.016863	12.9027
me~m	.0000529	.00027	0.19	0.847	-.000483	.000589	152.699
Total_~e	-.0000298	.00007	-0.46	0.649	-.000158	.000098	1821.83
Produc~m	-.1891043	.3177	-0.60	0.552	-.811788	.43358	2.48673
Belong~O*	-.1362162	.42282	-0.32	0.747	-.96492	.692487	.40708
Access~s*	.0320179	.39222	0.08	0.935	-.736724	.80076	.548673
Acces~et*	.0731893	.4583	0.16	0.873	-.825058	.971437	.823009
Acces~it*	.6652164	.41802	1.59	0.112	-.154081	1.48451	.300885
Farm~ted	.725688	.20207	3.59	0.000	.329646	1.12173	2.54867
Willin~t*	.2135965	.80804	0.26	0.792	-1.37014	1.79733	.955752
WTA_Am~t	.0009837	.00066	1.49	0.136	-.000308	.002276	338.903

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

APPENDIX V

STATA Output of Poisson Regression for Savelugu-Nanton District

```
Poisson regression                              Number of obs     =         95
                                                LR chi2(14)       =      21.63
                                                Prob > chi2       =     0.0865
Log likelihood = -152.23903                     Pseudo R2         =     0.0663
```

Ifyes_Ecofriendly_Practice_Adopt	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Sex_respondent	-.0624912	.1919425	-0.33	0.745	-.4386916	.3137092
Age	.007921	.0072469	1.09	0.274	-.0062827	.0221248
Educational_level	.0084508	.0508537	0.17	0.868	-.0912205	.1081222
HH_size	-.0041966	.0100462	-0.42	0.676	-.0238868	.0154936
Income_Others	.0006497	.0007568	0.86	0.391	-.0008337	.002133
Total_Income	.0000373	.0000536	0.70	0.486	-.0000677	.0001422
Production_System	-.0071212	.1538491	-0.05	0.963	-.3086599	.2944174
Belong_FBO	-.0152059	.2228817	-0.07	0.946	-.4520461	.4216343
Access_Extension_Services	-.0311782	.2273528	-0.14	0.891	-.4767815	.414425
Access_Market	.087751	.1905164	0.46	0.645	-.2856543	.4611563
Access_Credit	-.0607973	.1558251	-0.39	0.696	-.3662089	.2446142
Farming_Practices_Adopted	.1214598	.0831017	1.46	0.144	-.0414164	.2843361
ingness_Participate_Contract	.3581158	.5406084	0.66	0.508	-.7014571	1.417689
WTA_Amount	.0004394	.0003431	1.28	0.200	-.000233	.0011119
_cons	-.0391039	.6726609	-0.06	0.954	-1.357495	1.279287

```
x

inal effects after poisson
  y  = Predicted number of events (predict)
     =  3.0154195
```

able	dy/dx	Std. Err.	z	P>|z|	[	95% C.I.]	X
re~t*	-.190149	.58922	-0.32	0.747	-1.345	.964703	.642105
Age	.0238853	.0218	1.10	0.273	-.018846	.066616	38.4211
at~l	.0254828	.15335	0.17	0.868	-.275076	.326041	1.88421
size	-.0126544	.03028	-0.42	0.676	-.072008	.0467	10.6737
me~s	.0019591	.00228	0.86	0.391	-.002513	.006431	17.3684
l_~e	.0001124	.00016	0.70	0.486	-.000204	.000429	1777.52
uc~m	-.0214735	.46392	-0.05	0.963	-.930738	.887791	2.63158
ng~O*	-.0459371	.67459	-0.07	0.946	-1.36811	1.27623	.621053
ss~s*	-.0945298	.69308	-0.14	0.892	-1.45293	1.26388	.673684
s~et*	.2563889	.53912	0.48	0.634	-.80026	1.31304	.863158
Acces~it*	-.1801589	.45366	-0.40	0.691	-1.06931	.708995	.210526
Farm~ted	.3662524	.24981	1.47	0.143	-.12337	.855875	2.57895
Willin~t*	.914534	1.15722	0.79	0.429	-1.35358	3.18265	.978947
WTA_Am~t	.0013251	.00103	1.28	0.199	-.000697	.003347	346.737

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

Appendix VI: STATA Output of Poisson Regression for Tolon District

```
Poisson regression                              Number of obs     =         92
                                                LR chi2(14)       =      24.58
                                                Prob > chi2       =     0.0390
Log likelihood =  -150.5927                     Pseudo R2         =     0.0754
```

Ifyes_Ecofriendly_Practice_Adopt	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Sex_respondent	.0343548	.1822497	0.19	0.850	-.3228481	.3915576
Age	.0128965	.0065802	1.96	0.050	-5.25e-07	.0257936
Educational_level	.0734857	.1131575	0.65	0.516	-.1482989	.2952703
HH_size	-.0040187	.0098086	-0.41	0.682	-.0232432	.0152059
Income_Offfarm	-.0006067	.0003788	-1.60	0.109	-.0013493	.0001358
Total_Income	-.0000126	.000015	-0.84	0.402	-.000042	.0000168
Production_System	.0582637	.1273659	0.46	0.647	-.1913689	.3078963
Belong_FBO	.1984962	.1686441	1.18	0.239	-.1320401	.5290326
Access_Extension_Services	-.3638606	.1731461	-2.10	0.036	-.7032208	-.0245005
Access_Market	.6993138	.4323804	1.62	0.106	-.1481361	1.546764
Access_Credit	.3055575	.2068934	1.48	0.140	-.0999461	.7110611
Farming_Practices_Adopted	.2241608	.0843892	2.66	0.008	.058761	.3895607
Willingness_Participate_Contract	.197851	.5625615	0.35	0.725	-.9047492	1.300451
WTA_Amount	.0001101	.0002914	0.38	0.706	-.0004611	.0006813
_cons	-1.165198	.7514522	-1.55	0.121	-2.638017	.3076216

```
. mfx

Marginal effects after poisson
      y  = Predicted number of events (predict)
         =  2.2017928
```

variable	dy/dx	Std. Err.	z	P>|z|	[95%	C.I.]	X
Sex_re~t*	.0755611	.40044	0.19	0.850	-.709284	.860406	.532609
Age	.0283955	.01436	1.98	0.048	.000259	.056532	36
Educat~l	.1618003	.24894	0.65	0.516	-.326123	.649723	1.27174
HH_size	-.0088482	.02159	-0.41	0.682	-.051169	.033472	9.51087
Income~m	-.0013359	.00083	-1.61	0.107	-.002962	.000291	153.304
Total_~e	-.0000277	.00003	-0.84	0.401	-.000092	.000037	2396.14
Produc~m	.1282845	.28026	0.46	0.647	-.42101	.677579	2.6087
Belong~O*	.4492475	.39157	1.15	0.251	-.318213	1.21671	.369565
Access~s*	-.8480744	.4239	-2.00	0.045	-1.67891	-.017236	.641304
Acces~et*	1.14186	.50582	2.26	0.024	.150478	2.13324	.956522
Acces~it*	.738759	.54541	1.35	0.176	-.330227	1.80775	.206522
Farm~ted	.4935557	.18305	2.70	0.007	.134775	.852337	2.6087
Willin~t*	.3977975	1.02934	0.39	0.699	-1.61966	2.41526	.967391
WTA_Am~t	.0002425	.00064	0.38	0.705	-.001015	.0015	360.261

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

Appendix VII: STATA Output of Tobit Regression for Overall/General Analysis

```
Tobit regression                                  Number of obs   =        300
                                                  LR chi2(10)     =      48.45
                                                  Prob > chi2     =     0.0000
Log likelihood = -491.18085                       Pseudo R2       =     0.0470
```

Ifyes_Ecofriendly_Pract~t	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
Sex_respondent	-.2880922	.1524585	-1.89	0.060	-.5881576	.0119732
Age	.0123913	.0064611	1.92	0.056	-.0003253	.0251079
Educational_level	.1657678	.0620031	2.67	0.008	.0437346	.287801
Access_Extension_Services	-.1372115	.1783653	-0.77	0.442	-.4882662	.2138433
If_Yes_Number	-.0850632	.0293839	-2.89	0.004	-.1428959	-.0272304
Marital_Status	-.1436716	.1936667	-0.74	0.459	-.5248421	.2374989
HH_size	-.0214401	.0118606	-1.81	0.072	-.0447838	.0019036
Production_System	-.1055793	.13319	-0.79	0.429	-.3677209	.1565623
Belong_FBO	.5047009	.1803514	2.80	0.005	.1497373	.8596645
Grant_Totalcost_Rainfed	.0005008	.0001114	4.49	0.000	.0002815	.0007202
_cons	2.419155	.558999	4.33	0.000	1.318945	3.519364
/sigma	1.262016	.0538736			1.155983	1.368049

```
   16  left-censored observations at Ifyes_Ecof~t <= 0
  284     uncensored observations
    0 right-censored observations
```

Appendix VIII: STATA Output of Tobit Regression for Kumbungu District

Tobit regression	Number of obs	=	113
	LR chi2(9)	=	18.49
	Prob > chi2	=	0.0299
Log likelihood = -174.13027	Pseudo R2	=	0.0504

Ifyes_Ecofriendly_Pra~t	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
Sex_respondent	-.2528276	.2789001	-0.91	0.367	-.8058969	.3002417
Age	.0054887	.0092811	0.59	0.556	-.0129161	.0238936
Educational_level	.1842724	.088834	2.07	0.041	.0081113	.3604335
HH_size	-.0058717	.0073171	-0.80	0.424	-.0203817	.0086383
Production_System	-.5227279	.21671	-2.41	0.018	-.9524719	-.0929838
Belong_FBO	.3976015	.2605513	1.53	0.130	-.1190814	.9142845
If_Yes_Number	-.0959326	.0413554	-2.32	0.022	-.1779419	-.0139233
Grant_Totalcost_Rainfed	.0000988	.0002671	0.37	0.712	-.0004309	.0006285
Marital_Status	.8594753	.3728373	2.31	0.023	.1201249	1.598826
_cons	1.903762	.9585653	1.99	0.050	.002891	3.804633
/sigma	1.133365	.0770667			.9805388	1.286191

3 left-censored observations at Ifyes_Ecof~t <= 0
110 uncensored observations
0 right-censored observations

. mfx

Marginal effects after tobit
y = Linear prediction (predict)
= 2.5641578

variable	dy/dx	Std. Err.	z	P>|z|	[95% C.I.	]	X
Sex_re~t*	-.2528276	.2789	-0.91	0.365	-.799462	.293807	.743363
Age	.0054887	.00928	0.59	0.554	-.012702	.023679	36.6726
Educat~l	.1842724	.08883	2.07	0.038	.010161	.358384	1.88496
HH_size	-.0058717	.00732	-0.80	0.422	-.020213	.008469	12.9027
Produc~m	-.5227279	.21671	-2.41	0.016	-.947472	-.097984	2.48673
Belong~O*	.3976015	.26055	1.53	0.127	-.11307	.908273	.40708
If_Yes~r	-.0959326	.04136	-2.32	0.020	-.176988	-.014878	2.06195
Gran~fed	.0000988	.00027	0.37	0.712	-.000425	.000622	769.681
Marita~s	.8594753	.37284	2.31	0.021	.128728	1.59022	1.90265

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

Appendix X: STATA Output of Tobit Regression for Savelugu-Nanton District

Tobit regression

Number of obs	=	95
LR chi2(9)	=	41.76
Prob > chi2	=	0.0000
Pseudo R2	=	0.1378

Log likelihood = -130.62642

Ifyes_Ecofriendly_Pra~t	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
Sex_respondent	-.3303641	.3230895	-1.02	0.309	-.9726448	.3119167
Age	.0349533	.0115034	3.04	0.003	.0120854	.0578213
Educational_level	.0083559	.0806796	0.10	0.918	-.1520297	.1687416
HH_size	-.0358662	.015052	-2.38	0.019	-.0657885	-.0059439
Production_System	.234384	.2274851	1.03	0.306	-.2178414	.6866094
Belong_FBO	.2605125	.3077437	0.85	0.400	-.3512618	.8722868
If_Yes_Number	-.0279309	.070372	-0.40	0.692	-.1678257	.111964
t_Totalcost_Rainfed	.000481	.0001369	3.51	0.001	.0002088	.0007532
Marital_Status	-.508317	.2182317	-2.33	0.022	-.9421474	-.0744867
_cons	2.180023	.740833	2.94	0.004	.707296	3.65275
/sigma	.9547658	.0698858			.8158375	1.093694

1 left-censored observation at Ifyes_Ecof~t <= 0
94 uncensored observations
0 right-censored observations

x

inal effects after tobit
y = Linear prediction (predict)
= 3.1232137

able	dy/dx	Std. Err.	z	P>|z|	[95%	C.I.]	X
re~t*	-.3303641	.32309	-1.02	0.307	-.963608	.30288	.642105
Age	.0349533	.0115	3.04	0.002	.012407	.0575	38.4211
at~l	.0083559	.08068	0.10	0.918	-.149773	.166485	1.88421
…_size	-.0358662	.01505	-2.38	0.017	-.065367	-.006365	10.6737
Produc~m	.234384	.22749	1.03	0.303	-.211479	.680247	2.63158
Belong~O*	.2605125	.30774	0.85	0.397	-.342654	.863679	.621053
If_Yes~r	-.0279309	.07037	-0.40	0.691	-.165857	.109996	2.32632
Gran~fed	.000481	.00014	3.51	0.000	.000213	.000749	1058.66
Marita~s	-.508317	.21823	-2.33	0.020	-.936043	-.080591	2.05263

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

Appendix XI: STATA Output of Tobit Regression for Tolon District

Tobit regression

	Number of obs	=	92
	LR chi2(9)	=	12.34
	Prob > chi2	=	0.1946
Log likelihood = -159.98244	Pseudo R2	=	0.0371

Ifyes_Ecofriendly_Pra~t	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
Sex_respondent	-.5628132	.4124836	-1.36	0.176	-1.383227	.2576001
Age	.011136	.0123591	0.90	0.370	-.0134457	.0357176
Educational_level	.3813881	.2461774	1.55	0.125	-.1082488	.8710251
HH_size	-.0157251	.0211366	-0.74	0.459	-.057765	.0263148
Production_System	-.0367915	.249484	-0.15	0.883	-.5330052	.4594221
Belong_FBO	.8192166	.3748835	2.19	0.032	.0735885	1.564845
If_Yes_Number	-.0948158	.0534066	-1.78	0.080	-.2010394	.0114079
Grant_Totalcost_Rainfed	.0004908	.0002983	1.65	0.104	-.0001026	.0010841
Marital_Status	-.7192237	.5005151	-1.44	0.154	-1.714728	.2762806
_cons	2.816214	1.19627	2.35	0.021	.4368816	5.195546
/sigma	1.480671	.1221083			1.237802	1.723539

12 left-censored observations at Ifyes_Ecof~t <= 0
80 uncensored observations
0 right-censored observations

. mfx

Marginal effects after tobit
y = Linear prediction (predict)
= 2.2519026

variable	dy/dx	Std. Err.	z	P>|z|	[95%	C.I.]	X
Sex_re~t*	-.5628132	.41248	-1.36	0.172	-1.37127	.24564	.532609
Age	.011136	.01236	0.90	0.368	-.013087	.035359	36
Educat~l	.3813881	.24618	1.55	0.121	-.101111	.863887	1.27174
HH_size	-.0157251	.02114	-0.74	0.457	-.057152	.025702	9.51087
Produc~m	-.0367915	.24948	-0.15	0.883	-.525771	.452188	2.6087
Belong~O*	.8192166	.37488	2.19	0.029	.084459	1.55397	.369565
If_Yes~r	-.0948158	.05341	-1.78	0.076	-.199491	.009859	3.01087
Gran~fed	.0004908	.0003	1.65	0.100	-.000094	.001075	972.255
Marita~s	-.7192237	.50052	-1.44	0.151	-1.70022	.261768	1.94565

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