UNIVERSITY FOR DEVELOPMENT STUDIES, TAMALE

SMALL HOLDER FARMERS' ADOPTION OF SUSTAINABLE LAND MANAGEMENT PRACTICES IN TWO DISTRICTS OF THE UPPER WEST REGION

BY

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JUNE, 2018.

DECLARATION

I hereby declare that I personally, under supervision, have undertaken study herein submitted.

………………………………… …………………………………

SYLVESTER SUNGBAAHEE **DATE**

(STUDENT)

I hereby declare that I have supervised the student in undertaking the study submitted herein and confirm that the student has permission to present it for assessment.

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REV. DR. ALFRED B. KPIETA **DATE**

(SUPERVISOR)

DEDICATION

This dissertation is dedicated to my extended family especially Gillain Banenwie Ganaa, my wife, and three daughters.

I equally dedicate this work to all brilliant but needy students especially in the Kaleo Traditional Area.

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ABSTRACT

The continuous decline in cereal crop yields has serious impact on food security and related issues on the environment. This situation has led the study into the exploitation of profitable production measures proposed by stakeholders to enhance sustainable yield increases to facilitate the sustenance of the environment. This study was conducted in Wa East and Lawra Districts of the Upper West Region. The study uses both qualitative and quantitative methods in arriving at its findings. Questionnaires were used with face to face interviews to collect data for this study. The major findings of this study were that, the tools that were largely used in the application of animal manure included sacks and head pans. Compost application largely required sacks and head pans as well. Other tools mentioned for compost application included shovels, pick axe, wheel barrow, bicycle and weedicides. Minimum tillage application tools were mainly Knap sack sprayers & weedicides. The estimated cost of the tools for the application of the respective practices were GH¢ 449.2, GH¢467.56, GH¢131.73 for animal manure, compost and minimum tillage respectively. The study also evaluated the profitability as well as sensitivity analysis of animal manure, compost and minimum tillage using partial budget analysis. The results showed profitability margins of GH¢ 448.2, GH¢327.5 and GH¢98.2 per acre per production season for animal manure, compost and minimum tillage respectively. These values were compared to GH¢15.3 when the farmer is not applying any of the three practices. Respondents' perception of animal manure, compost and minimum tillage showed that, respondents have good perception for the three practices leading to positive perception index scores of 5.23, 4.93, and 3.94 for animal manure, compost and minimum tillage respectively. The study therefore concludes that, smallholder farmers have good perception towards animal manure, compost and minimum tillage but their adoption decision is constrained by demographic characteristics, economic factors and plot characteristics. It is recommended that, smallholder farmers should come together in groups to acquire tools for the collective use of their respective groups and also boast their negotiation strengthen.

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ABBREVIATIONS AND ACRONYMS

Abbreviation	Full Meaning
ACDEP	Association of Church Development Project
DFID	Department for International Development
EPA	Environmental Protection Agency
FAO	Food and Agriculture Organisation
GHC	Ghana Cedis
GSS	Ghana Statistical Service
IAASTD	International Assessment of Agricultural Knowledge, Science and Technology for Developments
MoFA	Ministry of Food and Agriculture
NEPAD	New Partnership for African Development
SDSN	Sustainable Development Solutions Network
SLMPs	Sustainable Land Management Practices
Sustainet EA	Sustainable Agricultural Information Initiative
UN	United Nation
WFP	World Food Programme

CHAPTER ONE

1.0 INTRODUCTION

This chapter discusses the background to the study, problem statement, research questions and objectives. It further discusses the scope of the study, significance of the study, ethical considerations, and limitations of the study. The chapter closes with organisation of the study.

1.1 Background

The economies of most countries in sub-Saharan Africa, including Ghana, heavily depend on agriculture. Agriculture is dominated by smallholder farmers that are dependent on family labour (World Bank, 2006a). The fate of the agricultural sector directly impacts on food security, the environment as well as economic growth. However, the performance of the sector in sub-Saharan Africa is below potential. It is characterised by decades of stagnation and volatility in production and marketed volumes (NEPAD, 2013; World Bank, 2006a)

Reducing hunger requires increased food production which in turn requires farmers' access to productivity enhancing inputs, knowledge, skills and expansion of farm size (Kassie & Zikhali, 2009; World Bank, 2006a). However, majority of the chronically hungry are small holder farmers in developing countries. These farmers lack access to inputs and product markets as well as financial resources to procure costly chemical fertilizer and other agrochemicals to enhance the productivity of their land (Kassie & Zikhali, 2009).

In Ghana, approximately 57.1% of the country's total land area of 238,539 km^2 is classified as agricultural land, out of which 57.6% is under cultivation (MoFA, 2011). Smallholder farmers constitute about 90% of all farms in the country are less than two hectares (less than 5 acres) (MoFA, 2011). This has left the country still struggling, to attain self-sufficiency in food production throughout the country. The Northern, Upper East and Upper West regions still have 1.2 million of their populations been food insecure, and two million more being vulnerable, particularly during the months of March–September (lean season) or following shocks such as floods and drought (WFP, 2011). The Upper West Region stands out as with the highest food insecure population of 34.0% (WFP, 2011). The high dependence on small holder agriculture has made the land resource increasingly over stretched. This results in various ecological impacts that include degradation of agricultural lands, limited water availability, loss of biodiversity, declining agricultural genetic diversity and also contributing to climate change (MoFA, 2011; FAO, 2011a; DFID, 2004).

The Guinea and Sudan savannah agro-ecological zones cover fifty percent of Ghana's total land area. The zones included the entire Upper West Region and other parts of the country that have been identified to be the most susceptible agro-ecological zone to land degradation (Gyasi, Karikari, Kranjac-Berisavljevic, & Von-Vordzogbe, 2006; EPA, 2002) Studies in the Upper West Region have confirmed the soil fertility decline and poor yields due to agricultural land degradation (GSS, 2014; Nkegbe, 2013).

Stakeholders and development organizations in the field have introduced and encouraged the use of Sustainable Land Management Practices (SLMPs). These practices have the potential to restore soil fertility, conserve moisture and increase productivity (Nkegbe, 2013; FAO, 2011a; Pender, 2009). The potential benefits of sustainable land management did not only lie in conservation alone but also enhancing natural resources as in increasing soil fertility and soil carbon without sacrificing yield levels. These are necessary for the fields to act as a sink for carbon, increase the capacity of the field to hold water and reduce erosion (Kassie, Zikhali, Manjur, & Edward, 2009a; Allmaras, Schomberg, Douglas Jr, & Dao, 2000; Quansah, Safo, Ampontuah, & Amankwah, 2000).

Given the benefits, the major challenge is the up-front costs associated with the adoption and use of these technologies which vary depending on agro-ecological conditions (FAO, 2011a). Unraveling these smallholder farmers' decision to adopt these SLMPs especially in the Lawra and Wa East Districts of the Upper West Region taken into consideration the income levels is worth exploring.

1.2 Problem Statement

The inhabitants of the Upper West Region constitute (702,110) 2.8% of the country's population with 72.3% depending on agriculture for their livelihoods (GSS, 2012). This population represented an increase of 21.8 % from the 2000 Census figure of 576,583 with 88.1% depending on agriculture (GSS, 2005). Population density over the years has equally increased steadily per square kilometers from 24, 31 and 38 in 1984, 2000 and 2010 respectively.

It is expected that the Region's population density will rise considering an inter-censual growth rate of 1.9%.The Lawra and Wa East Districts as well constitute 14.4% and 10.3% of the regions' population respectively. The Lawra District also has 83.5% of its households involved in agriculture for their livelihoods. Over 85% of households in Wa East District are dependent on agriculture for their needs (GSS, 2014; GSS, 2012).

The high dependence on agriculture coupled with the increasing population density has led to continuous overexploitation of the soil resource making it difficult to maintain adequate fallows. Woodfine (2009) and Diao & Sarpong (2007) both reported shorter fallow periods in many densely populated areas of sub-Saharan

Africa due mainly to pressure from shortage of arable land. The consequences are numerous including soil fertility decline, leaching of soil nutrients, organic matter depletion, water logging, erosion and acidification of the soils. Continuous cultivation, though aims at productivity increases is often not achieved largely due to low organic matter content of the soils. The amount of organic matter in the field is an indication of the health of the soil as it serves as a biological pool for major plant nutrients (SDSN, 2013; Baldwin, 2006).

The dominant agricultural practices in the savannah zone (slash and burn, improper rotation, overgrazing and uncontrolled bushfires) are considered unsuitable because they deprive the soil of organic materials making the soil insensitive to even the application of inorganic fertilizers in worse cases (Kassie & Zikhali, 2009). Farmers therefore look up to the use of inorganic inputs (agrochemicals) to augment the depleted soil fertility. However, procurement, distribution network and declining access to agricultural credits have been observed in many parts of Africa. These make their use increasingly expensive (DFID, 2004; DFID, 2001). The future livelihood of farmers especially smallholders is therefore threatened if effective practical measures are not put in place to avert the continuous soil fertility decline.

Government and development organizations in most developing countries have increasingly promoted the use of SLMPs. FAO (2011a) explained that, SLMPs have reduce soil fertility decline and increase productivity. Maize yield increases of between 93%-400% have been reported across Africa with various SLMPs (FAO, 2011a; Pretty, 2006). Though there are low cost innovations, relatively easy to implement and technically supported to an extent, large scale adoption is not clearly understood.

Also, the financial implications of adoption as well as the compatibility of these technologies with existing farming systems are worth exploring specially among smallholder farmers to guide policy decision. Socioeconomic and biophysical factors have been reported to affect adoption of SLMPs in parts of Africa (Kassie et al., 2012; Teklewold, Kassie, & Shiferaw, 2012; Akudugu, Guo, & Dadzie, 2012; Nkala, Mango, & Zikhali, 2011). This study, therefore seeks to answer the central question; how does perception, profit, farming system, socio-economic and biophysical factors influence the adoption of SLMPs among smallholder cereal crop farmers?

1.2.1 Main Research Questions

Which factors determine the small holder farmers' adoption behaviour of SLMPs in the Lawra and Wa East Districts of the Upper West Region? The sub-research questions are as follows:

. Which equipment or tools are used for the practice of SLMPs in Lawra and Wa East Districts?

. What are the short-term profit levels on the adoption of SLMPs?

. How do farmers perceive SLMPs in the Lawra and Wa East Districts?

. What factors determine the adoption of SLMPs?

1.2.2 Main Objectives

The main objective of this study is to evaluate smallholder farmers' perception and determinants of adoption decisions on SLMPs in two Districts of the Upper West Region.

1.2.3 Specific objectives

To achieve the main objective, the study examines the following specific objectives to facilitate it.

i. Determine the tools or equipment required for Animal manure, compost and minimum tillage application in Wa East and Lawra Districts
ii. Estimate the short term profit levels of animal manure, compost and minimum tillage applications.
iii. Assess the demand for Sustainable Land Management Practices in Lawra and Wa East Districts
iv. Examine which factors affect the adoption of SLMPs in the study area

1.3 Scope of the study

The study focused on all smallholder farmers in the Lawra and Wa East Districts of the Upper West Region. The target crops were cereals (maize, sorghum, rice, millet.) because they are the staple food of the area. Data was captured on farmer characteristics, farm characteristics and productivity estimates. Farming activities and yield estimates were based on farmers' recall of 2016 production season. The analysis of profitability and sensitivity was limited to three practices (Minimum tillage, composting and animal manure application). The study was expected to last 10 months (August 2017 to June 2018).

1.4 Significance of the Study

Various studies in the field have reported socio-economic and biophysical factors that have affected adoption decisions of SLMPs in parts of Africa (Kassie et al., 2012; Teklewold et al., 2012; Akudugu et al., 2012; Nkala et al., 2011). However, the returns in the short run, perception of farmers relating to the practices have not been adequately discussed. Diao and Sarpong (2007) estimated US$ 4.2 billion income losses in Ghana due to land degradation between the periods of 2006-2015 i.e. ten year interval. The effect of the loss is equivalent to 5.4% increase in poverty rate by

2015. SLMPs could lead to a general economic benefit of US$6.4 billion over the same period. It is therefore very significant in reducing poverty particularly in Northern Ghana. This work may also provide policy direction to decision makers on sustaining agricultural productivity and thus enhancing food security. It also adds up to the requirement for the award of Master of Philosophy in Environment and Resource Management Degree.

1.5 Ethical Considerations

It is a branch of philosophy that involves systematizing, defending and recommending concepts of right and wrong conduct (Wikipedia). These concepts of right or wrong are defined at disciplinary levels through a professional code of conduct and enforced by Institutional Review Board (Bhattcherjee, 2012). Researchers are therefore expected to be aware of and abide by general agreements shared by the scientific community on what constitutes acceptable and non-acceptable behaviors in the professional conduct of research. Kumar (2011) indicated that, what is considered acceptable or non-acceptable varies from one profession to the other. He also implied that any judgment about whether a particular practice is ethical or not is made on the basis of the codes of conducts prevalent at that point in time and may change in the future. Codes of conducts are necessary because research has often been manipulated in unethical ways by people and organizations to advance their private agenda and engaging in activities that are contrary to the norms of research conduct (Bhattcherjee, 2012). Some of these unethical behaviours in research may include any dilemma stemming from a moral predicament is a basis of ethical conduct. There are certain behaviours in research such as causing harm to individuals, breaching confidentiality, using information improperly and introducing bias which are considered unethical in any profession (Kumar, 2011).

In this study therefore, the ethical behaviours as identified were largely adhered to in the following ways.

Informed consent

The respondents were adequately informed in a language understood by the respondents prior to the interview the type of information to be taken from them, why the information is being sought, what purpose it will be put to, how they are expected to participate in the study, and how it will directly or indirectly affect them. It is important to know that all respondents gave their consent before they were interviewed. Any respondent whose consent was not given was left out.

Incentives

Some researchers provide incentives to participants for their participation in a study. In this study, no form of incentive was given to any respondent to induce him or her to provide any information. They were some few instances where respondents were provided with one or two pots of pito on after the interview section. This was gladly responded to show appreciation but never before the interview.

Sensitive information

The researcher consulted the Extension area officers prior to the interviews to know which information were sensitive the people and in which community. This gives the researcher upper hand on how to go about such information. Some measures and carefulness were adopted ahead of time to deal with any type of information are regarded as sensitive or confidential and thus an invasion of privacy by some respondents.

Confidentiality of information

Respondents were informed ahead of interviews in a language understood by them that, the information to be provided were only going to be used for academic purposes and nothing else. It was also shown that, names were not written, which could have compromise the identity of the information provided. The information therefore provided by respondents was kept anonymous.

Biases

A bias on the part of the researcher is unethical in social research. The researcher reported exactly the findings of the research as it is from the data collected. I did not allow background, training and competence in research, and or philosophical perspective to influence the findings of the research. Bold and conscious effort was made in providing exactly what was found and no part of the findings was hidden. It must be noted that, apart from reporting the findings of the study for academic degree the researcher has no personal interest or gains in any part of this study.

1.6 Limitation of the Study

This study was limited to the Upper West Region which lies within the Guinea Savannah ecological zone with a longer period of dry spell. Findings of the study may be different in other ecological zones.

Limited time span coupled with budget constraint affected the number of respondents in the study. This could have increased the accuracy of predictions made on the study.

1.7 Organisation of the Study

This study is put into five sections and each section represents a chapter. It starts from chapter one to chapter five. Chapter one begins with introduction. In the introduction is the background to the study, followed immediately by the problem statement. The problem statement is followed by research questions leading to the objectives of the study. The objectives are categorized into two; the main objective and the specific objectives. The scope of the study is next after the objectives of the study which is followed immediately by the significance of the study. The significance of the study, ethical considerations, limitations of the study and Organisation of the study closed chapter one of this study.

Chapter two discusses literature review. In the literature review, we examine related findings of earlier researchers in the field of study. It begins with the definitions and history of Sustainable Land Management Practices. The definitions and the history is followed by categories of SLMPs across the globe projecting it to the mode and extend of use of SLMPs. The remaining literature was reviewed in respect of the study objectives starting with objective one which discusses the tools that are employed in the application of the SLMPs. It starts with tools that are used for the application of animal manure, compost and minimum tillage. The second objective which discusses profitability of the respective practices was also reviewed starting with the profitability of animal manure, compost and then minimum tillage. The third objective which studies small holder farmers' perception of the SLMPs under study was also reviewed. The review started with related findings on animal manure by earlier researchers, then on compost and minimum tillage. Following the third objective is four and final objective which reviewed the socioeconomic, plot and biophysical characteristics that influenced the adoption of SLMPs bringing chapter two to an end.

Chapter three is partitioned into two, the study design and the research method. The study design describes the period within which the study will be carried out. It also reviewed the profile of the study area. This was followed by a review of the vegetation, the climate conditions and rainfall patterns in the study area. This is followed immediately by the review of agricultural activities within the study area and the soil characteristics of the study area. Part two of chapter three discusses research methods which begin with the conceptual framework. The conceptual framework is followed by the method used in analysing the first objective, that is, tools required for the application of animal manure, compost and minimum tillage. Next is the method used in analysing profitability and sensitivity analyses of the respective practices under the study. The method used in arriving at the Knowledge and perception of this study was also discussed. The empirical framework leads to the model used in estimating the factors influencing smallholder farmers' adoption behaviour. The description of variables in the model was presented followed by the population and sample frame for the study. The sampling and sampling procedure was next leading us to methods of data collection. Preceding the Organisation of the study is data analyses describing how data was analysed leading to the achievement of the objectives set for the study.

Chapter four presents the results of the study and discussions starting with the characteristics of respondents in the study. The results and discussions followed objective by objective presentation and discussions as set in the study.

The final chapter is chapter five which presents conclusions and recommendations of the study. This begins with the summary of the findings of the research and ending with the recommendations made from the study.

1.8 Summary of Chapter one

The introduction discussed Small holder farming which dominates Ghana's agricultural sector. The agricultural sector directly impact on food security and economic growth with dire consequences on the environment. The dominance of small holder agriculture has left the country with food insecurity with Upper West Region lead with the most insecure population (34%). The problem statement discussed population growth and the future food insecurity situation in the country. It further discussed stakeholder recommendations and the work that need to be than to help small holder farmer's success story. The research questions are also discussed which lead us the research objectives.

The chapter further discussed the scope of the study to include small holder cereal crop farmers. Significance of the study was also discussed to include the quantum of loss to the economy without such research and necessary action. Some ethical considerations with regards to the study were discussed taking into consideration respondents' consent, privacy issues and sensitive issues within respondents' respective locations. The chapter concluded with the organisation of the entire study.

CHAPTER TWO

2.0 LITERATURE REVIEW

Chapter two discusses literature relevant to the study. The chapter started by looking at definition and history of sustainable land management. It also discusses the various categories of sustainable land management, the mode and extent of use of sustainable land management practices, theories behind the study to be untaken and a review of tools used in earlier in executing animal manure, compost and minimum tillage. The study further review literature on the profitability of earlier adopted sustainable land management practices, small holder farmers' perception of the practices and factors that influence small holder farmers' adoption behaviour on sustainable land management practices.

2.1 Definitions and Brief History of SLM

Sustainable Land Management (SLM) refers to the capacity of land over time to contribute to overall welfare by providing sufficient food and other goods and services in ways that are economically efficient and profitable, socially responsible, and environmentally sound (United Nation, 2009). It involves a combination of inter-related soil, crop and livestock production practices. It also involves the discontinuous or the reduced use of external inputs that are potentially harmful to the environment and/or the health of farmers and consumers. It rather emphasizes the use of techniques of food production that integrate and are adapted to local natural processes (United Nation, 2009). According to FAO, 2011a, SLMPs are land use systems that, through appropriate management practices, enable land users to maximize the economic and social benefits from the land while maintaining or enhancing ecological support functions of the land resources. The practices include the management of soil, water, vegetation and animal resources. SLMPs are low-input conservation technology or practices that are socially acceptable and technically feasible, and can substantively reduce land degradation while enhancing productivity (World Bank, 2006a). In all the definitions, the need to maintain and enhance ecological balance, socially acceptability and ensuring economic viability of the practices are of great significance as much as SLM is concern.

The promotion of Sustainable agricultural technologies was first pioneered by North American countries in the late 1980s that included Canada. But adoption has been low around 26%. In African, adoption of SLMPs has witnessed little success not more than 10% of their farmland being cultivated using selected SLMPs. This has been due to lack of official programs or resources to promote SLMPs (Tey, et al., 2012). The impressive global crop yield growth achieved earlier in the 1990s has decelerated sharply due to diminishing returns to further input use and environmental constraints (DFID, 2004). The significance of adopting SLMPs is viewed as the maintenance of ecological balance and biodiversity, enhancing sustainable productivity of arable land so as to ensure food security, profitable and cost efficiency of investments on the land among other offsite benefits that are economically justifiable (FAO, 2011a).

2.1.1 Categories of SLMPs

Different researchers have classified and categories SLMPs depending on the problem it seeks to solve so as to ensure sustainable production of agricultural land i.e. whether the SLMP is improving fertility of the soil, enhancing water holding capacity or preventing run off. Woodfine (2009) identified the following crop, livestock and improved rainwater management categories that could ensure the sustainability of agricultural land and in the long run prevent the degradation of the land in sub-

Saharan Africa. Table 2.1 below represents Woodfine's categorization of Sustainable Land Management Practices.

Table 2.1: Categories of SLMPs in Sub-Saharan Africa.

Category	**Practices/Technologies**
Crop management	Mulching and crop residues, crop rotation, allowing fallows, legume intercropping, conservation tillage and agriculture, organic agriculture, integrated plant nutrient management and integrated plant pest management.
Pasture and livestock Management	Sustainable grazing management, silvo-pastoral system, integrated crop and livestock systems.
Improved rainwater Management	Rainwater harvesting and improved drainage, irrigation systems, watershed management
Others	Agro-biodiversity protection, avoided deforestation, afforestation and fire reduction

Source: Woodfine, 2009.

According to Woodfine (2009), suitable agricultural technologies and approaches for a particular area are dependent on the qualities and characteristics of local land resources and the sustainable land management requirement of the land use to be pursued. It is also dependent on the socio-economic context and priorities of the land users. FAO (2011b) describes the practices as improved crop management practices which are categorized below:

Table 2.2: Improve Crop Management Practices

Category	**Practices**
Improve agronomic practices	Cover cropping, crop rotations, improved varieties and use of legumes in rotation.
Integrated nutrient management	Legumes and green manure, composting, animal manure and increase use of N fertilizers.
Tillage and residue management	Reduced/zero tillage and incorporation of residues
Water management	Irrigation, bund/zai, tied ridge system, terracing, contour farming and water harvesting.
Agro-forestry	Live barriers/fence and the various agro-forestry practices

Source: IPCC (2007) cited in FAO (2011b)

These practices according to FAO (2011b) can be adopted in a wide range of different combinations for an impact on yield at different locations while ensuring sustainability. Smallholder farmers will not pay for inputs unless they are reasonably sure that their produce can be sold at a profit. They will also not accept sustainable agricultural measures unless the long-term advantages will accrue to them but not to others who may be occupying the land later. Reaping the benefits of SLMPs is a major concern to smallholder farmers (Woodfine, 2009).

Similarly, FAO (2009) has classified SLMPs as food security adaptation options and the impact their use have on food production. The Table 2.3 presents the type of SLMPs/food security adaptation options and the impact they have on food production.

Table 2.3: Type of SLMPs and Impact on Food Security

Crop Management Practice	**Positive**	**Negative**
Improved crop/fallow rotations	Higher yields due to increased soil fertility	Reduced cropping intensity may compromise household food security in short-run
Use of legumes in crop rotations	Higher yields due to increased Nitrogen in soil	Reduced cropping intensity may compromise household food security in the short run
Use of cover crops	Higher yields due to reduce on-farm erosion and reduced nutrient leaching	May conflict with using crop land for grazing in mixed crop-livestock systems
Increased efficiency of N-fertilizer or manure use	Higher yields through more efficient use of N fertilizer and/or manure	
Incorporation of residues	Higher yields through increased soil fertility, increased water holding capacity	Potential trade-off with use as animal feed
Reduced/zero tillage	Higher yields over long run, particularly where increased soil moisture is valuable	May have limited impacts on yields in short term; weed management becomes very important; potential waterlogging problems
Live barriers/fences	Higher yields	Reduced arable land
Perennials/agro-forestry	Greater yields on adjacent crop lands from reduced erosion in medium-long term, better rainwater management	Potentially less food, at least in short-term, if displaces intensive cropping patterns
Water Management		
Irrigation	Higher yields, greater intensity of land use	
Bunds	Higher yields, particularly where increased soil moisture is key constraint	Potentially lower yields when extremely high rainfall

Terraces	Higher yields due to reduced soil and water erosion, increased soil quality	May displace at least some cropland
Pasture and Grazing Management		
Improving forage quality and quantity	Higher livestock yields	
Seeding fodder grasses	Higher livestock yields due to greater forage availability	
Improving vegetation community structure	Greater forage/fodder in medium-long term	May reduce forage/fodder in short-term
Stocking rate management	Potential increased returns per unit of livestock	Returns at the herd level may decline, at least in the short term
Rotational grazing	Higher livestock yields due to greater forage availability and potentially greater forage quality	Short-term losses likely if rotational system supports fewer head of livestock
Restoring Degraded Lands		
Re-vegetation	Improved yields when crops are sown in the medium-long run; improved yields on adjacent crop or grassland due to reduced wind, soil and/or water erosion	
Applying nutrient amendments (manures, bio-solids, compost)	Improved yields when crops are sown in the medium-long run	

Source: FAO (2009)

This study concentrates on soil fertility maintenance practices for improve crop yields. This is because the study area is low in soil nutrient content which impact negative on crop yields and thus threatening food security.

2.2 Mode and Extend of Use of SLMPs

Significant potential benefits have been reported on large number of the practices on both farmer and aggregate levels, but large-scale adoption of these practices continues to be limited in Ghana (World Bank, 2006a). The adoption and use of sustainable agricultural practices can create multiple benefits. These include reduction in production cost, environmental benefits and at the same time increase food production. It is therefore crucial to understand what drives resource poor farmer from adopting the practices (United Nation, 2009). The use of sustainable agricultural practices is affected by factors, such as profitability, risk associated with adoption of technologies, and their ability to generate immediate benefits to meet urgent livelihood needs of the resource poor farmers (Kassie et al., 2012). Government of Ghana has paid more attention to production and technological aspects of land degradation to the neglect of socio-economic factors that determine adoption of technologies on land productivity and resource management (World Bank, 2006a). Furthermore, the adoption of the most appropriate SLMP in a particular situation will be determined by the local topographic, soil and vegetation conditions. Socio-economic context, such as land tenure, farm size and assets, which may make certain, practices locally ill-advised (Woodfine, 2009). Finally, the adoption, use and economic performance of sustainable agriculture technologies are determined by many different factors which are classified as plot characteristics and socio-economic characteristics of households. Therefore, making blanket statements on recommendation and promotion of these technologies are inadequate in many contexts (Kassie & Zikhali, 2009; Kassie et al., 2009a; Amsalu & de Graaff, 2007). Levels of adoption of SLMPs are largely not reported. A study in Zambia has found less than 10% of respondents adopting minimum tillage among hand-hoe farmers and more prominent in low rainfall or drought prone areas. This means that smallholder hand-hoe farmers found minimum tillage adoption as a remedy to their low rainfall challenges (Ngoma, Mulenga, & Jayne, 2016).

2.3 Theoretical Framework

Africa, most farmers are usually subsistence based, that is farming to feed their families and sell the small surplus that may be left to meet other family needs. These farmers therefore face a variety of decisions about what crops to grow, what inputs to use, and how much of each input to use on different parts of their land in order to meet their farming objectives (Hall, 2010). It may be assumed that because relatively few of the farmers' decisions involve monetary transactions, economics might not be the best fit for analyzing developing country smallholder agriculture. While the other social sciences have much to offer, economics is particularly suited to analyzing rational resource allocation choices, regardless of whether cash is involved or not (de Janvry, Fafchamps, & Sodoulet, 1991). Hall (2010) showed that, a rational farmer will seek to maximize his or her own wellbeing through the choices he or she makes on crops and inputs given the land, labour and capital they can access. The farmers' attitude towards risk is also an important factor in their decision-making, that is, how much are they willing to put to gamble in the event of failed harvest? All of these factors vary per individual, though general trends may exist which can be useful in improving smallholder farmers' productivity (de Janvry, Fafchamps, & Sadoulet, 1991).

Farmers therefore adopt a mix of technologies to deal with a multitude of agricultural production constraints. This implies that the adoption decision is inherently multivariate. A univariate model would not capture certain useful information of economic importance (Yu et al., 2011; Shiferaw, Okello, & Reddy, 2007). This study adopts the multinomial logit (MNL) econometric technique, which simultaneously models the influence of the set of explanatory variables on each of the different practices. It at the same time allows the unobserved and unmeasured factors (error terms) to be freely correlated. One source of correlation may be complementarities (positive correlation) and substitutabilities (negative correlation) between different practices (Belderbos et al., 2004). Figure 2.1 is the authors' creation of the concept frame. The frame assumes that smallholder farmer decision to adopt animal manure, compost and or minimum tillage is affected by the demographic characteristics, economic factors and plot characteristics of the farmer.

Some empirical studies of technology adoption decisions assume that farmers consider a set (or bundle) of possible technologies and choose the particular technology bundle that maximizes expected utility conditional on the adoption decision (Yu, Harley, Kliebenstein, & Orazem, 2011; Amsalu & de Graaff, 2007).

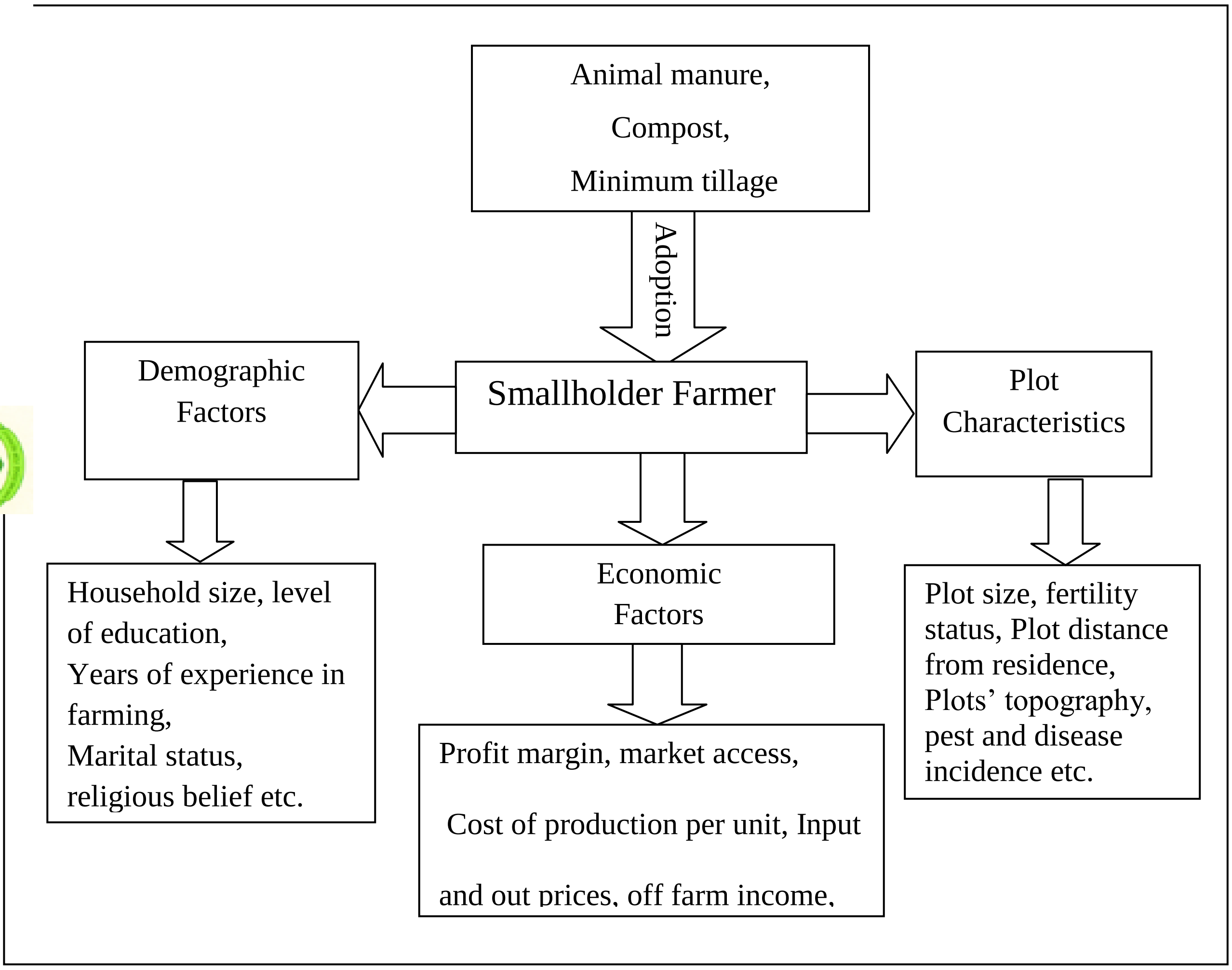

Figure 2.1: Conceptual Framework on Adoption Decision on SLMPs Source: Author's Construct (2018).

2.4 Tools for the application of SLMPs

According to Cambridge University Advanced Learner's Dictionary (2018) a tool is a device or equipment, especially held in ones' hand and used to carry out a particular function. A tool is synonymous to implement, instrument, utensil, apparatus, appliance, or a machine. The tools for the application of SLMPs are reviewed in the following pages. A tool is any physical item that can be used to achieve a goal, especially if the item is not consumed in the process. Tools that are used in particular fields or activities may have different designations such as instrument, utensil, implement, machine, device or apparatus. The set of tools needed to achieve a goal is equipment (Wikipedia, 2018).

2.4.1 Animal Manure

Grabowski (2011) revealed that, hoe-cutlass farmers used ox-cart, baskets, head pan and sacks for the application of animal manure. He further indicated that people who do not have ox could still rent its service for the transport of manure to their fields. Manure is a valuable, but often neglected resource in livestock and mixed farming systems because of its bulky nature. Farmers' use of ox-carts, wheelbarrows, head pans, baskets, sacks for transportation of manure to their fields for application. Ox-cart and wheel barrow is not readily accessible to all smallholder farmers (FAO, 2011a). An interaction with the Upper West Regional plant protection manager in his office in December, 2016 showed that, farmers use various ways and means of carting animal manure to their fields depending on their abilities. While others will use bicycles and sacks to transport to their fields, others will carry with either head pans or sacks on their heads to their fields for application. The Lawra district agricultural officer contacted in December, 2017 and January, 2018 indicated that, majority of farmers have fields around their compounds. It was therefore easier for them to transport manure with head pans. Others whose fields are some miles away use tricycles, ox-carts or bicycles. He said majority use bicycles or motorcycles with sacks to transport manure to their fields.

2.4.2 Compost

Composting is the natural process of 'rotting' or decomposition of organic matter such as crop residues, farmyard manure and waste by micro-organisms under controlled conditions (FAO, 2011a). The preparation of compost pits requires excavation of the soil to lay the base for deposition of the organic materials. This desired for pick axe and shovel especially at the smallholder farmer's level. Ox-carts, wheelbarrows, head pans, baskets and sacks may be used for transportation of prepared compost to their fields for application. However, Ox-carts and wheelbarrows are not readily accessible to all smallholder farmers (FAO, 2011a). Grabowski (2011) indicated that, pick axe and shovel were rented for compost pits construction in some communities. Other tools including ox-carts, baskets, head pans and sacks were also used in the transportation of materials during compost preparation and application. According to the Regional Plant Protection Officer, compost pit construction requires the use of pick axe and shovel with either hired or family labour which is usually done during the dry season when they are less busy. He added that, the transportation in most cases is the most difficult part which is usually done during the farming season using largely their bicycles or head pans. Some few farmers who might have access to tricycle may also use it to cart their prepared compost to the field for application. Plate 2.1 shows a compost pit surrounded by community members and some field officers assisting community on compost making and application.

Plate 2.1: Compost Pit Surrounded by Community Members
Source: FAO (2011b).

2.4.3 Minimum tillage

FAO (2011b) reported that smallholder farmers in Ghana use weedicide/herbicides along with knapsack sprayers to spray and kill the weeds and the herbs on the plot before planting. This accordingly, reduces man days per acre from 33.2 days to 19.2 days. The cost of the weedicides and knapsack sprayer were estimated to be at GH¢211.2 and was expected to last several years depending on the care provided. An enquiry from the Upper West Plant Protection Manager and Wa East District Agricultural Officer in December 2016 and June 2017 respectively revealed that, farmers combine weedicides/herbicides for application on their fields when applying minimum tillage at various levels. They also indicated that farmers who could not purchase the knapsack sprayers could borrow from their colleague farmers for use on their respective fields. Figure 2.2 shows minimum tillage plot to the left with maize planted on it to the right.

Plate 2.2: Minimum Tillage Field with Maize Plants
Source: FAO (2011b).

2.5 Profitability

Profit is an excess of revenue over associated expenses over an associated activity over a period of time. Profit is associated with earnings, income and margins. According to Lord Keynes 'profit is the engine that drives a business enterprise.' Every business should therefore earn sufficient profit to survive and grow over a long period of time (Pandey, 2002). Pandey (2002) explained that, a firm ability to make profit from all the business activities of the firm is its profitability. Profitability shows how efficient a firm can make profit from its available resources (Pandey, 2002).

In the context of agriculture, the profitability of a given practice depends on prevailing agro-ecological conditions (United Nation, 2009). Increasing prices of purchased inputs are expected to encourage adoption of sustainable practices. This is because farmers substitute external inputs with practices that are often more labor-intensive and utilize locally available resources (United Nation, 2009). Financial profitability is the ultimate measure to recommend a technology. Any technology that is agronomically feasible and is beneficial for soil improvement would not be attractive to farmers unless it is financially profitable. This financial benefit is in addition to the benefit in terms of soil improvement which we could not quantify in terms of monetary value (Melaku, Bayu, Tesfaye, & Sommer, 2014).

Profitability alone is not a sufficient condition for widespread adoption of SLMPs. There are many examples of profitable practices that are not widely adopted, due to lack of awareness, land tenure constraints, limited endowments, or other constraints. An increase therefore in food prices will not be sufficient by themselves to ensure widespread adoption of SLM practices in Sub-Saharan Africa (Pender, 2009). Poverty and lack of farmer capacity can be a major limiting factor for certain sustainability-enhancing investments. Access to investment credit at farmer affordable rates and availability of pro-poor options for beneficial conservation (that is, offer short-term livelihood benefits) will be an important step in solving some of the long-standing constraints (Shiferaw et al., 2007).

Farmers are willing to adopt and use sustainable agricultural practices if they provide higher net returns, lower risks or a combination of both. Cost efficiency, including short and long term benefits, are the key issues for adoption of SLMPs (FAO, 2011a). Smallholder farmers are more willing to adopt practices that provide rapid and sustained payback in terms of food or income. The cost of maintaining an adopted technology may hinder smallholder farmers' adoption decision since the benefits are not immediate. Subsequently, for improved livelihoods and for adoption and spreading of SLM, costs and benefits play a central role. Usually, investments in SLM should aim at both short-term (rapid) and long-term (sustained) paybacks. Thus, inputs for both initial establishment and continued maintenance afterwards need to be compared with benefits (FAO, 2011a).

It thus implied that, if investments in the resource provide worthwhile returns, then, smallholder farmers often try to protect their land and water resources from degradation (Shiferaw et al., 2007). The use of profitability could be argued to be better than the use of yields (it could be the case that production plans with the best yields are not necessarily the most profitable). Accordingly, estimating benefits of adopting SLMPs should include environmental benefits and any other benefits associated with the practice (Kassie et al., 2009b).

2.5.1 Profitability of Animal Manure

Adopting animal manure is widely found to have positive effects on the yields. Accordingly, they have been reported cases of yield increases that included 100% increase in maize and between 75%-195% increase in millet. Integrating crops with animal production will allow for adequate manure that could be applied back into the soil for crop yield improvements (FAO, 2011b). Similarly, yield increases of 79% were reported on various types of soils across Africa on different types of crops upon the use of different sustainable agricultural management practices (Pretty, 2006). During the survey (2017), the lead farmers indicated that the application of manure is very lucrative and explains their rationale for the application. The lead farmer in Baazing said no farmer will waste his/her time applying animal manure if it was not profitable. A number of farmers across both districts however complained of accessibility to manure because, not all the farmers have animals that they could gather and apply their manure. Some farmers, including the lead farmer in Luggu also indicated that those of the farmers who do not have animals most often gather their manure from the Fulani people because they (Fulani) have manure in larger quantities.

The farmers across both districts complained of the difficulty in conveying larger quantities to their distant farms as the manure is so bulky. Farmers are discouraged from applying animal manure and even in sufficient quantities when yields are less certain. The farmers would rather accept low-output in yield than invest heavily in pursuit of higher, but uncertain, output. Although farmers are driven by profit/output maximization, they are also risk averse and would minimize investing in risky ventures. A higher probability of crop failure (downside risk) increases the farmers' chances of adopting sustainability measures (Juma, Nyangena, & Yesuf, 2009). Juma et al., (2009) further explained that farm households possibly view terrace adoption and more intensive application of manure as measures for rehabilitating plots that are heavily degraded and no longer promise any yields.

2.5.2 Profitability of Compost

The application of compost resulted in wheat yield increased by 169%–236 % when the compost was applied. The increase continued the following season by 19%–128 % due to the residual effects of compost. Straw yield also increased 193%–237 % in the current and 40% in the residual season, respectively, as a response to inorganic fertilizer application (Melaku et al., 2014). The extra straw achieved as a result of compost application could also be used either for soil application to maintain the organic matter content or could be sold to generate income. Increase in grain and straw yields from the application of compost could be attributed to better crop growth, the improved nutrient availability and controlled release of nutrients from the compost. This crop growth and improved availability of nutrients could be made better by the addition of inorganic fertilizers to the compost which will ensure readily availability of nutrients (Melaku et al., 2014).

FAO (2011b) reported that, it is highly beneficial to apply compost on crop production fields. Accordingly, compost application has resulted in 100% increase in maize yield, 75% - 195% increase in millet yield, 100%-200% in groundnut yield and 250% - 375% in potato yields across the globe. Similarly, yield increases of 79% were reported on various types of soils across Africa on different types of crops upon the use of different sustainable agricultural management practices (Pretty, 2006). It is worth reporting that, where soil moisture is a key constraint on yields, sustainable agriculture can have very immediate yield benefits. However, in humid areas on water-logged soils the same practices could lead to yield decreases. There is a possibility for Sustainable Land Management Practice not to generate any yield benefit or reduced benefits. But such are much less likely to be published and thus a bias exists in the literature in terms of our understanding of SLM impacts on yield (FAO, 2011b). This conclusion is only a mere speculation and not based on any evidence, but may be important to keep in mind as a possibility (FAO, 2011b).

The use of compost can lead to significantly higher yields. Benefits of compost would be even more significant if benefits associated with environment and its long-term impacts on plot productivity were estimated. Fields that received compost may not need fertility enhancing input in the following year (Kassie et al., 2009b).

2.5.3 Profitability of Minimum Tillage

Minimum tillage provides opportunities for increasing soil water retention. Therefore, crop yields are often higher, especially in semi-arid and dry sub-humid agro ecosystems (FAO, 2011b). FAO (2011b) reported yield increases of 34% to over 67% in maize with minimum tillage across various types of soils across the world. Soya yield increases of 11% to over 83% have equally been reported on various soils with minimum tillage across the globe (FAO, 2011b). The benefits of conservation tillage occur gradually over time. This means that, a typical smallholder farmer in Sub-Saharan Africa will find it difficult to adopt such techniques, especially without any confidence as to the benefits and the ability to make upfront investments (IAASTD, 2009).

2.6 Farmers' Perception of SLMPs

In philosophy, psychology, and the cognitive sciences, perception is the process of getting, interpreting, selecting and organizing attaining sensory information. It includes the collection of data from sense organs through to the interpretation made by the brain. Perception is one of the oldest fields in psychology (Wikipedia, 2018). According to Audi (2003) perception describes a source of knowledge and justification, because it yields to beliefs that constitute knowledge or beliefs that are justified. Audi (2003) further explained that, perception is affected by four main factors, the perceiver in this case the smallholder farmer. Secondly, the object been perceived (the respective SLMPs under study), the sensory experience that is, the visual, auditory, olfactory, among others, experience in relation to the respective SLMPs. The last element is the relationship between the object (SLMPs) and the perceiver (the smallholder farmer).

Individually, perception is a process concerned with the acquisition and interpretation of information from one's own environment, it depends on the individual, where he/she lives as well as his/her experiences. It thus suggests that increasing farmers' knowledge and perception may be the important consideration for the dissemination of any improved technology for crop production (Farouque & Takeya, 2007). Generally, consumer demand studies have shown that consumers generally have subjective preferences for characteristics of products and that, their demand for products is significantly affected by their perception of the product attributes (Adesina & Baidu-Forson, 1995).

2.6.1 Farmers' Perception of Animal Manure

Traditionally, the livestock should be fed with the residues in the field so that the manure goes directly onto the soil. The manure should be returned to the field as soon as possible, if the residues are removed and fed to livestock elsewhere (World Bank, 2006b). For the problem of uncontrolled grazing and browsing during the cropping season, small stock manure production is considered an easy and efficient method to produce organic manure for the conservation and improvement of soil fertility. The main item within this practice is the so-called 3-4 m diameter circular pit, enclosed by a stone wall or fence (FAO, 2011a). The transport and spreading of manure on fields, however, is often a problem because of labor constraints according to the farmers (Grabowski, 2011; FAO, 2011a; DFID, 2001). One potential reason for the high use of manure may be due to their belief that it makes the soil fertile of which 82% actually affirmed and attributed the fertility of the soil to the application of manure. Some farmers attributed their poor soil fertility to inadequate manure application (Kim, et al., (2011).

Furthermore, yields of maize, sorghum, among other crops were reported to have doubled as a result of the application of animal manure (Kim et al., 2011). Also, most farmers perceive manuring to lead to more weeds growth on the field but, they concede the weeds are easier to pull out from manured fields than from non-manured fields (DFID, 2001). Given manure from different farm animals farmers in Northern Ghana are of the opinion that poultry and pigs manure release nutrients faster than that from ruminants. Nutrient release to crops is slowest in the case of cattle manure, but its residual effect appears to be higher than in the case of the manure from other livestock species lasting two to three years as compared to one year for pig and poultry manure.

2.6.2 Farmers' Perception of Compost

The composting of crop residues is an efficient way to conserve farm nutrients and enables farmers to redistribute the nutrient-rich compost to fields (World Bank, 2006b). The application of improved compost (mainly from plant residues) helps to close the nutrient cycle by ensuring that these do not become losses to the system. This enhances the building up of soil organic matter, maintains soil structure as well as soil fertility. It is further believed that, compost making and usage is within the reach of the poorest farmers (FAO, 2011a). The major constraint as perceived by most farmers across Africa is that, Compost is labor intensive and therefore can only be applied to small areas (Grabowski, 2011; FAO, 2011a; World Bank, 2006b).

2.6.3 Farmers' Perception of Minimum Tillage

Minimum tillage describes the practice of restricting the amount of general tillage of the soil to the minimum possible to establish a new crop and/or effect weed control or fertilization. The aim of tillage emphasizes on the amount of surface residue retention (Sustainet EA, 2010). The principles of minimum tillage reduces destruction of the soil structure, little exposer of soil to erosion, improve infiltration of water, ensure organic matter build-up and little destruction to soil living organisms. Other principles are, it saves cost of production, reduces compaction of soil due to undisturbed plants roots (FAO, 2011b; Sustainet EA, 2010; FAO, 2011a). In Ghana, minimum tillage requires that land is prepared by slashing the existing vegetation and allowing regrowth up to 30 cm of height. Herbicide is then sprayed with a knapsack fitted with a low-volume nozzle. The residue is left on the soil surface without burning. After 7–

10 days, direct planting is carried out in rows through the mulch. Maize is the main crop planted under this system (FAO, 2011a).

A study in Bangladesh found that about 80% comprising smallholder farmers, marginal and landless farmers had low level of perception for minimum tillage and other conservational agricultural practices. In contrast, large farmers had medium to high perception for conservational agricultural practices for sustainable crop production (Farouque & Takeya, 2007). Farmers' view of minimum tillage is that, it is the practice that increases weeds growth on their fields. But decreases nutrient availability for use by crops where materials do not decompose fast (Grabowski, 2011).

2.7 Factors Influencing Smallholder Farmers' Adoption Decision

2.7.1 Experience

Earlier studies have revealed that, the adoption of various SLMPs is influenced by the age of the household head. It has been reported that, older farmers are less receptive to newly introduced technologies (Akudugu et al., 2012; Arellanes & Lee, 2003). Akudugu et al (2012) explained that, years of experimentation and observation makes it difficult for experienced farmers to adopt new technologies leaving behind older practices. Younger farmers may also not meet the resource requirement of new technologies especially cost intensive technologies and therefore are likely not to adopt.

Years of experience increases the probability of uptake of all adaptative options. Highly experienced farmers are likely to have more information and knowledge on changes in their crop and livestock management practices. Experienced farmers are usually leaders and progressive farmers in rural communities. These farmers can be targeted in promoting sustainable land management practices to other farmers.

Making use of local successful lead farmers as entry points in promoting sustainable land management options among smallholder farmers can have significant positive impacts in increasing usage (Nhemachena & Hassan, 2007).

On the contrary, the age of the household head (whether affecting aversion to risk and/or life-cycle dynamics) will have a differential impact on adoption, depending on the type of practice (Kassie et al., 2009b). Similarly, Odendo et al (2011) assert that age, relative farming experience and market liberalization retarded the adoption of SLMPs. Speeding up adoption and diffusion of soil fertility management practices require policies. The policies must promote farmers' participation in land management programs and target existing practices to households. Locations with characteristics that favour their adoption, whilst generating alternative technologies that suit the other households and areas should be the center of the policies to enhance adoption (Odendo, Obare, & Salasya, 2011).

2.7.2 Access to Information

Kassie et al (2009a) found out in the Tigray region of Ethiopia that, public policy can affect adoption of sustainable agriculture. Specifically, public policies aimed at improving access to information will help promote adoption of SLMPs. Inadequate information on availability, net benefits of adoption and technical details of implementation of sustainable practices are barriers to adoption. Inadequate properly trained extension service providers have been identified as constraining adoption of productivity-enhancing technologies (Kassie et al., 2009b).

Constant training and organizational development are required to upgrade the capacity of extension workers. This will ensure their technical competence particularly in 'unconventional' farming practices such as sustainable agriculture practices. Extension services are a pre-requisite to ensuring that correct and up-to-date information is efficiently disseminated by extension workers (Kassie & Zikhali, 2009; Mgbenka & Mbah, 2016). A study in Malaysia found that, relevant information and knowledge significantly influenced the adoption of SLMPs. It thus suggests that, useful information gained by a farmer is more likely to help the farmer develop positive adoptive decisions on SLMPs (Tey, et al., 2012).

Informal networks among farmers have always been powerful channels for exchanging information and spreading knowledge. Belonging to a farmer association increases the adoption and use of SLMPs. Individual members of farmer associations interact with each other both internally and externally. They therefore share information and their experiences with each other particularly on best agricultural practices (Kassie et al., 2012; Akudugu et al., 2012; Teklewold, Kassie et al., 2012; Odendo et al., 2011).

2.7.3 Level of Education

Educated farmers are able to read, decode and interpret available information on new technologies and best practices. They as well have higher understanding of issues and therefore are able to make informed decisions and therefore have a positive influence on the adoption of SLMPs (Akudugu et al., 2012; Teklewold et al., 2012; Juma et al., 2009).

A study by Sserunkuuma (2005) found that, households whose heads have acquired formal education recorded higher yields of maize compared to those with uneducated household heads (probably because they are more likely to use inorganic fertilizer). Investment in rural public education with special focus on women will facilitate the adoption and use of SLMPs (Teklewold et al., 2012).

Conversely, findings in Uganda show that, educated households are less likely to adopt labour intensive conservational practices comparatively. Accordingly, educated farmers have higher labour opportunity costs and therefore discouraging them from using labour-intensive technologies, such as application of animal manure and crop residues management (Sserunkuuma, 2005). Participation in agricultural training and short-term extension programs is associated with higher use of inorganic fertilizers, animal manure, and mulching. This underscores the need for technical assistance in the form of training and extension services to increase farmers' awareness of the land management problems they face and the appropriate means of addressing them (Sserunkuuma, 2005).

The general lack of access to information or awareness among smallholder farmers can be attributed to their high level of illiteracy. This contributes to the low level of adoption of agricultural production technology. Extension service is a type of education which is functional rather than formal. It is better provided by extension workers whose main task is to convey information in a meaningful form to farmers usually through a contact farmer which is expected to have a trickle-down effect on other farmers (Mgbenka & Mbah, 2016). Farmers with higher formal education are more likely to adopt SLMPs. Accordingly, with their level of knowledge they become less risk-averse when evaluating SLMPs. In other words, the farmer is more willing to accept innovation that requires alteration in farm operation (Tey, et al., 2012).

2.7.2 Plot Characteristics

2.7.2.1 Steepness and Fertility

Plots which are steeper and perceived to be less fertile are more likely to benefit from adoption of SLMPs. This is because steeper lands are more prone to degradation and therefore the need for investments to enhance productivity of the land (Arellanes & Lee, 2003). Kassie et al., (2012) observed in Tanzania that, the slope of a plot as well as its perceived fertility of the soil is significant determinants of adoption decisions on soil and water conservation practices. Furthermore, Kassie et al., (2009a) and (2009b) revealed in the Tigray Region of Ethiopia that, compost and conservation tillage are less likely to be practised on plots that are predominantly black soil. The success therefore of sustainable agriculture practices depends on their ability to address site-specific characteristics. Teklewold et al., (2012) showed that farmers in Ethiopia were likely to adopt animal manure on plots with good soil qualities. The probability of adopting animal manure and minimum tillage decreases with an increase in the steepness of the plot. Minimum tillage was practised on plots considered to be flat plots.

2.7.2.2 Plot Tenure Status

Plots which are owned by farmers are more likely to benefit from use of sustainable technologies, because the security of land access is necessary to induce farmers to make the necessary investment in their land (Arellanes & Lee, 2003). The acquisition of land for new entrants into farming is a challenging task for many in Africa especially small holder farmers. Smallholder farmers lack capital which they can use to acquire land for agriculture. Unavailability of land is one of the serious problems militating against small scale farming (Mgbenka & Mbah, 2016).

A study in the Tigray Region of Ethiopia indicates that, land ownership significantly influences adoption and that its impact varies from one technology to the other. Similarly, migrant farmers in Ghana who rent land for their farming activities have been found to be mining the soil. Their reason has been that, they cannot guarantee the benefits of any investments in soil fertility. They are therefore unwilling to adopt any practice aimed at improving the fertility of the soil as any such investment could cause them to lose the land the subsequent years. Land owners usually take back their lands from them with improvement in soil fertility (Gyasi et al., 2006).

Land tenure system is bedeviled with uncertainties and the inadequate access to smallholder farming in East Africa. The constraints are related to insecurity of land tenure, unequal access to land and lack of a mechanism to transfer rights of ownership and consolidate plots. These have resulted in under-developed agriculture, high landlessness, food insecurity, and degraded natural resource (Salami, Kamara, & Brixiova, 2010). Furthermore, the available land in East Africa is overly subdivided into small and uneconomic units, resulting generally in fragmented production systems and low productivity. In fact, the farm sizes range from as low as about 1hectare per household to 2.5 hectares (Salami et al., 2010). Policies are therefore needed to improve the land rental market performance (Kassie et al., 2009b).

2.7.2.3 Rainfall satisfaction

Agricultural production in sub-Saharan Africa is characterized by wide variability in the timing and levels of rainfall as well as increases in temperature. This implies that, plots with easy access to water or irrigation are less likely to enjoy sustainable technologies comparatively (Kassie et al., 2012; Kassie et al., 2009b). The findings of Teklewold et al (2012) in Ethiopia on the adoption of SLMPs such as composting, mulching, minimum tillage and soil and water conservation are a justification for the positive correlation with unreliable rainfall. The subjective rainfall satisfaction in terms of timeliness, amount and distribution influenced the adoption of SLMPs in Ethiopia.

The individual rainfall satisfaction index as to whether it was favorable or unfavorable for crop production affected adoption. Unsatisfactory rainfall outcomes triggered adoption of SLMPs (Teklewold et al., 2012). Similarly, increasing the mean annual precipitation increases the probability of farmers changing their management practices, in particular, growing crop varieties that suit the prevailing and forecasted precipitation. Lower rainfall increases the probability of the farmer to efficiently use water resources for food production and other uses. The probability of adopting sustainable land management practices that increase water retention increases with decreasing precipitation because farmers have learnt from drought experiences to conserve rainwater in times of good rains. Increasing knowledge and empowering communities to use water conservation techniques including water harvesting can significantly help farmers cope with changing rainfall and temperature regimes (Nhemachena & Hassan, 2007).

2.7.2.4 Plot Size

Akudugu et al (2012) observed in Bawku West District that farm size has a positive correlation with technology adoption. Farmers with large commercial farms are more willing to invest in their lands than smallholder farmers. Similarly, Odendo et al (2011) realised in Western Kenya that, large farm size increases the probability of the adoption of sustainable agricultural practices. This he explained as due to the fact that large scale farmers are less risk averse. Conversely, Sserunkuuma (2005) showed that, farm size is negatively associated with manure use and incorporation of crop residues, suggesting that the use of such practices is more common on smaller farms than in large farms.

Furthermore, Pretty (2006) showed that, sustainable agriculture was first started by smallholder farmers in Southern America. It then spread to large scale farmers only after success have been achieved by the smallholder farmers.

2.7.2.5 Farming System

Farming system describes the inter-relationship between soil, water, plants, animals, labour, capital, energy and other resources with the farm family at the center managing the agricultural and related activities (Behera & Sharma, 2007; Ngoc Chi &

Yamada, 2002). There are various farming systems in Ghana but, the major farming systems commonly practised in the Upper West Region are mixed farming, mixed cropping (commonly legumes with cereals), land rotation and mono cropping in the case of cotton (ACDEP, 2010). Most of the farmers in the Upper West Region are predominantly smallholders. They either cultivate at least two of the following crops on a plot or on different plots; maize, sorghum, millet, groundnuts and Bambara groundnuts purposively for domestic consumption. Sorghum may also be used for brewing pito, a beverage while cotton and cowpea are mainly produced as cash crops. Each farmer either rears one or more livestock or poultry or both to supplement income from crop farming as a result, every farmer is considered as mixed farmer in the region (MoFA, 2011; ACDEP, 2010; EPA, 2002). The use of a farming system is determined by natural resources and climate factors, science and technology, indigenous technical knowledge, trade liberalisation and market development. Others include policies, institutions, information and human capital (Behera & Sharma, 2007).

2.7.2.6 Plot distance from household

Plot distance from households reduces the probability and intensity of manure use. This is so because manure is normally accumulated in the backyard and is heavy and bulky. Farmers therefore may be less willing to apply it if the farm is farther from the household. Moreover, where the farmer relies on hired labor, it becomes more expensive to apply manure on farms far from the homestead. Equally important are the management challenges of farms that lie far from the household. These farms are more exposed to crop theft and invasion by animals. As a result, a household may not find it prudent to invest heavily in such plots (Juma et al., 2009).

Teklewold et al (2012) explained that, distance to the plot is an important determinant for the adoption of SLMPs. The distance increased transaction costs on the farthest plot, particularly the cost of transporting bulky materials/inputs to and from the plots. Distant plots usually receive less attention and less-frequent monitoring such as watching and guarding, particularly for maize and legume crops which are edible at green stage, and hence farmers are less likely to adopt SLMPs on plots that are far away.

2.7.3 Socioeconomic Factors

Similarly, some other studies have reported that, the adoption and economic returns of a technology are a function of several factors. Some of these include prices, consumer demand for food type, physical infrastructure, market access and development, agro-ecology, and household characteristics such as rich versus poor and male versus female headed households (Kassie & Zikhali, 2009).

2.7.3.1 Market Access

Access to market for agricultural produce often facilitates commercialization of production and adoption of technologies (Kassie & Zikhali, 2009). Farmers' ability to clearly forecast the future costs of current land degradation coupled with policy and institutional mechanisms that support changes in behavior, improved market access can be a greater incentive for sustainable agriculture (Shiferaw et al., 2007). Kassie & Zikhali (2009) further explained that, knowledge of SLMPs and improved channels of communication have increased consumers demand for organically produced food in many developed countries. This could be an opportunity to adopt SLMPs by developing countries. Farmers in developing countries are also not well integrated into input and output markets. Smallholder farmers need market information on the crops to grow at a particular point in time to enhance marketability, update on agricultural product prices, forecast of market trends and information on sales time. Other information needed include improved market practices and cooperative marketing. However, these pieces of information are often not available in many parts of Africa (Mgbenka & Mbah, 2016). Improved access to input and output markets is a key precondition for the transformation of the agricultural sector from subsistence to commercial production. Smallholder farmers must be able to benefit more from efficient markets and local-level value-addition, and be more exposed to competition (Salami et al., 2010). Salami et al., (2010) indicated that, East African countries are still grappling with marketing of both agricultural inputs and outputs, with markets not adequately equipped to serve the needs of the poor. Accordingly, 30 percent of communities surveyed did not have access to roads that were passable even in the dry season and two-thirds of communities lacked any bus or taxi connections. In addition, more than half of the population lives five hours or more from a market center. Mgbenka & Mbah (2016) showed agricultural market information to smallholder farmers should be provided by the Ministry of Agriculture through the field level extension workers and broadcasting media but these extension field level workers need proper training to deliver this work well. This is expected to affect trade as well as promote adoption of technologies.

2.7.3.2 Own livestock

Livestock ownership influences the adoption of the use of manure and compost. Increasing the number of livestock might not be a feasible solution option. However, introducing high-yield breeds and improved forage legumes can increase livestock products quality, including manure (Teklewold et al., 2012; United Nation, 2009). The quantity of biomass available to smallholder farmers is commonly insufficient. Their decision to use any practice that adds organic matter to the soil is usually challenged. This is because resource-poor farmers have limited resource endowments (examples, land, livestock and/or labour) (United Nation, 2009). A study in South Africa found that neighboring farms were the main source of manure for application on their fields. The study added that less than 33% of the farmers kept livestock, mainly cattle. Only 23% used manure from their animals but this quantity was not enough. This shows that these livestock farmers kept very few livestock. The neighbouring farms in this case referred mainly to feedlots and poultry farms ran by commercial farmers which could be quite a distance away (Odhiambo & Magandini, 2008). A study by United Nation (2006) has found evidence that livestock ownership conditions the adoption of compost and animal manuring. Though livestock ownership has been reported to significantly influence the adoption of SLMPs more especially compost and manuring, large livestock size discourages investment in SLMPs. This perhaps is due to the tendency of households to focus more on livestock than on crop production (Amsalu & de Graaff, 2007).

2.7.3.3 Household Size

Kassie et al., (2009b) asserts that, availability of household labour conditions the type of technology adopted, given that the labour requirements differ from technology to technology. Similarly, a higher ratio of household members who contribute to farm work is generally associated with a greater labour force available to the household. It therefore ensures the timely operation of farm activities including soil management (Odendo et al., 2011). Due to the high labour demands for preparation and application of SLMPs, higher ratio of household members who contribute to farm work increases the speed of the adoption of sustainable agricultural practices (Odendo et al., 2011; Kassie et al., 2012).

2.7.3.4 Gender and Cultural Factors

Different crop technologies may require concentrations of labour at different times of the season. However, labour distribution in a household is affected by the gender division of labour. A typical farm household in Sub-Saharan Africa has clear distinction between men's and women's roles, including management of different types of production either individually or together. The result is limited access to labour to the extent that women and men perform different tasks or have different access to outside resources. This has dire consequences on adoption of a technology (IAASTD, 2009).

Odendo et al., (2011) observed in Western Kenya that, gender of the household head stands out as an important predictor of technology adoption. They indicated that male headed households have a high likelihood of adopting manure and compost application faster than their female headed counterparts. This is possibly due to the fact that, male-headed house-holds are relatively wealthier and controls the financial resources, which could be used to carry out the technology, unlike female-headed households. Nhemachena & Hassan (2007) found in Southern Africa that, female-headed households are more likely to take up sustainable land management options. They explained that most rural smallholder farming communities in the region much of the agricultural work is done by women with the men most often found in towns. The women therefore have more farming experiences and information on various management practices and how to change them based on available information on climatic conditions and other factors. Also, female household heads have a higher chance of adopting soil conserving and conditioning technology, compared to their male counterparts. This is perhaps because smallholder agriculture is dominated by women, and any crop failure would affect them more heavily. This is probably because men control more resources (Juma et al., 2009).

Furthermore, accumulating manure requires keeping livestock, an activity most commonly associated with men. A more intensive application of fertilizer and manure is also associated with male-headed households (Juma et al., 2009). In certain ethnic groups in Ghana and some African countries such as the Dagaaba for example, women do not own certain types of animals. These animals strengthen farmers financially and also make available their manure for use in the application of animal manure and compost (Kpieta & Bonye, 2011).

Policies targeting women groups and associations in smallholder rural communities can have significant positive impacts for increasing the uptake of sustainable land management measures by smallholder farmers (Nhemachena & Hassan, 2007). Studies by Morris et al, (1999) on improved maize production technologies in Ghana found no significant association between the gender of the farmer and the probability of adopting technologies.

2.8 Summary of Chapter two

Several researchers have written on the Sustainable land management with various definition and history. All the researchers came to consensus that sustainable land management practices must ensure economic and social benefits without compromising ecological sustenance. The sustainable land management categories are many depending on the goal the problem the practice is meant to satisfy. However, this study concentrated on soil fertility enhancing practices for improved crop yields because that is a major threat to the study area compared to the other categories. Chapter two equally reviewed literature on basins/head, basket, oxcart, knap sack sprayer among others as tools used in the application of animal manure, compost and minimum tillage.

Also literature on the benefits of Sustainable land management practices was reviewed. The benefits ranged from financial to environmental benefits but the study was more on the financial benefits i.e. profitability. The study found in literature that the profit from sustainable land management practices could range from 50% to over 100% depending on the particular practice and ecological conditions of the area in which the practice is applied.

Literature on small holder farmers' perception of sustainable land management practices showed that, small holder farmers largely have good perception towards sustainable land management practices. The perceptions varied largely from practice to practice and from one ecological zone to the other.

Finally, chapter two closes with literature on factors affecting small holder farmers' adoption behaviour. It showed that, small holder farmers' adoption behaviour is determined by economic factors, social factors, biophysical factors and plot characteristics.

CHAPTER THREE

3.0 STUDY AREA AND RESEARCH METHODOLOGY

This chapter discusses the study area and the research methodology used in arriving at the findings. In the study area the profile of the area is reviewed followed by the vegetation, the climate and rainfall pattern within the area. It also discusses the agriculture, nature of soil, economic activities and occupations.

Chapter three also discussed methodology base on the research design, and methods used in arriving at the four objectives set for the study. This is followed immediately by empirical framework, sampling technique, methods of data collection. The chapter three ends with the methods of data analysis.

3.1 The Study Area

This study considers two districts representative of the Upper West Region in terms of their locations. The Lawra District is in the North-Western corner of the region and crossing diagonally to the Wa East District in the South- Eastern corner of the region. The following pages give a brief profile of the study area.

3.1.1 Profile of the Study Area

The region covers a geographical area of approximately 18,478 square kilometers representing about 12.7% of the total land area of Ghana. It is bordered to the North by the Republic of Burkina Faso, to the East by Upper East Region, to the South by Northern Region and to the West by Cote d'Ivoire. Upper West Region was carved out of the former Upper Regions in 1983. It has the lowest population of 702,110, representing 2.9% of the country's total population of 24.2 million. The region's population growth rate stands at 1.9% (MoFA, 2011; GSS, 2012). Figure 3.1 shows a Map of the Upper West Region with 11 Districts. However, it is worth noting that, Nandom District is presently created out of Lawra District, Lambusie District out of Jirapa/Lambusie District and Daffiama, Bussie, Issa (DBI) District out of Nadowli District, making a total of eleven Districts.

3.1.2 Vegetation

The Region is located in the guinea savannah vegetation belt consisting of grassland. The land is covered with scattered drought resistant trees such as the Shea trees, the baobab trees, African Locust bean trees (dawadawa), and neem trees. The heterogeneous collection of trees provides all domestic requirements for fuel wood and charcoal, construction of houses, cattle kraals and fencing of gardens. The shorter shrubs and grasses provide fodder for livestock (ACDEP, 2010; MoFA, 2011).

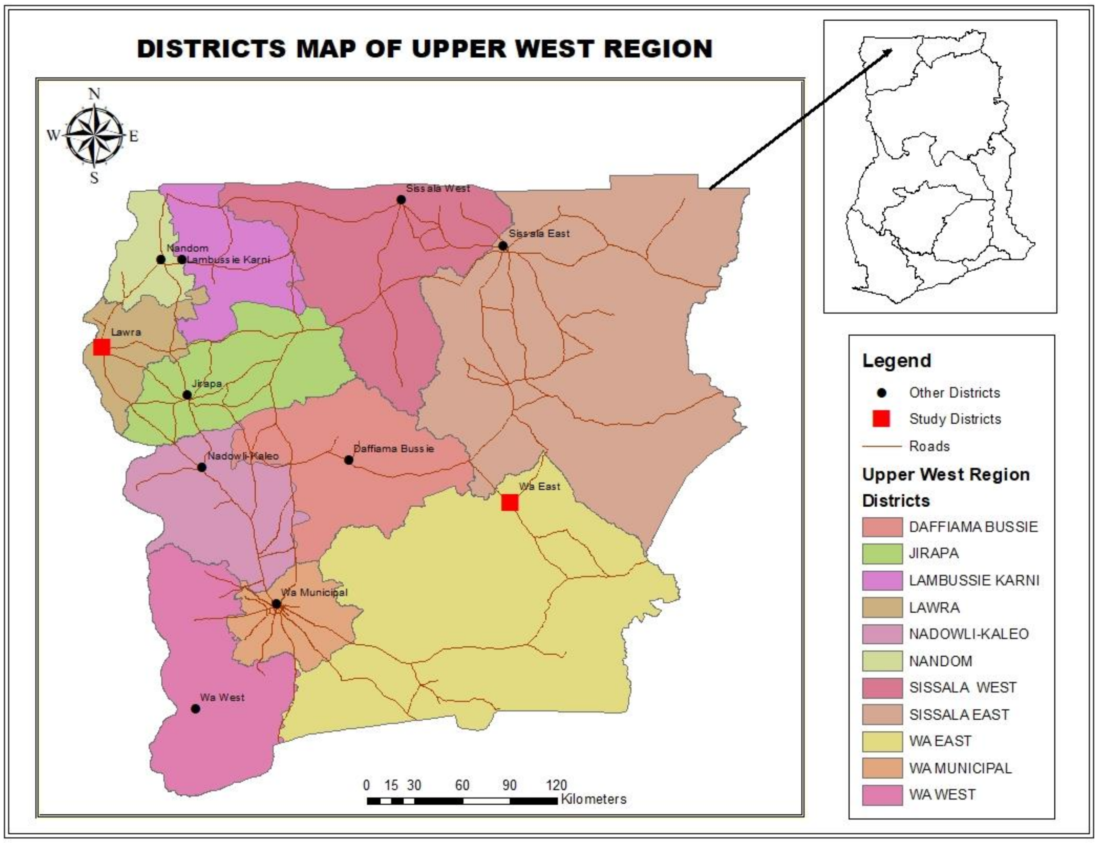

Figure 3.1 Map of Upper West Region
Source: Author's Construct (2018).

3.1.3 Climate and Rainfall

The climatic regime is semi-arid with annual rainfall of 900mm – 1200mm. The region experiences two seasons each year, the dry and the wet seasons. The wet season commences from early April and ends in October. The dry season is characterized by the cold and hazy harmattan weather. It starts from early November and ends in the latter part of March when the warm weather begins. The intensity of the warm weather ends only with the onset of the early rainfall in April (ACDEP, 2010). The mean monthly temperature ranges between 21°C and 32°C. Temperatures rise to their maximum (40°C) in March, just before the onset of the rainy season, and fall to their minimum (20°C) in December during harmattan which is brought about by the North-East Trade winds. The Region has an almost entirely flat topography, especially west of the capital of Wa and around Lawra, better referred to as the Wa-Lawra plains. The height of the land is generally between 275m and 300m above sea level, except eastwards of Wa where the land rises over 300m above sea level. Further eastwards, the land falls to about 150m above sea level (GSS, 2013; MoFA, 2011).

3.1.4 Agriculture

The predominant occupation in the Region is agriculture in its various forms that is, crop farming, livestock and poultry keeping as well as vegetable growing. The farming season starts in March/April and gets to its climax in November/December when farmers harvest their crops. The major crops cultivated include guinea corn, millet, maize, cowpea, yam, cotton, groundnuts and tobacco (GSS, 2014). Most of the farmers practised mixed cropping. However, other methods like land rotation, crop rotation and mono cropping in the case of cotton are also practised alongside. Another important agricultural activity in the Region is livestock and poultry keeping. The people rear animals like cattle, goats, sheep and keep birds like guinea fowls, ducks and fowls to supplement income from crop farming (GSS, 2014). The Ministry of Food and Agriculture, however, tries to encourage farmers to increase crop and animal production by sending agricultural extension officers around from community to community to assist farmers with knowledge and technical skills to improve crop and livestock production (ACDEP, 2010).

3.1.5 Soils

Different types of soils are found in the Region. They include the Savannah ochrosols, tropical brown yeast, terrace soils found along the banks of rivers and streams, and groundwater laterites. The types of soils in the Region favour the cultivation of various crop types including grains such as maize, sorghum, millet, rice among others (MoFA, 2011). The pulses grown are cowpea, soya bean, groundnuts among others. The Region also grows roots and tubers such as yam, potatoes, and some varieties of cassava. It is also known for the cultivation of cotton and tobacco especially on the terrace soil type (GSS, 2013).

3.1.6 Economic Activity

The Upper West Region has 21,253,417 of its population aged 5 years and older, 54.2% is economically active (employed and unemployed). The economically inactive population, that is, those not employed, not seeking nor available for work constitutes 45.8% (GSS, 2012). Of the economically active population, 95.0% are employed while the unemployed that is those without work but are seeking and available for work make up 5.0%. Among those who are unemployed, majority (58.9%) of them are first time job seekers. The proportion of males who are economically active (54.7%) is slightly higher than females (53.7%). Females, on the other hand, are more likely to be unemployed (5.5%) than males (4.6%). The results also show that students form a large proportion of the economically not active population (66.6%). The remaining is the homemaker category which constitutes 13.4%. A larger proportion of males (72.1%) than females (61.5%), are students. More females (17.5%) than males (9.0%) are homemakers. Children who are too young to work constitute 10.9% of the economically not active child population. In the entire region, high proportions of economically not active children are in full time education (GSS, 2013).

3.1.7 Occupation

The Regional population of 41.2% of the economically active population aged 15 years and older is skilled agricultural, forestry and fishery workers. About 21% is also engaged as service and sales workers while 15.2% is into craft and related trade work. Skilled agricultural, forestry and fishery work remains the dominant occupation for both males (44.9%) and females (37.7%). However, a much higher proportion of females (31.7%) than males (10.2%) are engaged in service and sales work (GSS, 2012). This pattern is generally the same for most of the regions, with the three Northern Regions, that is, Northern, 73.3%; Upper West, 72.3%; Upper East, 70.1 % having relatively high proportions of the economically active population engaged as skilled agricultural, forestry and fishery workers (GSS, 2013). In the Lawra District, about 82.4% of the employed population is engaged as skilled agricultural, forestry and fishery workers. Among the employed population, 7.8% is in craft and related trade and 3.6% in service and sales. About 3.1% is engaged as managers, professionals, and technicians (GSS, 2014).

3.2 Research Methodology

3.2.1 Research Design

The study was carried out in two districts of the Upper West Region that is, Lawra and Wa East Districts. This is because the two districts are representative diagonally of the Region moving from North-Western corner of the Region (Lawra District) to the South-Eastern corner of the Region (Wa East District) respectively. Data was collected in December, 2017 from both Districts using structured questionnaire. This is because during the month, farmers are less busy and are more likely to spare some time for the collection of their data. The timing also allowed the researcher to finish on time considering the time frame for the study. Data on yield was collected based on recall of farmers' previous year (2016) yield estimates.

The first part of the questionnaire collected information on small holder farmers' background and household characteristics. The second part collected information on tools used by farmers in the application of animal manure, compost and minimum tillage. The part three collected information on farm production and yields and then followed with data on smallholder farmer perception of animal manure, compost and minimum tillage. The final part was on socio economic and plot characteristics of farmers which enables the regression of their socio economic and plot characteristics against their choices of SLMPs.

This survey employed face to face interviews to solicit the required data in the study. Despite the high cost and interviewer bias of face to face interviews, it has high response rate and also permits the longest and most complex questionnaire to be administered. It also allows interviewers to observe the surroundings and to use nonverbal communication and visual aids. Interviewers can ask all types of questions and can use extensive probes in soliciting the requisite information (Newman, 2014).

3.2.2 Tools for Animal manure, Compost and Minimum Tillage Application

Structured questionnaire were used in collecting information from farmers regarding the tools they use in applying each of the practices using face to face interviews. The questionnaire were designed based on prior information provided by both Lawra and

Wa East Districts Agricultural officers on the tools used by farmers in executing the respective practices in the Districts. A preliminary survey was also done on some smallholder farmers on the tools they used in executing the respective practices. The questionnaire provided a set of tools with options for other tools not captured in the set for each respondent to tick in accordance with the particular practice(s) and the appropriate tool he/she uses in carrying out the practice(s). The responses for both districts were collectively analysed in frequencies and percentages. The prevailing cost prices for each of the tools in the neighbouring shops around the communities were obtained through the survey. The costs for the respective set of tools for each of the practices were estimated and used in obtaining total cost for the set of tools used in carrying out each practice. The mean cost of tool for applying each of the practices was then computed in line with the set of tools selected for the practice.

3.2.3 Estimating the Profitability of SLMPs

The study employed partial budget analysis for analysing the profitability of each of the practices. Greene (2002) explained that partial budget is most appropriate for analysing the profitability of farm business in which changes were added to certain aspects of the business but not the entire farm business. Table 3.1 is a presentation of partial budget format followed in arriving at the profitability figures.

Table 3.1: Partial Budget for Alternative SLMPs

Added Costs	**Cost in GH¢:**	**Added Returns**	**Benefits in GH¢:**
Activity/Item1	X	Activity/Item1	X
Activity/Item2	X	Activity/Item2	X
Activity/Item3 etc.	X	Activity/Item3 etc	X
Reduced Returns	**In GH¢**	**Reduced Cost**	**In GH¢**
Item/Activity 1	X	Item/Activity 1	X
Item/Activity 2	X	Item/Activity 2	X
Item/Activity 3 etc.	X	Item/Activity 3 etc.	X
Total Costs	**X**	**Total Benefits**	**X**
NET CHANGE IN PROFIT = Total benefits – Total costs or (F−E)			

Source: New Jersey Department of Agriculture, 2001.

3.2.3.1 Sensitivity Analysis

This describes the responsiveness of profit to changes in the prices of inputs and or output (Gittinger, 1984). It was based on the average inflation rate over the year 2017. The Ghana Statistical Service estimated 11.8% annual inflation rate for the year 2017. The sensitivity estimates of profit in response to either 11.8% changes in input price which will reduce profit or 11.8% increase in output price which will increase profit was estimated using the formula below:

$$\left(\frac{Profit}{Total\ \text{cost of SLMP}}\right)\times 100 \quad \text{or} \quad \left(\frac{Profit}{Total\ \text{benefit of SLMP}}\right)\times 100 \qquad 1$$

3.2.3.2 Weakness of Partial Budget

Partial budgeting, like any other technique has some weaknesses. The weaknesses are that, partial budgeting is restricted for evaluating only two alternative projects. The efficiency and effectiveness of partial budgeting depend on the quality of data used.

Partial budgeting does not account for the time value of money, that is, the difference between the value of money received and or expended now versus the value in a future date. Another limitation is that, partial budgeting only provides an estimate of the profitability of an alternative relative to current operations. It does not provide an estimate of the absolute profitability of the business (New Jersey Department of Agriculture, 2001).

3.2.3.3 Strengths of Partial Budget

Partial budgeting provides detailed information regarding the new change to be added. It indicates the added benefits due to the change (added returns), the benefits to be lost due to the change (reduced returns), the additional expenses to be made due to the change (added costs), and the reduction in expenditure due to the change (reduced costs). Added costs and reduced returns constitute the cost section of the partial budget. It also provides details of all cost to be incurred and all benefits to be accrued due to the change so as to facilitate decision on whether or not to continue with the change (New Jersey Department of Agriculture, 2001; Gittinger, 1984).

3.2.4 Knowledge and Perception of Farmers on SLMPs

Farmers' knowledge and perception on the studied SLMPs was assessed by using a Likert-scale. The Likert-scales were developed in 1930 by Rensis Likert to provide an ordinal-level measure of a person's attitude. The Likert-scale is often used in survey research in which people express their attitudes or other responses in terms of ordinal-level categories (example, agree, disagree) that are ranked along a continuum (Newman, 2014). The Likert scale usually asks people whether they agree or disagree with a statement and other modifications may be added (Bhattcherjee, 2012). In using the Likert-scale, eight statements were composed that included four positive and four negative statements addressing the individual practices, that is, animal manure, compost and minimum tillage. Table 3.2 presents the four positive and negative statements used in the study in relation to the three practices under study.

Table 3.2: Positive and Negative Statements Relating to SLMPs

Positive	Negative
1. Increase yield on cultivated fields	1. It is very complex to use on the field
2. Maintain the fertility of the soil	2. It can lead to complete crop failure
3. Control/prevent erosion of the soil	3. It is very expensive to apply on the field
4. Reduce cost of crop production	4. It is not compatible with existing farming practices

Source: Author's Construct, 2018

A five-point Likert-type scale was then used to solicit responses from respondents. The responses included: 1. strongly agree, 2. Agree, 3. Neutral, 4. Disagree and 5. Strongly disagree. Strongly agree for positive statement and a reverse system of scoring for negative statements.

Descriptive statistics including frequency distributions were used to explain the relationship. Perception indexes for each of the practices were estimated to find out whether farmers have good (positive) perception towards the practices or otherwise. A positive perception is a measure of smallholder farmers' demand for the practices and vice versa (Owusu & Anifori, 2012). In the estimation of the indexes, the frequency distribution for each of the positive and negative statements was computed. The Likert-scale responses for each statement were coded with numerals starting from 1 for the positive responses (strongly agree) to -1 for the negative responses (strongly disagree). Each statement frequencies were then multiplied by their respective codes and divided by the total sample for the particular practice. The values were summed up to get the indexes for each statement. The indexes for the statements were in turn summed up for each SLMP to get its Perception Index. Neuman (2014) showed that scale and indexes can improve reliability and validity. The use of multiple indicators that measure several aspects of a construct or opinion improves content validity.

Finally, the indexes give a more quantitative measure of a person's opinion (Newman, 2014; Bhattcherjee, 2012; Leary, 2001). The reliability refers to a measure of dependability and validity refers to the truthfulness or the fit between a construct and data. In both quantitative and qualitative studies, researchers try to measure in a consistent way and seek a tight fit between the abstract ideas and the empirical social world (Kumar, 2011).

3.2.4.1 Weaknesses of the Likert-scale

The major weakness of the Likert type scale is that, different combinations of several scale items produce the same overall score. The other weakness is that, the response set is a potential danger. Response set describes the tendency of a respondent to answer all questions the same way without necessarily thinking about it (Newman, 2014). These weaknesses as identified were overcome by the selection of different mix of communities randomly. Respondents were also of diverse backgrounds who were as well interviewed individually. This ensures that, the responses of every respondent were as independent as possible.

3.2.4.2 Strength of Likert-Scale

The real strength of the Likert Scale is its simplicity and ease of use. When several ranked items are combined, it gives a more comprehensive multiple indicator measurement (Kumar, 2011).

3.2.5. Empirical Framework

The SLMPs model follows that, given alternative technologies, a farmer i^{th} (i =1…..N) who is to take a decision on the adoption of SLMPs on plot $p(p=1....P)$. Let $U_0 =$ represent the benefit to the farmer from traditional management practices, U_k represent the benefits to the farmer from adopting the k^{th} SLMP. Where $k=1,\ 2,\ 3,\ 4,\ 5,\ 6,\ \text{and}\ 7$ denoting the alternative SLMPs and their combinations on the plots of land. The farmer decides to adopt the k^{th} SLMP, if $Y_{ipk}^{*} = U_k^{*} - U_0 > 0$. The net benefit (Y_{ipk}^{*}) that the farmer derives from the k^{th} SLM practice is a latent variable determined by observed farmer, plot and location characteristics (X_{ip}) and unobserved characteristics (ε_{ip}):

$$Y_{ipk}^{*} = X_{ip}^{'}\beta_k + \varepsilon_{ip} \qquad \text{k=1, 2, 3, 4, 5, 6, 7} \tag{2}$$

Using the indicator function, the unobserved preferences in equation (1) translate into the observed binary outcome equation for each technology adopted as follows (Greene, 2002):

$$Y_k = \left\{ \begin{matrix} 1\ if\ Y_{ipk}^{*} > 0 \\ 0\ if\ otherwise \end{matrix} \qquad k = (1,2,3) \right\} \tag{3}$$

In the multinomial model, where the choice of several SLMPs are possible, the error terms jointly follow a multivariate normal distribution (MVN) with zero conditional mean and variance normalized to unity (for identification of the parameters) where $(\varepsilon_1, \varepsilon_2, \varepsilon_3) \sim MVN(0, \Sigma)$ and the symmetric covariance matrix Σ is given by:

$$\Sigma = \begin{bmatrix} 1 & \rho_{12} & \rho_{13} \\ \rho_{12} & 1 & \rho_{23} \\ \rho_{13} & \rho_{32} & 1 \end{bmatrix} \tag{3}$$

Of particular interest are the off-diagonal elements in the covariance matrix, which represent the unobserved correlation between the stochastic components of the different types of SLMPs. This assumption means that equation (2) gives a Multinomial Logit Model that jointly represents decisions to choose a particular technology. This specification with non-zero off-diagonal elements allows for correlation across the error terms of several latent equations, which represent unobserved characteristics that affect the choice of alternative SLMPs (Greene, 2002).

The empirical model is as follows:

$$Y_{P_i} = \beta_0 + \beta_1 EXP + \beta_2 ACCEXTSER + \beta_3 ACCREADYMKT + \beta_4 TFARMSIZE + \beta_5 HHSIZE + \beta_6 TNUMB\_ANIMALS + \beta_7 MEMFARMASS + \beta_8 PCEIVE\_PROFIT + \beta_9 FERTSTATUS + \beta_{10} COST\_PDN / ACRE + \varepsilon_{p_i} \quad \text{.........} 4$$

3.2.5.1 Variable Description

The SLMPs are the dependent variables.

$Y_1 = AnimalManure$

$Y_2 = Compost$

$Y_3 = MinimumTillage$

$Y_4 = AnimalManure \,\&\, Compost$

$Y_5 = AnimalManure \,\&\, MinimumTillage$

$Y_6 = Compost \,\&\, MinimumTillage$

$Y_7 = AnimalManure, Compost \,\&\, MinimumTillage$

3.2.5.2 Explanatory Variables

These include plot characteristics and socioeconomic characteristics of farmers.

3.2.5.2.1 Socio-economic and Household Characteristics of the Farmer

$$X_1 = Experience(EXP)$$
$$X_2 = AccessToExtensionService(ACCEXTSER)$$
$$X_3 = AccessToReadyMarket(ACCREADYMKT)$$
$$X_4 = TotalFarmSize(TFARMSIZE)$$
$$X_5 = HouseholdSize(HHSIZE)$$
$$X_6 = TotalNumberOfAnimals(TNUMB\_ANIMALS)$$
$$X_7 = MemberFarmerAssociation(MEMFARMASS)$$
$$X_8 = PerceivedProfititability(PCEIVE\_PROFIT)$$
$$X_{10} = CostOfProduction/acre(COST\_PDN/ACRE)$$

3.2.5.2 Plot/Farm Characteristics

$$X_9 = FertilityStatusOfPlot(FERTSTATUS)$$

3.2.6 Sampling Technique

This study employs a multistage sampling technique. Two districts were selected representative of the Upper West Region in terms of location and Cereal crop production. The Lawra District located in the North-Western corner of the Region produces less cereal grains compared to Wa East District located in the South-Eastern corner of the Region is the food basket of the Region according to the Regional Plant Protection Manager. A stratified sampling technique was employed in sampling communities for the study. The district Agricultural offices classified each district into Extension Areas commonly known as EAs. Among the Extension areas, at least one community was randomly selected from each Extension Area depending on the number of communities in the Extension Area. The Project Officer of Sustainable Land and Water Management in Wa East district indicated that, there was an on-going World Bank Project to Promote Sustainable Land and Water Management along the major water bodies within the district. The Lawra District Agricultural Officer when contacted equally indicated that, the district benefited from an earlier World Bank Project known as Ghana Environmental Resource Management Project (GERMP).

The two projects both introduced and encouraged the use of animal manure application, compost and minimum tillage among other practices. The selection of communities took into consideration the communities that benefited from these projects and those that have never benefitted. This gave us eight communities in each district giving us a total of 16 communities in both districts. The following communities were selected as a result, Baazing, Bagri, Kalsegre, Lissa, Tanchara, Yagra, Yikpee and Zambo from the Lawra District. Communities from Wa East District included Bufiama, Duccie, Funsi, Kpaglahi/Kpalinye, Kundugu, Luggu, Manwe and Yaala.

The population included all smallholder farmers in these communities. The targeted group was smallholder farmers who cultivate cereal crops particularly maize, sorghum and millet. Smallholder farmers were chosen because they constitute large percentage of farmers within the Region and the country at large. The smallholder farmers will be largely affected following any major change in farm policy. The study considered cereal crops particularly maize, sorghum and millet because they are widely cultivated and consumed within the Region (GSS, 2013).

A sample size of 256 respondents was selected across Lawra and Wa East districts of purposively due to their involvement in SLMPs use in the Region. A preliminary check from Districts Agricultural officers indicated that almost every farmer in the districts practised at least one of the practices under study. The study selected 16 respondents in each community across the two districts making a total of 128 respondents from each district and a total sample size of 256 respondents. They were several communities in each of the two districts but a preliminary survey showed that, more than 95% of the communities in the districts were small holder farmers. This implies that, every community in each of the districts was qualified to be selected for the study. The 16 communities were randomly selected using excel application software giving equal chances for every community to be selected. In the selection of respondents the researcher adopted several methods but was largely accidental, because some farmers selected did not avail themselves for the interview. They indicated they were busy with their produce and therefore had little time to spend on the interviews. Data was therefore collected on respondents who were willing and largely available and ready to be interviewed in each community. Table 3.3 presents a detailed breakdown of sample size from the two districts.

Table 3.3 Sample Size

Lawra District		**Wa-East District**		**SampleSize**
Community	Respondents	Community	Respondents	
Baazing,	16	Bufiama,	16	
Bagri	16	Ducie	16	
Kalsegre	16	Funsi	16	
Lissa	16	Kpaglahi/Kpalinye	16	
Tanchara	16	Kundugu	16	
Yagra	16	Loggu	16	
Yikpee	16	Manwe	16	
Zambo	16	Yaala	16	
Total	**128**	**Total**	**128**	**256**

Source: Author's Creation.

3.2.7 Methods of Data Collection

Different writers have discussed extensively the various methods as used in research (Newman, 2014; Bhattcherjee, 2012; Kumar, 2011). But this study employs a survey method in the collection of the data. The researcher employs the survey method because it involves the use of standardized questionnaire or interviews to collect data about people and their preferences, thoughts, and behaviors in a systematic manner (Bhattcherjee, 2012).

Bhattcherjee (2012) further explained that the survey method is best suited for studies that have individual people as the unit of analysis. Although other units of analysis, such as groups, organizations are also studied using surveys, such studies often use a specific person from each unit as a "key informant" or a "proxy" for that unit, and such surveys may be subject to respondent bias if the informant chosen does not have adequate knowledge or has a bias opinion about the phenomenon of interest.

This study therefore uses structured questionnaire with personal interview (face to face), whereby trained enumerators were deployed to ask household heads to provide their background information. The household heads were also asked to tick from a list of tools provided in a questionnaire. The household heads were also asked to recall production cost and yields estimates made during a reference period of 2016 expending a lot of time with respondents. This approach provided the primary data for the study.

Respondents characteristics, tools use for animal manure, compost and minimum tillage, production cost and yields estimates, perception and socio economic factors were collected using face to face interviews with smallholder farmers using structured questionnaire. Key stakeholders in the districts and Regional Agricultural offices were asked for their view in prevailing situations and findings. Also, secondary data was sourced from MoFA, journals, bulletins, FAO reports among others. Experts' opinions were sourced from the Upper West Plant Protection Manager, Wa East District Plant Protection Officer, and a delegate from Lawra District Agricultural Directorate for additional information.

3.2.7.1 Questionnaire

The English Dictionary described a questionnaire as a form with a set of questions administered to people especially during a survey to obtain statistical information. A questionnaire consists of a number of questions printed or typed in a definite order on a form or set of forms. The main aspects of a questionnaire considered by researchers in designing the questionnaire are the general form, question sequence, question formulation and wording (Kothari, 2004). Kothari (2004) explained two types of questionnaire, the structured questionnaire and the unstructured questionnaire. Structured questionnaires are those questionnaires in which there are definite, concrete and pre-determined questions. The questions are presented with exactly the same wording and in the same order to all respondents. The form of the questions may be either closed (that is, of the type 'yes' or 'no') or open (that is, inviting free responses). Structured questionnaires may also have fixed alternative questions in which responses of the informants are limited to the stated alternatives.

In this study semi structured questionnaires were used with both yes or no responses and in other instances inviting free responses from respondents. Unstructured questionnaire on the other hand are questions that allow for respondents own views, answers and comments without any specification or restriction. The questionnaires used in the survey exhibit characteristics of both the structured and unstructured.

3.2.7.2 Limitations of Structured Questionnaire

Wide range of data and in respondent's own words cannot be obtained with structured questionnaire. Structured questionnaire is inappropriate in investigations where the aim is a probe for attitudes and reasons for certain actions or feelings. They are equally not suitable exploratory studies (Leary, 2001). The above limitation was overcome by using both the structured and unstructured to ensure a balance in respondents' presentation of their opinions.

3.2.7.3 Advantages of Structured Questionnaire

Despite the above limitations, structured questionnaires are simple to administer and relatively inexpensive to analyse. The provision of alternative replies, at times, helps to understand the meaning of the questions clearly (Kothari, 2004; Leary, 2001).

3.2.7.4 Questions in a Questionnaire

Questions in a questionnaire may be open ended or close ended. Open-ended questions are those in which the possible responses to a question are not given. In this type of questions, the respondent is at liberty to write down the answers in his or her words. Open-ended questions have the advantage of providing in-depth information and variety. Open-ended questions can also provide a wealth of information provided respondents feel comfortable about expressing their opinions and are fluent in the language used. On the other hand, analysis of open-ended questions is more difficult because researchers need to spend time and energy classifying data. Also, some respondents may not be willing to express themselves, and so information can be lost (Kumar, 2011). In the closed-ended questions, the possible answers are set out in the questionnaire or schedule and the respondent or the investigator ticks the category that best describes the respondent's answer. In most cases however, a category is provided to accommodate any response not listed in the questions. The disadvantages of closed questions are that the information obtained through them lacks depth and variety. There is also a greater possibility of investigator bias because the researcher may list only the response patterns that s/he is interested in or those that come to mind and as a result, the findings may reflect researcher bias. In a questionnaire, the given response patterns for a question could condition the thinking of respondents, and so the answers provided may not truly reflect respondents' opinions. The ease of answering a ready-made list of responses may create a tendency among some respondents and interviewers to tick a category or categories without thinking through the issue. The strength however of closed questions is that, because they provide 'ready-made' categories within which respondents reply to the questions asked by the researcher, they help to ensure that the information needed by the researcher is obtained and the responses are also easier to analyse (Kumar, 2011).

3.2.7.5 Weaknesses of Face to face Interview

The high cost involved in executing face to face interviews is the biggest disadvantage to researchers using face-to-face interviews. The cost of training enumerators, traveling cost and supervision cost can be extremely high. The second point of weakness is interviewer bias in face-to-face interviews. The interviewer's appearance, tone of voice, question wording, and so forth may affect the respondents in their response to questions being asked during the interview. In addition, interviewer supervision is lower compared to other forms of interviews (Newman, 2014).

3.2.7.6 Strength of Face to face Interviews

The face-to-face interviews have shown to present the highest response rates. It also permits the longest and most complex questionnaires. The face to face equally has higher advantage over other forms of interview because it allows interviewers to observe the surroundings and to use nonverbal communication and visual aids. Well-trained interviewers can ask all types of questions and can use extensive probes for elaboration on answers to enhance accuracy of response (Newman, 2014; Leary, 2001).

3.2.7.7 Validity and Reliability of Survey Data

Kumar (2011) explained that, **t**he reliability refers to a measure of its dependability and validity refers to the truthfulness or the fit between a construct and data. Survey method even though exhibits greater strengths and advantages, it is often tainted with systematic biases that may invalidate some of the inferences derived from such surveys. Some of such biases are the non-response bias, sampling bias, social desirability bias, recall bias, and common method bias (Bhattcherjee, 2012). Non response bias which was reduced or prevented by using face to face interviews with short, simple, straight forward questions.

Additionally, respondents were assured of the confidentiality of the data they were providing. The issue of sampling bias was improved by clearly defined target population coupled with the combination of stratified and random sampling of respondents. Another type of bias that could affect the validity of data was the social desirability bias which describes the tendency among respondents to "spin the truth" in order to portray themselves in a socially desirable manner (Bhattcherjee, 2012). Simple and straight forward questions were asked according to the objectives of the study. The questions by their nature have little to do with social desirability and therefore data was valid.

Furthermore, recall bias which is an issue with survey data was dealt with by reminding respondents with events which anchor their memories. It has also ensured that questions do not lapse more than a year so as to reduce recall bias. The last but not the least, is common method bias which refers to the amount of spurious covariance shared between independent and dependent variables that are measured at the same point in time, such as in a cross-sectional survey, using the same instrument, such as a questionnaire. The dependent variable in this study refers to the SLMPs which were known ahead of the study. The data collected by the questionnaire was mostly on the explanatory variables otherwise known as independent variables which implied that, the issue of common method bias is reduced if not prevented.

3.2.8 Data Analysis

The term, analysis refers to the computation of certain measures along with searching for patterns of relationship that exist among data-groups (Kothari, 2004). Kothari (2004) implied that, data analysis is preceded by processing which include editing, coding, classification and tabulation of collected data so that they are amenable to analysis. Data from the field was manually edited to ensure accuracy, consistency with other facts gathered and uniformity. The data was carefully coded such that the classes are appropriate to the research problem under study. Coding is necessary for efficient analysis and reduction of responses to a small number of classes which contain the critical information required for analysis (Kothari, 2004). The data was then classified into similar groups based on the data attributes. The data was subsequently entered into Statistical Package for Social Scientist (SPSS) application installed on the Laptop. Copies of the data were made and some of it converted into STATA for use in the regression analysis. A combination of analytical tools in SPSS and STATA were used in analyzing the results. Both descriptive and inferential analyses were used. In the former, descriptive statistics, charts and tables were used to report the frequencies and percentages of background characteristics of respondents. Frequencies, percentages, means and standard deviations were used to report the tools and equipment used in the application of the three practices under study that is animal manure, compost and minimum tillage. Estimates of profitability were computed from data employing partial budgeting technique and reported in tables. Responses on perception were computed in frequencies and using indexes. The final results on perception indexes were computed and reported on tables. In the latter regression analysis of the factor influencing smallholder farmers' adoption decisions of SLMPs were analysed with STATA. Some statistical tests of hypotheses were considered using both the z-test and F-statistics. The results were presented in tables. The findings and conclusions are reported in chapters four and five of this write up.

3.3 Summary of Chapter three

In this chapter, literature on the study area was reviewed to give the reader a perspective picture of the study area. This will enable the reader to better understand the findings of the study and the setting. The methodology discussed the research design with some supporting literature on the study. Questionnaires were used to collect literature on the tools for the application of animal manure, compost and minimum tillage. Profitability was analysed with partial budget analysis and sensitivity analysis carried out using 2017 annual inflation rate. The Likert scale analysis of small holder farmers' perception was carried out on sustainable land management practices. The frequencies obtained were used to estimate the perception index for each of the practices.

In the nutshell, a multinomial logit analysis of determinants of small holder farmers' adoption behaviour was carried out. The outcome of the findings with their respective methodologies is reported in chapter four.

CHAPTER FOUR

4.0 RESULTS PRESENTATION AND DISCUSSION

4.1 Introduction

This chapter discusses the characteristics of respondents, findings from the study and opinions of stakeholders in the study area. Findings were also compared with findings of other researchers in other areas. Interactions with some individual farmers were also discussed.

4.2 Characteristics of Respondents

Respondents for the study were selected from 16 communities. In each district, 16 respondents were selected from 8 communities summing up to 128 respondents from each District. This makes up a total of 256 respondents from both districts. These respondents were of diverse characteristics which were expected to have effects on SLMPs adoption behaviours.

The following communities were selected randomly from Lawra District, Baazing, Bagri, Kalsegre, Lissa, Tanchara, Yagra, Yikpee and Zambo due to their involvement in small holder agriculture. Communities from Wa East District were equally randomly selected to include Bufiama, Duccie, Funsi, Kpaglahi/Kpalinye, Kundugu, Luggu, Manwe and Yaala because of their involvement in small holder agriculture. Sixteen smallholder farmers were then sampled accidentally from each community. Some respondents in the study areas did not give their consent for the interviews to be conducted on them with the view that, the interviews were wasting their time. The Wa East District Project Officer of Sustainable Land and Water Management indicated that, there was an on-going World Bank Project to Promote Sustainable Land and Water Management along the major water bodies within the district. The Lawra

District Agricultural Officer when contacted indicated that, the district benefited from an earlier World Bank Project known as Ghana Environmental Resource Management Project (GERMP). The two projects both introduced and encouraged the use of animal manure application, compost and minimum tillage among other practices. The selection of communities took into consideration the communities that have benefited from these projects and those that have never benefitted. Figure 4.2 below represents frequencies of adoptions of SLMPs as applied within the two Districts under study.

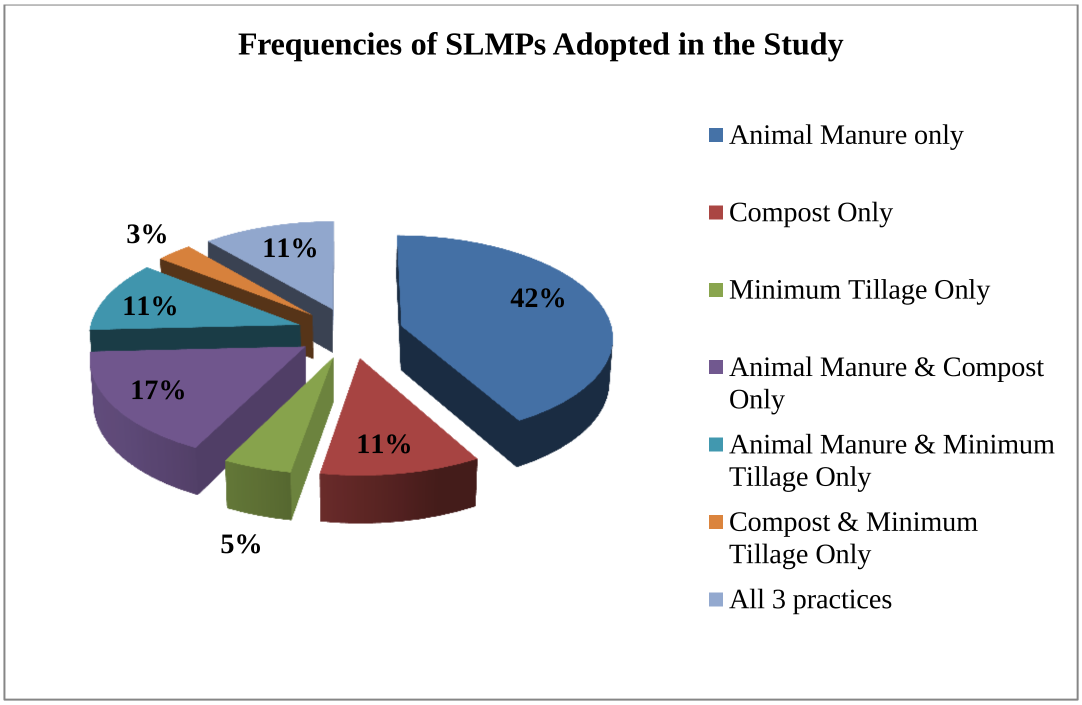

Figure 4.1: Frequencies of SLMPs Adopted in the Study
Source: Field Survey (December, 2017).

4.1.1 Gender

As represented in the Table 4.2., 93.8% of respondents are male household heads. These districts are largely agricultural based which is dominated by male headed households who take all the farm decisions. This is representative of the 87.1% male headed household in Wa East District and 78.1% in Lawra District (GSS, 2013). It is equally reflective of our national situation particularly in the Northern Regions where majority of household heads are male headed (GSS, 2012). This may positively affect adoption since household decisions and control are in the hands of male household heads. However, the Region is dominated by females with 51.4% to 48.6% as has been the National Population (GSS, 2013). In Kenya, gender of the household heads stands out as an important predictor of technology adoption. They indicated that male headed households have a high likelihood of adopting manure and compost application faster than their female headed counterparts. This is possibly due to the fact that, male-headed households are relatively wealthier and controls the financial resources, which could be used to carry out the technology, unlike female-headed households (Odendo et al., 2011). Studies by Morris et al, (1999) on improved maize production technologies in Ghana found no significant association between the gender of the farmer and the probability of adopting technologies. On the other hand, female household heads have a higher chance of adopting soil conserving and conditioning technology, compared to their male counterparts. This is perhaps because smallholder agriculture is dominated by women, and any crop failure would affect them more heavily. They do not also control adequate financial resources to procure expensive technologies (Juma et al., 2009). IAASTD (2009) indicated that different crop practices may require concentrations of labour at different times of the season. This affects both household and gender division of labour. A typical farm household in Sub-Saharan Africa has a clear distinction between men's and women's roles, including management of different types of production either individually or collectively. The result is limited access to labour as both women and men perform different tasks. This has dire consequences on technology adoption.

4.1.2 Marital Status

About 85% of respondents were married as shown in Table 4.2. This is characteristic of the northern rural communities where farming is the main occupation as marriage provides a help mate for most farm households. The Wa East District is 100% rural while the Lawra District is 86.7% rural. This means that, their livelihood is dependent on agriculture which is usually dominated by married families with the female partner being a help mate on the farm. This explains why there is higher percentage of married households in the study compared to the regional values reported. The 2010 population and housing census report showed 51.1% of the married population in the Upper West Region. About 9% of the respondents were also widowed (GSS, 2013). The rest were either divorced or singled.

4.1.3 Level of Education

The respondents were very varied in their levels of education. About 52% of respondents have never sat in any classroom to be taught. This probably explains why many of them are involved in smallholder farming where skill is not a pre requisite especially in our part of the continent. These findings conform to the 2010 Population and Housing Census Report that, literates in the Upper West Region were less likely to be involved in agriculture, forestry and fishery. About 19% had at least entered basic school but did not go beyond basic school. This is characteristic of their low level of skills and hence their involvement in smallholder farming.

According to the 2010 Population and Housing Census Report, agricultural, forestry and fishery workers formed 72.8% of the workforce, by far the biggest segment in the Upper West Region. The report showed that, those with degrees or higher educational levels were less likely to be employed in agriculture, forestry and fishery (6.0%) whereas 15.3% of those in managerial positions and 55.9% of professionals had degrees or higher education (GSS, 2013). The remaining 5.1%, 3.1%, 3.2% had secondary, tertiary and non-formal education respectively. These farmers were therefore less likely to adopt SLMPs as their sources of information on SLMPs will be limited.

Education increases the understanding of farmers on issues which make them able to make informed decisions and therefore have a positive influence on the adoption of SLMPs (Akudugu et al., 2012; Teklewold et al., 2012). Investments in education of farmers at this level should be focused on influencing non-formal education and equipping the Extension division of Ministry of Food and Agriculture. Investment in rural public education with special focus on women will facilitate the adoption and use of SLMPs (Teklewold et al., 2012). Conversely, findings in Uganda show that, educated households are less likely to adopt labour intensive conservation practices comparatively. Accordingly, educated farmers have higher labour opportunity costs and therefore discouraging them from using labour-intensive technologies, such as application of animal manure and crop residues (Sserunkuuma, 2005).

ACDEP (2010) attributed the slow development of Northern Ghana to low level of education. Magbenka & Mbah (2016) indicated that, the general lack of access to information or awareness among smallholder farmers can be attributed to their high level of illiteracy. This contributes to the low level of adoption of agricultural production technology. Extension is a type of education which is functional rather than formal. It is therefore best recommended for the conveyance of farm information to the farmers. Table 4.2 presents a breakdown of respondents, characteristics from the field survey, December 2017.

4.1.4 Religious Beliefs

Religiously, the respondents were very balanced. With 39.5%, 30.5%, 29.7%, 0.78% been Traditional, Christianity, Islamic and others religious believers respectively. Table 4.1 presents the breakdown of respondents according to their religious beliefs.

Table 4.1: Respondents' Characteristics

	Male		Female		
Gender	240* (93.8)		16* (6.2)		
Marital status	Married		Widowed	Single	Divorced
	217* (84.8)		24* (9.4)	9* (3.5)	6* (2.3)
Level of Education	None	Basic	Secondary	Tertiary	Non formal
	185* (52)	48* (18.8)	13* (5.1)	8* (3.1)	3* (1.2)
Religion	Others	Christianity	Islam	Traditionalist	
	2* (0.78)	78* (30.5)	76* (29.7)	101* (39.5)	
Ethnicity	Others	Sissala	Dagaaba	Waala	Lobi
	5* (2.0)	57* (22.3)	151* (59)	39* (15.2)	5* (2.0)
Off farm income	Yes		No		
	178* (69.5)		78* (30.5)		
Off farm job type	Others		Formal	Trading	Artisan
	186* (72.7)		20* (7.8)	21* (8.2)	29* (11.3)

***=Frequency, () = percentage out of the total**
Source: Field Survey (December, 2017).

Belonging to a religion affects the type of animal one can consume and for that matter rear. For example, being a Muslim forbids the person from eating pork. Such a person is unlikely to rear pigs even in an area where pigs may have competitive advantage.

This therefore has a greater influence in the adoption of animal manure. According to the 2010 Population and Housing Census, Regional Analytical Report indicated 44.5%, 35.6% and 13.9% for Christianity, Islam and Traditionalist respectively. The Wa East District however, has 57.9% Muslims and among the largest Muslims' dominated districts in the Upper West Region. The Lawra District reported 72.3% Christians and the largest Christian dominated district in the Region (GSS, 2013).

4.1.5 Ethnicity

The various ethnic representation of the Region is presented in Table 4.1. 59% of respondents were Dagaaba. This is very reflective of the ethnic groupings in the Region. Majority of the respondents in Lawra and Wa East Districts for that matter the Upper West Region are Dagaaba. The Sissala, Waala, Lobi and other groups were presented as 22.3%, 15.2%, 5% and 5% respectively. The type of animal an individual rears is determined by the ethnic group the person belongs. Some animals are considered sacred (untouchable), others can be used for ritual sacrifices whilst others cannot. The Dagaaba who are largely present in all the districts of the Upper West Region for example, use cattle and sheep in offering rituals to the ancestors but goat, pig, and dog cannot be used in offering ritual sacrifice (Kpieta & Bonye, 2011). This has dire consequences on animal manure adoption among others and the amount of organic materials available for the preparation and use of compost.

4.1.6 Off Farm Income

About 69% of respondents indicated that, they earn income outside the farm. This is an assurance of additional income to support farming activities. An enquiry into the type of work carried out by respondents indicated the following results as presented on the Table 4.1 above. About 72% representing respondents do not have well-defined jobs. They earn their income only on information that their services are needed and they respond to the information which sometimes is not reliable. This observation correlates with that presented by Ghana Statistical Service (2013) which showed 67.3% of the population, 15 years and above employed in various categories of work and 2.9 percent unemployed, while 29.8% was not economically active. About 11.3% earn income from their craft of which the work is not always available and immediate payment not guaranteed. About 9% of respondents are involved in trading which expanded from petty trading to any form of buying and selling. About 8% earn salary monthly from formal employment. This is an assurance of regular income to support farming activities. Earlier studies have shown that off farm income moves farmers away from concentrating on adoption of SLMPs (Amsalu & de Graaff, 2007; Kassie et al., 2012)

4.1.7 Animal Manure Preparation for Field Application

In Baazing, one of the study communities in the Lawra District, the lead farmer who was also one of the respondents during an interview section in his backyard gave a brief narration of how he and many others collect and apply animal manure on their fields. The narration was directly translated into English written in the report as follows:

The animals are housed to enable the farmer get adequate manure. Any farmer who does not house the animals can only get manure from colleagues who house their animals or from the Fulani people who usually have them in larger quantities (Lead farmer Baazing, December 2017). Housing of cattle for instance constitutes an important aspect of manure management. Confined animals optimization of both housing and manure management is important to facilitate feeding, hygiene and animal health/welfare, manure collection and nutrient conservation (Snijders, et al., 2009).

The animals' house is cleaned once weekly and the waste (droppings mixed with urine and feeds) are heaped at a particular place close to the animals' house. The gathering of the manure continues until the dry season when large quantities of the manure are gathered (Lead farmer Baazing, December 2017).

Kim, et al., (2011) explained that, manure collected and heaped over-ground piling in storage before application is commonly applied by most farmers. But the practice has the tendency to affect the quality of the manure.

Most farmers are usually less busy during the dry season and therefore spend their time conveying the manure from their homestead to wherever they want to apply.

The manure usually increases crop yield. The yield can be sustained for several years. The manure is better than even fertilizer when applied on the field (Lead farmer Baazing, December 2017).

Nutrient excretion and manure quality strongly vary, due to variation in feed quality and intake, addition of organic material, nutrient losses and contamination with soil (Snijders, et al., 2009). Animal manure including cow dung enhances maximum productivity in sustainable way with better soil health. It is an effective tool for improving the physico-chemical and biological properties of the soil with higher yield of plants in sustained basis without deleting the fertility of soil (Raj, Jhariya, & Toppo, 2014). Plate 4.1 below is pig manure gathered around a piggery for application on the field as described by the lead farmer in Baazing.

Plate 4.1: Manure from Piggery Conveyed for Field Application
Source: Field Survey (December, 2017).

4.1.8 Compost Preparation for field application

In this study the researcher sought information from the lead farmer in Kpalinye/Kpaglahi community on what compost is and the preparation process. Below is the lead farmer's narration of what compost was and the processes that lead to compost. He spoke the local language (Waale) which was directly translated and written in English by the researcher since speaks and understand Waale. *'kompos e la kuolong teng mang maale ning te siindikyakyerehi aning te weo buuho ka te nang wa de abie baahi aning te duuhi bini' (Lead farmer Kpalinye/Kpaglaghi, December 2017).* This is translated below as: Compost is decomposed or broken down organic waste materials (either from the farm or kitchen and or faecal matter from animals) that are applied on crop fields to increase yields (Lead Farmer Kpalinye, December, 2017). He narrated the preparation process of compost as follows:

Compost is decomposed or broken down organic waste materials that are applied on crop fields to increase yields (Lead Farmer Kpalinye, December 2017). He narrated the preparation process of compost as follows:

A Compost pit is first constructed on the ground. The size of the pit depends on the strength of the farmer and the quantity of compost s/he intends to prepare (Lead farmer Kpaglaghi/Kpalinye, 2017).

The second stage has to do with gathering of waste materials from either plant or animal sources which are put into the pit where they are heaped for decomposition. A long stick or metal is inserted into the pit with the heap so that the heap can be stirred from time to time (Lead farmer Kpaglaghi/Kpalinye, December 2017).

Edwards and Araya (2011) indicated regular stirring provides enough oxygen for microbes to increase decomposition rate and also prevents bad odour from the heap.

The heap produces heat after some time in the decomposition process which indicate to us that the decomposition is ongoing. Edwards & Araya (2011) explained that, the decomposition of organic waste produces heat. The heat and moisture hasten the thorough break down of the plant and animal materials. It also destroys most of the weed seeds, fungal diseases, pests and parasites that might be found in the materials (Edwards & Araya, 2011). The increased temperature speeds-up the degradation process of the materials in the pit. Though temperature hastens decomposition of compost, too high temperature may destroy beneficial soil fauna responsible for decomposition (Inckel, de Smet, Tersmette, & Veldkamp, 2005).

The final product of the process is the compost which is carried and applied in the field to increase crop yield. The compost is ready for use if it feels crumbly and looks like good brown/black organic soil (Lead farmer Kpaglaghi/Kpalinye, December 2017).

Inckel et al., (2005) indicated that, the advantage of using compost is that it improves soil fertility in the long run, by improving the soil structure. Another aspect is that, compost releases the nutrients slowly, which means that the effect of compost spans over years.

For success in preparing compost and in using the compost to the best advantage, caution should be taken to prevent excessive water from entering the pit, but decomposing compost must be made wet enough to enhance decomposition. Regular stirring is also necessary for increase air movement within the heap as well as the addition of wood ash to the heap to neutralize the acids that may be produced (Lead farmer Kpaglaghi/Kpalinye, December 2017).

4.1.9 Minimum Tillage and its Application on the Field

During the survey, the researcher sought information from the lead farmer in Bulenga on how he and other farmers in their community apply minimum tillage. He spoke the local language Waala/Dagaare but was directly translated into the English language and written in this report by the researcher as follows:

Firstly, the land area to be applied minimum tillage is demarcated. Secondly, Weedicides commonly known as 'condemn' are purchased from agrochemical shops. This is then followed by mixing the weedicides proportionally with water and the mixture transferred into the Knapsack sprayer (Lead farmer Bulenga, December 2017). The content is then finally applied on the plot of land being prepared to kill the weeds and shrubs that are on the land. The farmer then goes to plant his choice of crop days after the application. Little tilling is only done when weeds begin to grow and are being weeded off. However, in some cases weedicides are used for the weeding when the weeds grow (Lead farmer Bulenga, December 2017).

Mafongoya, Jiri, & Phophi, (2016) explained that, minimum tillage has less labour demand at land preparation, a farmer will need to invest in herbicides in order to control the weeds as the practice results in higher weeds growth. Minimum tillage practice results in lower maize grain yield, higher bulk density, reduced water intake and higher weed infestation leading to high labour demand during weeding (Mafongoya et al., 2016).

4.2 SLMPs and the Tools Required for Application

4.2.1 Animal Manure and the Tools Required for Use

The study reveals that, with just sacks and head pans, an individual is good to go with the application of animal manure. A farmer indicated that, he sometimes uses his bare hand or hoe to help in gathering the manure for application from the dump site. He further said that, 'I can borrow a hoe from a farmer even if I do not have but all of us use hoes in this community to farm'. The researcher asked respondents to know how they would get the manure since they were not keeping animals. In a response, one of the farmers said, '*You only need to get to the Fulani's settlement and you can fetch as much as you want*' *(farmer Yikpee, 2017).*

About 45% of farmers who applied animal manure were of the view that one needs only sacks and head pans to apply animal manure. Also, 29.3% of the farmers think that one needs a bicycle, sacks and head pans to apply animal manure. The bicycle was meant to facilitate transport of the manure from the point of collection to the farm. The study also found 14.4% of the farmers who were of the view that, one needs a set of (shovel, wheel barrow, bicycle and sacks) to enable one apply animal manure on one's farm. The size of the farm was not considered in this discussion.

The set of tools mentioned by the respondents could be used over several years before exhausting their utility value. Grabowski (2011) revealed that, hoe-cutlass farmers use ox-carts, baskets, head pans and sacks for the application of animal manure. He further indicated that people who do not have ox-carts could still rent their services for the transport of manure to their fields. Farmers primarily used tridents, hoes and baskets to facilitate manure handling and transportation. Some farmers used their hands to gather cow manure in preparation for application on the field (Kim et al., 2011). Table 4.2a below represents frequencies and percentages and the associated tools required for the application of animal manure on the farm.

Table 4.2a: Tools Required for Animal Manure

Tools	**Frequency**	**Percentage**
Shovels, wheel barrow, bicycle, sacks, weedicides, head pan	2	1.0
Shovel, wheel barrow, bicycle, sack	30	14.4
Wheelbarrow, bicycle, sack	20	9.6
Bicycle, sacks, head pan	61	29.3
Sacks and head pan	94	45.2
Missing	1	0.5
Total	**208**	**100**

Source: Field Survey (December, 2017).

A survey of market prices for the sets of tools mentioned in the survey by the respondents resulted in a mean cost of tools as GH¢ 449.2 for animal manure application as presented in Table 4.2b below. The amount GH¢449.2 might probably be difficult to afford by a smallholder farmer and therefore might affect his adoption decisions. Formation of groups to contribute and purchase the tools for collective use could significantly influence adoption decisions. Also, subsidies for the purchase of these tools could be of great assistance to the smallholder farmer.

Table 4.2b: Cost of tools for animal manure

Variable	Sample	Minimum	Mean	Maximum
Cost of equipment for animal manure	208	0.00	449.2	575.00

Source: Field Survey (December, 2017).

Plate: 4.2 is a field application of animal manure in Lissa, one of the study communities. The dots of manure across the field are display of how farmers apply the manure on their fields. The dots of manure are later ploughed into the soil during tilling in preparation for sowing. Prepared compost is equally dotted across the fields when applied as shown in the case of animal manure application.

Plate 4.2: Manure Dotted on the Field
Source: Field Survey (December, 2017).

4.2.2 Compost and the Tools Required for Preparation and use

About 42% of respondents indicated that, one needed only a sack and a head pan to apply compost. The respondents explained that other tools such as shovel and pick axe may be required but could be solicited for from colleague farmers if one did not have them. “Oh I can borrow pick axe for my pit from my neighbour” said a farmer in Kpalinye. Other respondents (33.3%) were of the view that, one needed (shovel, wheel barrow, bicycle, sacks, pick axe and head pan) to ensure complete application compost. These farmers however complained that, it was expensive for them to acquire pick axe, shovel and means of transport to cart compost to their farms especially when it was prepared far from the farm. The Wa East District Plant Protection Officer confirmed the findings by indicating that, the list of tools was similar to that provided by the ongoing water and soil conservation programme in the District sponsored by World Bank. Accordingly, the communities involved have each been provided with these sets of equipment at a common location accessible to every farmer. The selection of beneficiary communities for the project was based on the closeness of the community to a major river and the potential of their farming activities impacting negatively on the river. This reaffirms the findings of Grabowski (2011) in Mozambique who indicated that, pick axe and shovel were rented for compost pit construction in some communities. Other tools including ox-carts, baskets head pans and sacks were used in the transport of materials during compost preparation and application. Policies should also be directed at providing a pool of equipment for every community at a central location accessible to everyone. About 11.1% of the respondents showed that, one needed a wheel barrow, a bicycle and sacks and that any other equipment where the need be could be solicited from colleagues. Table 4.3a below presents the opinions of farmers on the tools needed to prepare and apply compost.

Table 4.3a: Tools Required for Compost

Tools	Frequency	Percentages
Shovels, wheel barrow, bicycle, sacks, pick axe, head pan	36	33.3
Shovel, wheel barrow, bicycle, sack	9	8.3
Wheelbarrow, bicycle, sack	12	11.1
Bicycle, sacks, head pan	6	5.6
Sacks and head pan	45	41.7
Total	**108**	**100**

Source: Field Survey (December, 2017).

Estimates of the cost of these sets of tools from the surrounding markets showed a mean cost of GH¢467.6 for compost preparation and application. This amount GH¢467.6 might be beyond the reach of the smallholder farmer. Formation of groups that will accept collective purchase and use of these tools could be of great relieve to the smallholder farmer. Subsidies that will reduce the cost burden of the tools will also go a long way to facilitate adoption of compost. Table 4.3b shows the cost estimates of tools from field data.

Table 4.3b: Cost of tools for compost preparation and application

Variable	Sample	Minimum	Mean	Maximum
Cost of tools for compost	108	176.00	467.56	586.00

Source: Field Survey (December, 2017).

4.2.3 Minimum tillage and the tools required for its use

A study of tools required for minimum tillage application which ensures very little cultivation of the soil revealed that 87.2% of farmers need knapsack sprayer and weedicides to ensure minimum tillage application. The results further indicated that, 6.4% may also need a set of (bicycle, sacks, weedicides and pick axe) to ensure smooth execution. They however, explained that, they could always get knapsack sprayer from a friend if the need be. Additionally, 6.4% of farmers were of the view that a set of (shovel, knapsack, wheel barrow, bicycle, sacks and weedicides) are required for the application. This set of farmers tends to include everything they will require to enhance their farming. This observation was confirmed by the Wa East District Plant Protection Officer who mentioned the knapsack sprayer and the weedicides but added that, in some of the communities, spraying with knapsack sprayer and weedicides was only necessary where stubborn weeds were involved. He added that in some instances, one does not need any tool apart from his usual hoe or cutlass with labour to carry out minimum tillage as the practice is task reducing practice. This is in accordance with the observation of Grabowski (2011) who found that farmers in Mozambique did not apply any new tool in their application of minimum tillage but their usual labour and the hoe. The details of the results are presented in Table 4.4a.

Table 4.4a: Tools Required for Minimum Tillage

Tools	Frequency	Percentage
Bicycle, sacks, weedicides, pickaxe	5	6.4
Knapsack, weedicides	68	87.2
Shovel, knapsack, wheelbarrow, bicycle, sacks, weedicides,	5	6.4
Total	78	100

Source: Field Survey (December, 2017).

Table 4.4b: Cost of Tools for Minimum Tillage

Variable	Sample	Minimum	Mean	Maximum
Cost of equipment for minimum tillage	78	0.00	131.73	457.00

Source: Field Survey (December, 2017).

The mean cost of the tools required for minimum tillage application using the prevailing market prices was estimated to be GH¢131.7 which is equivalent to $28.6. This amount might be a little beyond the reach of the smallholder farmer and therefore might need assistance to enable him or her acquire the tools. Assistance in the form of subsidies on the tools will go a long way to help the smallholder farmers acquire the tools for minimum tillage application.

FAO (2011b) reported that smallholder farmers in Ghana use weedicides/herbicides along with knapsack sprayers to spray and kill the weeds and the herbs on their fields before planting. This accordingly reduces man days per acre from 33.2 days to 19.2 days. The cost of the weedicides and knapsack sprayer were estimated to be GH¢211.2 and was expected to last several years depending on the care provided. FAO (2011b) also indicated that, knapsack sprayers could be rented from business people who make available knapsack sprayers for individual farmers who needed the services to rent. The details of the cost of tools are presented in Table 4.4b below.

4.2.4 Summary of Tools for the application of the SLMPs

The respondents in Wa East and Lawra Districts largely used sacks and head pans in their application of animal manure. Some other respondents added bicycle or wheel barrow or shovel or all for conveying and transporting animal manure for application on their fields. These tools were estimated to cost an average of GH¢449.2 using the prevailing market prices within the surrounding markets. In effect, it will cost a farmer an average of GH¢449.2 to acquire tools for the application of animal manure on their fields. It was however noted that, these tools could be used for an extended period of time and could also be shared among neighbouring farmers.

It was also found out that, the respondents largely used sacks and head pans for the application of compost. Other farmers added that, they used bicycle, wheel barrow, shovel, pick axe or all for the application of compost. These tools were estimated to cost an average of GH¢467.56 using the prevailing market prices in the surrounding markets. According to the results, it will cost a farmer an average of GH¢467.56 to prepare and apply compost in his or her field. These tools however could be used jointly among neighbouring farmers and over an extended period of time.

Respondents in the study area used knapsack sprayers and weedicides for the application of minimum tillage. The mean cost of tools for the application of minimum tillage was estimated to be GH¢131.7 equivalent to $28.6 at an exchange rate of 1Dollar to GH¢4.6. These tools could be used over an extended period of time and could equally be used jointly among neighbouring farmers.

4.3 Profitability and Sensitivity Estimates from Data

Table 4.5a presents the prices of various cereal crop yields per bag (cocoa sack) over the study period and their relative measurement in kilograms that were used in this study. The prices were collated from respondents based on the prevailing market prices at which their respective produce was sold. The estimated means were then used in the following computations. The relative standard measurements (kg) were obtained from MoFA staff as the standard measurements for the yields of the respective crops.

Table 4.5a: Estimated Prices of Crop Yields from Survey

Item	Mean Value (GHC)	Minimum Value(GHC)	Maximum Value(GHC)
Price per bag (100Kg) maize	97.50	70	120
Price per bag (105Kg) sorghum	204.4	160	240
Price per bag (95Kg) millet	216.3	180	240
Price per bag(rice)	234.0	220	250
Cost of producing cereals per acre	380.2	6.0	875.0
Dollar to Ghana Cedis rate	1 Dollar	GH¢4.6	

Bag=cocoa sack
Source: Field Survey (December) 2017.

4.3.1 Estimates of Animal Manure Profitability

Table 4.5a and Table 4.5b show prices and profitability estimates of cereal crops from the field survey as at December, 2017 respectively. The application of 8 maxi-bags of animal manure rewarded the farmer with GH¢448.2 which is equivalent to $97.4 per acre/season compared to GH¢15.3 ($3.3) per acre per season when the farmer was not applying animal manure considering an exchange rate of 1Dollar to GH¢4.6. Increasing the number of acres could bring about economy of scale hence increased benefits to the farmer.

Table 4.5b: Animal Manure, Compost and Minimum Tillage Profitability Estimates

Item	AM (GHC)	Sensitivity (AM)	Comp (GHC)	Sensitivity (Comp)	M. tillage (GHC)	Sensitivity (M. tillage)
Quantity/acre	8.0*		9.5*			
Actual cost of production/acre	380.2 (11.8)	425.1	380.2 (11.8)	425.1	380.2 (11.8)	425.1
Added Cost/acre	31.1 (11.8)	34.8	44.8 (11.8)	50.1	40.7 (11.8)	45.5
Total revenue/acre	867 (11.8)	969.3	701.9 (11.8)	784.7	501.0 (11.8)	560.1
Total revenue without	395.5 (11.8)	442.2	395.5 (11.8)	442.2	395.5 (11.8)	442.2
Total profit with	448.2	407.1 558**	327.5	226.7 366.1**	98.2	86.51 109.89**
Total profit without	15.3	-29.6 62**	15.3	-29.6 62**	15.3	-29.6 62**

AM=animal manure, Comp=compost & M.tillage=minimum tillage, *=maxi bags, **= 11.8 % rise in output value

() =Annual inflation rate for 2017

Source: Field Survey (December, 2017).

Acquiring and applying animal manure in the field especially by the smallholder farmers could go a long way to solve the problem of food security especially in our part of the continent where food security is a major constraint. This result is consistent with what was reported in Rwanda where farmers who applied animal manure on their fields indicated more than double their maize yields, sorghum yields among other crops (Kim, Tiessen, Beeche, & Kamatari, 2011).

A study in Mozambique has showed that, the benefits of animal manure application could span over four years (Grabowski, 2011). The farmer therefore stands the chance of benefiting from animal manure for at least, four years, all other things being equal. This value is similar to data reported by MoFA (2011) which showed 1700Kg of maize yield per hectare, 680Kg/ acre and GH¢ 302.3 per acre returns. In estimating how sensitive the benefits were to changes in prices over time, the annual inflation rate for 2017 which was 11.8% (GSS, 2017) was used. An increase in input cost will result in a decrease in benefits from GH¢448.2 to 407.1. An increase in output value increases profit margin from GH¢448.2 to GH¢ 558.0. A rise in input price usually, results in an increase in output price. The margin in the output price triggered by the rise in input will determine the value of the benefits. Similar findings were reported across the globe upon overview of experimental fields on SLMPs on various soil types that gave 79% average yield increase (Pretty, 2006). It is worth noting that this study did not take into accounts the cost of processing harvested crops into seeds.

4.3.2 Compost Estimates

It was also found out that, the application of compost would result in a net profit value of GH¢327.5 per acre equivalent to $71.2 compared to GH¢15.3 when the farmer is not applying compost as shown in Table 4.5b. The findings show that compost has the potential of increasing smallholder farmers' food security if properly integrated into smallholder farming activities. This observation is similar to MoFA (2011) reports which reported 1700Kg per hectare of maize and a net returns of GH¢ 302.3 as estimated from the reports. Net returns of GH¢198.57 and GH¢248.5 were also reported among rice farmers without and with fertilizer application respectively (Donkoh & Awuni, 2011). The application of compost alone in wheat fields' significantly increased grain yield with a yield benefit ranging from 151 to 351% (Melaku et al., 2014). The cost of preparing and applying compost outweighs that of animal manure and hence the net profit value. Considering the 11.8% annual inflation rate of 2017 (GSS, 2017), a rise in input price leads to a reduction in net benefits from GH¢327.5 to GH¢226.7. An increase in output price will also increase returns to the farmer, holding all other things constant. A general study of experimental fields across the globe on various soil types reported a 79% yield increase across board (Pretty, 2006). Table 4.5b presents detail analyses of estimates. The estimates of profits from animal manure, compost and minimum tillage were arrived at using the formula in equation 6:

$$PROFIT = OUTPUT(V_p) - (NORMALCOST_{PDN} + ADDCOST_P) \ldots\ldots\ldots\ldots\ldots\ldots\ldots 6$$

Where:

PROFIT= Benefits per acre from animal manure, compost and minimum tillage

OUTPUT (V_p) =Value of yield from animal manure, compost or minimum tillage

$NORMALCOST_{PDN}$ =Normal cost of production without any of the practices

$ADDCOST_p$ =Added cost due to the use of animal manure, compost or minimum tillage

4.3.3 Minimum Tillage Estimates

The study found that, it was prudent to carry out minimum tillage on the farm as it resulted in net profit value of GH¢ 98.2 per acre which is equivalent to $21.3 as compared to GH¢15.3 when the farmer was not applying minimum tillage as shown in Table 4.5b. It however scores the lowest net profit value comparing it to animal manure and compost. This value was less than that reported by MoFA (2011) which gives 1700Kg per Hectare of maize and net benefit of GH¢ 302.3 per acre as estimated from the report. Grabowski (2011) revealed that, benefits from minimum tillage can span for over four years and goes beyond yield benefits but equally enhancing environmental quality. This means that accumulating the yearly benefits of GH¢ 98.2 or $21.3 per acre per production season for four years could make significant monetary impact to the smallholder farmer.

This result is in line with FAO (2011a) report which commented on yield increases ranging mostly from 10-20% in the initial years if all other conditions remain the same. The yield increases could go as high as 100% after 4-5 years of continued application for the ecosystem to adjust. Similarly, yield increases of 50% were recorded in Ghana with the adoption of minimum tillage (World Bank, 2006a). Pretty (2006) reported a 79% average increase in yield after a study on a collection of SLMPs experimental fields across the globe. Yield increases of as low as less than 3% were reported however, which he attributed to the exhaustion of the genetic potentials of some of the crops in the study such as millet, sorghum among others. The literature available justifies the need for large scale adoption and use of animal manure, compost and minimum tillage. Details of estimates are presented in Table 4.5b.

4.3.4 Summary of Profitability and Sensitivity (Objective Two)

It was found out that, the application of animal manure in the study area rewarded the farmer with GH¢448.2 equivalent to $97.4 per acre per production season. Compared to the respondent not applying animal manure, his/her earnings were GH¢15.3 equivalent to $3.3. The study also found out the effect of inflation on the respondents' income using the 2017 annual inflation rate of 11.8%. The results showed that 11.8% increase in output price rewarded the respondents with GH¢558.0. An increase in the input prices led to a reduction in respondents' income from GH¢448.2 to GH¢407.1.

The application of compost rewarded the respondents with GH¢327.5 equivalent to $71.2 per acre per production season compared to GH¢15.3 ($3.3) when the respondents were not applying compost. An annual inflation rate of 11.8% over the year 2017 on output prices will lead to an increase in income for the respondents from GH¢327.5 to GH¢366.1. An increase in input prices on the other hand led to a reduction in respondents' income from GH¢327.5 to GH¢226.7.

Respondents earned GH¢98.2 equivalent to $21.3 per acre per production season with the application of minimum tillage compared to GH¢15.3 when the respondents were not applying minimum tillage. An annual inflation rate of 11.8% on output prices led to a rise in respondents' income from GH¢98.2 to GH¢109.9. A rise in input prices by 11.8% led to a reduction in respondents income from GH¢98.2 to GH¢86.5.

4.4 Respondents' Perception of SLMPs

Respondents' perception of animal manure, compost and minimum tillage were evaluated using a five point Likert-scale consisting of four positive statements and four negative statements. Respondents chose their level of agreement to each statement. The each level of agreement was the coded ranging from (-1, -0.5, 0, 0.5, and 1) for strongly disagree, disagree, neutral, agree and strongly agree respectively. The frequency of each choice was multiplied by its code divided by the sample size for the practice to obtain the perception index.

Table 4.6a: Animal Manure Perception Index Estimates from Data

Positive statements	Strongly agree (1)	Agree (0.5)	Neutral (0)	Disagree (-0.5)	Strongly Disagree (-1)	Mean Score
Animal manure increase crop yield	147 (0.71)	57 (0.27)	4 (0)	0 (0)	0 (0)	0.98
Animal manure maintains the fertility of soils	144 (0.69)	63 (0.15)	1 (0)	0 (0)	0 (0)	0.84
Animal manure prevents soil erosion	81 (0.39)	85 (0.20)	26 (0)	16 (-0.038)	0 (0)	0.56
Animal manure reduces cost of crop production	69 (0.33)	95 0.23	30 0	11 (-0.026)	3 (-0.014)	0.52
Negative Statements	Strongly agree (-1)	Agree (-0.5)	Neutral (0)	Disagree (0.5)	Strongly Disagree (1)	Mean Score
Animal manure is very complex to apply on fields	3 (-0.014)	29 (-0.07)	16 (0)	106 (0.25)	54 (0.26)	0.36
Animal manure leads to complete crop failure	1 (-0.005)	15 (-0.04)	9 (0)	61 (0.15)	122 (0.59)	0.69
Animal manure is very expensive to apply	5 (-0.024)	18 (-0.04)	10 (0)	60 (0.144)	115 (0.55)	0.63
Animal manure is not compatible with existing farming practices	1 (-0.005)	13 (-0.03)	11 (0)	77 (0.19)	103 (0.50)	0.64
Perception Index						**5.23**

Source: Field Survey (December, 2017). () is the value of frequency*code/total frequency

4.4.1 Farmers' Perception of Animal Manure

Respondents expressed positive perception of the first four positive statements relating to animal manure. The mean scores are 0.98, 0.84, 0.56 and 0.52 for animal manure increases crop yield, prevents soil erosion, maintains the fertility of the soil and reduces cost of crop production respectively as shown in Table 4.6a. The respondents largely, rejected the negative statements made relating to animal manure respectively. The negative statements gave a mean score of 0.36, 0.69, 0.63 and 0.64 for animal manure is very complex to apply on the field, leads to complete crop failure, very expensive to apply on the field and not compatible with existing crop production practices respectively as shown in Table 4.6a. The total perception index for animal manure was therefore estimated to be 5.23 as shown in Table 4.6a. This implies that, farmers have good perception towards the practice. A good perception towards a practice has a higher propensity to be adopted. The demand for animal manure will increase among smallholder farmers given the required resources. The implication is that respondents have benefitted from the application of animal manure on their fields. This probably is due to experience as it significantly influenced all the practices under study on farming among farmers. The results confirmed findings in Rwanda where 82% of farmers surveyed attributed the fertility of their soils to high use of animal manure (Kim, et al., 2011). Donkoh & Awuni (2011) found 58% of farmers defending the incorporation of organic materials into production fields as it improved the fertility of the soils. However, results of a study in Bangladesh indicated that majority of the farmers' surveyed showed low perception for integrated soil fertility and nutrient management (Farouque & Takeya, 2007).

Table 4.6b: Compost Perception Index Estimates from Data

Positive Statements	Strongly agree (-1)	Agree (-0.5)	Neutral (0)	Disagree (0.5)	Strongly Disagree (1)	Mean Score
Compost increases crop yield	64 (0.59)	40 (0.19)	0 (0)	1 (-0.005)	3 (-0.028)	0.75
Compost maintains the fertility of soils	67 (0.62)	39 (0.18)	2 (0)	0 (0)	0 (0)	0.80
Compost prevents soil erosion	31 (0.29)	49 (0.23)	24 (0)	4 (-0.019)	0 (0)	0.50
Compost reduces cost of crop production	22 (0.20)	59 (0.27)	22 (0)	5 (-0.023)	0 (0)	0.45
Negative Statements	Strongly agree (-1)	Agree (-0.5)	Neutral (0)	Disagree (0.5)	Strongly Disagree (1)	Mean Score
Compost is very complex to apply on fields	3 (-0.028)	13 (-0.06)	7 (0)	55 (0.25)	30 (0.28)	0.44
Compost leads to complete crop failure	1 (-0.010)	3 (-0.01)	3 (0)	35 (0.16)	66 (0.61)	0.75
Compost is very expensive to apply	2 (-0.019)	10 (-0.05)	8 (0)	32 (0.15)	56 (0.52)	0.60
Compost is not compatible with existing farming practices	4 (-0.037)	5 (-0.02)	6 (0)	36 (0.17)	57 (0.53)	0.63
Compost Perception Index						**4.93**

() is the value of frequency*code/total frequency

Source: Field Survey (December) 2017.

4.4.2 Respondents' Perception of Compost

The study revealed that, farmers in the study area have good perception as much as compost making and application on the field was concerned as shown in Table 4.6b. An estimation of the mean scores resulted in in 2.5 for the positive statements and 2.4 for the negative statements. The resultant perception index score for compost is 4.93 as depicted in Table 4.6b. This is positive, implying that, respondents have good perception for the preparation and use of compost. Good perception is a recipe for adoption. The demand for compost application among smallholder farmers is likely to increase given the required resources, holding all other factors constant. The addition of organic materials into the soil is a practice respondents are convinced improves upon the fertility of their soils. Respondents may however be constrained by some other factors in their effort to adopt any such practices. The findings of Donkoh & Awuni (2011) in Northern Ghana make a case for the inclusion of organic materials into the soil, as 58% of farmers in the study indicated organic materials improved the fertility of the soils. This observation equally confirmed the results of a study in Ethiopia which showed 40% households perceptions of compost to have positive impact on soil fertility and yield (Kassie et al., 2009b). They further confirmed the observation of a study in Ethiopia that, majority of farmers has good perception for compost as a soil conservation practice (Kassie et al., 2009a). However, studies in Bangladesh disagreed with these results as majority of farmers showed low perception towards integrated soil fertility and nutrient management (Farouque & Takeya, 2007).

Table 4.6c: Minimum Tillage Perception Index from Data

Positive Statements	Strongly agree (-1)	Agree (-0.5)	Neutral (0)	Disagree (0.5)	Strongly Disagree (1)	Mean Score
Minimum tillage increases crop yield	31 (0.40)	28 (0.18)	8 (0)	8 (-0.05)	3 (-0.04)	0.49
Minimum tillage maintains the fertility of soils	35 (0.45)	29 (0.19)	1 (0)	12 (-0.077)	1 (-0.01)	0.54
Minimum tillage prevents soil erosion	31 (0.40)	35 (0.22)	5 (0)	5 (-0.032)	2 (-0.03)	0.56
Minimum tillage reduces cost of crop production	19 (0.24)	36 (0.23)	15 (0)	5 (-0.03)	3 (-0.04)	0.40
Negative statements	Strongly agree (-1)	Agree (-0.5)	Neutral (0)	Disagree (0.5)	Strongly Disagree (1)	Mean Score
Minimum tillage is very complex to apply on fields	7 (-0.09)	6 (-0.04)	9 (0)	40 (0.26)	16 (0.21)	0.33
Minimum tillage leads to complete crop failure	3 (-0.04)	9 -0.058	4 0	23 0.15	39 0.5	0.55
Minimum tillage is very expensive to apply	6 -0.077	8 (-0.05)	4 (0)	25 (0.16)	35 (0.45)	0.48
Minimum tillage is not compatible with existing farming practices	3 (-0.04)	5 (-0.03)	9 (0)	22 (0.14)	39 (0.5)	0.57
Perception Index Minimum tillage						**3.94**

() is the value of frequency*code/total frequency
Source: Field Survey (December) 2017.

4.4.3 Respondents' Perception of Minimum Tillage

It was found out that, farmers in the study area have positive perception for minimum tillage. An estimate of the perception index scores 3.94 as shown in Table 4.6c. This is good as it implies an increase in farmers' propensity to adopt the practice. It is also a significant indicator of respondents' demand for the application of the practice. This revelation confirmed the findings in Ethiopia where 74% of farmers affirmed the ability of minimum tillage to improve the fertility of soil (Kassie et al., 2009a). The findings however contradicted the findings in Bangladesh which showed farmers' low perception of integrated soil fertility and nutrient management (Farouque & Takeya, 2007). A study by Donkoh & Awuni (2011) showed 58% defending the addition of organic materials into soils as they improved the fertility of the soil. Comparing the indexes for the three practices, animal manure application has a higher perception index of 5.23. This was followed by compost perception index of 4.93 and then minimum tillage perception index of 3.94. This implies that, given the practices, farmers are more likely to choose animal manure over compost and minimum tillage.

4.4.4 Summary of Respondents Perception

Respondents have good perception for animal manure, compost and minimum tillage. Animal manure scores a positive perception index of 5.23, meaning smallholder farmers in the study area are willing to apply animal manure, holding all other factors constant. Compost also scored a positive perception index of 4.93, implying that respondents considered compost application to be a good practice for their fields and will therefore be willing to apply it on their fields, holding all other factors constant. The study equally estimated a positive perception index of 3.94 for minimum tillage, indicating that respondents have good perception for minimum tillage and will demand for more of minimum tillage, holding all other factors constant.

4.5 Factors Affecting on Adoption of SLMPs

The factors that influenced smallholder farmers' adoption of SLMPs were estimated using a Multinomial Logit Model. The factors were grouped into economic, social and plot characteristics. The economic factors include access to ready market, total farm size, total number of animals and cost per acre. The social factors are years of experience in farming, access to extension service, household size, member of farmer association and perceived profitability. The fertility status of farm was captured as plot characteristic. The Multinomial Logit Model estimation gave rise to a Pseudo R^2=0.3375 as shown in Table 4.7 implying most of the predictors were relevant to the model. The likelihood ratio test was significant at 1% as shown in Table 4.7) explaining the probability of obtaining a Chi-square test statistic (307.03). This means that, all the explanatory variables included in the model jointly explained smallholder farmers' adoption decision of SLMPs in the Upper West Region. Given the above measures, it is concluded that, the Multinomial Logit Model employed was appropriate for evaluating smallholder farmers' behavior on SLMPs adoption.

Number of years of farming experience was found to have positive relationship with the probability of adoption of animal manure only, compost only and minimum tillage only. It was found to be significant at 1% for all the respective practices under study and all their combinations. This implies that, a unit increase in the number of years in farming will result in 0.65 rise in the probability of adopting animal manure only, compost only and 0.66 rise in the probability of adopting minimum tillage only. A unit increase in the number of years of farming will also result in a 0.67, 0.65, 0.64 rise in the probability of adopting animal manure and compost only, animal manure and minimum tillage only and compost and minimum tillage only respectively. The probability of adopting all the three practices simultaneously increases by 0.72 with a unit rise in the number of years in farming. This is a big challenge to policy makers as new farmers are more likely to reject SLMPs. It also implies that, the adoption and large scale use of SLMPs need much time for farmers to gain experience before adoption can be successful.

This finding disagrees with Akudugu et al (2012) in their study of technology adoption which found older farmers less likely to adopt new technologies. They argued that, it was difficult for older farmers to go for new technologies to the neglect of what they have been experimenting over years. On the contrary, Kassie et al (2009b) argued that, the age of the household head was found to have a differential impact on adoption, depending on the type of practice. Similarly, Odendo et al., (2011) asserted that, age and relative farming experience retarded the adoption of SLMPs in Kenya. Policies are therefore required to speed up adoption and diffusion of soil fertility management practices.

Farmers' access to extension service was found to have a negative relationship with the probability of adopting animal manure only and compost only. They were equally found to be significant at 5% and 10% respectively for animal manure only and compost only as presented in Table 4.7. The simultaneous adoption of animal manure and minimum tillage only was also significant at 5% for access to extension service. It showed a negative relationship with probability of adoption as shown in Table 4.7. The implication is that, with a unit increase in extension access, the probability of adopting animal manure only will decline by 4.3 units and compost only by 2.6 units. The probability of adopting animal manure & minimum tillage only and compost & minimum tillage only declined by 3.6 and 3.8 units with a unit increase in extension access.

Table 4.7: Factors that Affect the Adoption of SLMPs

	Dependent variables						
Expl vari	**Animal manure**	**Compost**	**Minimum tillage**	**Animal manure & Compost**	**Animal manure & Minimum tillage**	**Compost & Minimum tillage**	**Animal manure, Compost & Minimum tillage**
Cons	-9.77*** (3.31)	-3.566 (-1.17)	-1.294 (-0.37)	-7.869*** (2.61)	-8.159*** (2.63)	-9.702*** (2.73)	10.372*** (3.25)
Expe	0.654*** (2.96)	0.653*** (2.95)	0.657*** (2.96)	0.670*** (3.03)	.0653*** (2.94)	0.640*** (2.82)	0.723*** (3.26)
Acce Servi	-4.274** (-2.50)	-2.99* (-1.72)	-2.571 (-1.41)	-2.826 (-1.63)	-3.616** (-2.08)	-3.831** (-2.02)	-1.986 (-1.09)
Acce ready	-4.137** (-2.35)	-2.000 (-1.10)	-3.963** (-2.10)	-3.266* (-1.82)	-3.335* (-1.84)	-2.631 (-1.26)	-3.339* (-1.82)
Total	-0.149 (-0.92)	- 0.925*** (-3.74)	-0.278 (-1.40)	-0.281 (-1.60)	-0.240 (-1.36)	-0.666** (-2.21)	-0.174 (-1.00)
Household Size	.391** (2.11)	0.382** (1.97)	-466* (-1.87)	0.379** (2.01)	.301 (1.57)	0.424** (2.07)	0.236 (120)

Number of	0.441***	0.342***	.0385***	0.427***	0.411***	0.391***	0.428***
animals	(3.56)	(2.75)	(3.11)	(3.45)	(3.31)	(3.08)	(3.45)
Mem	1.957	1.910	1.723	2.664	0.445	1.109	3.041*
farm	(1.14)	(1.09)	(0.94)	(1.54)	(0.25)	(0.53)	(1.73)
Asso							
Perc	3.912*	2.935	3.821	3.539	4.657**	3.280	3.180
Profi	(1.70)	(1.29)	(1.58)	(1.53)	(1.98)	(1.31)	(1.36)
Ferti	-0.655	-1.884	-1.366	-2.272	-1.361	-0.453	-1.187
Statu	(-0.47)	(-1.35)	(0.89)	(-1.64)	(-1.22)	(-0.29)	(-0.83)
Cost	-0.003	-0.009**	-007	-0.008*	-0.005	-0.002	-0.006
prod	(-0.62)	(-2.05)	(-1.44)	(-1.94)	(-1.22)	(-0.37)	(-1.47)

Num ations = 254 Pseudo R^2 = 0.3375

LR C .03 Log likelihood = -301.30

Prob>Chi^2 = 0.000 z-values in parenthesis, ***significant @1%, **significant @ 5%, *significant @10%

Source: Field Survey December (2017)

Accordingly, extension access offer respondents better farming options of increasing and sustaining their yields rather than SLMPs adoption. It could also be that, the service so rendered by some of the officers add little value the farmers' yield and therefore their engagement with extension agents was a waste of time to the respondents which they could have invested in their farming activities. This probably explains the negative relationship of the probability of simultaneously adopting animal manure and minimum tillage only with extension service access. Even though, this complaint was not a measured variable, it was a cause for concern and probably explaining ill equipped officers, justifying the call for constant upgrading of extension officers.

Extension access provides farmers with adequate information on the net returns, availability and barriers to the adoption of SLMPs. Constant upgrading of the skills extension personnel increases adoption of SLMPs (Kassie et al. 2009a; Kassie et al., 2009b; Kassie & Zikhali, 2009). The effectiveness of the services of extension officers can be sustained by adequate government funding and staffing of extension agencies and research institutes (Mgbenka & Mbah, 2016).

This study also found that access to market was significant at 5% with the probability of adopting animal manure only and minimum tillage only as presented in Table 4.8. Access to market was also significant at 10% with the probability of simultaneous adopting animal manure & compost only, animal manure and minimum tillage only and the joint adoption of all the three SLMPs. The relationship across all cases has been negative. This means that, with a unit increase in farmers' market access, the probability of adopting animal manure only and minimum tillage only will decline by 4.1 and 4.0 respectively. It also implied that, animal manure & compost only, animal manure & minimum tillage only and the joint adoption of all the three practices will decline by 3.3, 3.3, and 3.3 respectively.

This finding was in contravention of the suggestion that, market access have positive influence on farmers' adoption decisions on conservation farming practices. They explained that, farmers closer to market centers are more likely to adopt conservation technologies because their production values can easily be marketed (Kassie et al., 2012). Pender (2009) reported that, access to market provided guaranteed income to the farmer and therefore increased the probability of adopting SLMPs. However, this finding is in line with claims that, farmers in developing countries are not well integrated into input and output markets. This affects promotion and adoption of technologies (Kassie & Zikhali, 2009). This revelation in this study is perhaps due to the fact that majority of the farmers are smallholders whose aim is just to take care of themselves and their families. They have no significant interest in profit maximization. Providing access to market has little or no significant motivation to increase adoption and for that matter, increase yield.

The study also found a total farm size to be significant at 1% for compost only. The probability of adopting compost only exhibited a negative relationship with farm size. This implies that, the probability of adopting compost will decrease by -0.925 if total farm size is increased by a unit. Total farm size was also significant at 5% for the probability of simultaneously adopting compost and minimum tillage only. Farm size equally exhibited a negative relationship with the probability of jointly adopting compost and minimum tillage only. This means that, the probability of simultaneously adopting compost and minimum tillage only will decline by 0.67 with a unit increase in farm size. It was however not significant for any of the other SLMPs and their combinations under study.

This confirms the assertion by Pretty (2006) that, smallholder farmers first introduced sustainable agricultural practices in Southern America but was taken over by large-scale farmers only after success have been achieved by the smallholder farmers. Additionally, Sserunkuuma (2005) showed that, farm size is negatively associated with manure use and incorporation of crop residues, suggesting that the use of such practices is more common on smaller farms than in large farms. On the contrary, findings of Odendo et al., (2011) realised in western Kenya that, large farm size increases the probability of the adoption of sustainable agricultural practices. Accordingly, large scale farmers are less risk averse. Similarly, the effect of farm size was found to have positive relationship and significant with the probability of adoption, suggesting that farmers who hold large farms are more likely to invest in soil fertility conservation (Amsalu & de Graaff, 2007).

Estimates of household size, reveals a 5% significant level with the probability of adopting animal manure only, compost only, the joint adoption of animal manure & compost only and compost & minimum tillage only as indicated in Table 4.8. The implication is that, with a unit increase in household size, the probability of adopting animal manure only, compost only, animal manure & compost only and compost & minimum tillage only will rise by 0.39, 0.38, 0.38 and 0.42 respectively. The study also revealed a 10% significant level with the probability of adopting minimum tillage only as indicated in table 4.8. There exists a positive relationship with household size and the probability of adopting all the SLMPs and their combinations under study except minimum tillage. This means that, an increase in household size will lead to an increase in the probability of adopting all the practices and their combinations. Household size however, showed a negative relationship with the probability of adopting minimum tillage only.

SLMPs application requires extra labour therefore; an increase in household size provides extra labour for the adoption of the practices. The minimum tillage requires little or no change in farming activities and therefore does not need extra labour as compared to animal manure and compost. Kassie et al., (2012) and Teklewold et al., (2012) both made similar observations in separate studies in Tanzania. They indicated that, collecting and transporting manure is labour intensive, hence large household size ensures readily availability of labour.

Additionally, availability of household labour conditions the type of technology adopted, given that the labour requirements differ from technology to technology (Kassie et al., 2009b). Similarly, it has been reported that, a higher ratio of household members is associated with a greater labour force available to the household. It therefore ensures the timely operation of farm activities including soil management (Odendo et al., 2011).

The number of animals a farmer owns was significant at 1% as indicated in Table 4.7 for all the SLMPs under study and all their combinations. There was also a positive relationship with the probability of adopting all the SLMPs and their combinations. The probability of adopting animal manure only, compost only, minimum tillage only will increase by 0.4, 0.3, .04 respectively with a unit increase in number of animals owned. The probability of simultaneously adopting animal manure & compost only, animal manure & minimum tillage only, compost & minimum tillage only will increase by 0.43, 0.41, and 0.39 respectively with a unit increase in number of animals owned.

This means that, the probability of adopting all the SLMPs under study and their combinations will increase with an increase in the number of animals the farmer owns. The adoption of almost all the practices requires animals' waste. So, increasing the number of animals ensures readily availability of the raw material for use in adopting animal manure and compost. Proceeds from the sales of the animals could as well be used in the procurement of other inputs and labour for use in the application of SLMPs.

This confirms the findings that, livestock ownership influences the adoption of the use of manure and compost. Introducing high-yield breeds and improved forage legumes can increase livestock products, including manure (Teklewold et al., 2012; United Nation, 2009). The quantity of biomass available to smallholder farmers is commonly insufficient. A study by United Nation (2006) has found evidence that livestock ownership conditions the adoption of compost and animal manure application. Though livestock ownership has been reported to significantly influence the adoption of SLMPs more especially compost and animal manure, large livestock size discourages investment in SLMPs. This perhaps is due to the tendency of households to focus more on livestock at the expense of crop production (Amsalu & de Graaff, 2007).

It was equally observed that majority of farmers in Wa East District were practicing the extensive system of rearing farm animals. Animals were allowed in search of their own feed and in some cases provided shelter only in the night. Animals in most cases were allowed to manage their own affairs whether rain or shine. The practice affected manure availability for use as animal manure or in the preparation of compost. These findings supported what was found in South Africa where neighboring farms were the main source of manure for application on fields by other farmers. The study added that, less than 33% of the farmers kept livestock, mainly cattle. Only 23% used manure from their animals but their quantities were not enough (Odhiambo & Magandini, 2008). This shows that, these livestock farmers kept very few livestock.

The neighbouring farms in this case referred mainly to feedlots and poultry farms ran by commercial farmers for animal manure which could be quite a distance away (Odhiambo & Magandini, 2008).

The survey also revealed that, being a member of a farmer association was significant at 10% for the simultaneous adoption of all the three SLMPs under study. The relationship was positive, implying that, the probability of adopting all the three SLMPs simultaneously increases with a farmer's participation in farmer association's activities. Farmer association members share information on good farming practices which thus confirms the findings. It was however not significant for any one of the SLMPs.

Perceived profitability was significant at 10% and 5% with the adoption of animal manure only and the simultaneous adoption of animal manure & minimum tillage. The two categories exhibited positive relationship with perceived profitability and the probability of adoption. This means that, an increase in the perceived profit from farming by a unit will result in the probability of adopting animal manure by 3.9 and simultaneous adoption of animal manure & minimum tillage only by 4.7.

This confirms the findings of Amsalu & de Graaff (2007) who indicated that, farmers' perceived profitability of stone terraces positively and significantly influenced their probability of adoption. In addition, Perceived economic return was stressed as a major impediment, limiting the adoption of SLMPs. SLMPs that are perceived as offering greater relative profitability are more likely to be adopted (Tey et al., 2012). The insignificance of the other practices that were adopted here means that, farmers adopt a series of agricultural practices not only because they perceive them to be profitable, but for other reasons such as a mechanism for disposal of waste and other spiritual benefits.

Cost of production per acre showed a negative relationship with the probability of adopting compost only and animal manure & compost only. This implies that, the probability of adopting compost only and simultaneously adopting of animal manure & compost only will decline by .009 and .008 respectively with an increase in the cost of production per acre. The survey found, cost of production to be significant with the probability of adopting compost only and the combined adoption of animal manure & compost only at 5% and 10% respectively. The survey did not find any significance with cost of production and the other SLMPs. This implies that, the cost involved in the adoption of compost only, and the combine adoption of animal manure and compost only must be within the reach of smallholder farmers. And the more the cost is reduced, the higher the probability of adoption. Animal manure only and minimum tillage only were not significant, because the category of farmers here are smallholders whose only interest is to feed their families. They would therefore not go for any practice that would increase their cost without guaranteeing the returns. Details of the factors influencing adoption are presented in Table 4.7.

It was also revealing to know that, the adoption of animal manure showed a positive but significant at 1% when none of the explanatory variables were present. The study also showed significant level of 1% for the intercept for the joint adoption of animal manure and compost only, animal manure and compost only, compost and minimum tillage only and the joint adoption of all the three practices. This is often the case when profit is not the focus of production.

4.5.1 Summary of Factors Affecting Respondents' Adoption Decision

The study revealed that, smallholder farmers' adoption decision of animal manure, compost and minimum tillage was affected by demographic factors such as household size, number of years of experience in farming, and access to extension service. The number of years of experience in farming was significant at 1% for all the practices and their combinations. It implies that, the probability of adopting each of the practices and their combinations increased with an increase in number of years of farming experience.

Household size was also significant at 5% for animal manure only, compost only, animal manure & compost only and compost & minimum tillage. They were all positive, implying that, the probability of adoption of any of the above mentioned increased with a unit increase in household size. Access to extension service was significant at 5% for animal manure only, animal manure & minimum tillage only and compost & minimum tillage only.

It was also found out that, the adoption decision of smallholder farmers of animal manure, compost and minimum tillage was affected by economic factors such as access to ready market, perceived profit, cost of production per acre and number of animals owned by the farmer. The number of animals owned by the farmer was significant at 1% for all the practices under study and their combinations. The implication is that, a unit increase in the number of animals owned by the farmer led to an increase in the probability of adoption for all the three practices and their combinations.

Access to ready market was significant at 5% for animal manure application only and minimum tillage only. They were negative in both cases indicating that, a unit increase in market access led to a reduction in the probability of adoption. Perceived profit was significant at 5% for animal manure & minimum tillage only. It was equally positive, implying that, a unit increase in perceived profit led to an increase in the probability of adoption of animal manure and minimum tillage simultaneously. Cost of production per acre was significant at 5% for compost application only. It was negative as well indicating that, a unit increase in the cost of production per acre brought about a reduction in the probability of jointly adopting animal manure and minimum tillage only.

Finally, the study showed that, smallholder farmers' decision to adopt SLMPs is affected by the characteristics of the plot such as fertility status, plot size among others on which the SLMP is applied that is, animal manure, compost and minimum tillage. Plot size was significant at 1% for compost only but negative, indicating that, a unit increase in plot size will result in the reduction in the probability of adopting compost only. Increase in plot size probably diverts extra labour into working on the increased plot size rather than adopting compost. Plot size was also significant at 5% for the joint adoption of compost and minimum tillage only but negative, indicating that, a one unit increase in plot size will result in a decline in the probability of jointly adoption compost and minimum tillage only. This is probably because the extra effort that would have been put into adopting compost and minimum tillage simultaneously would be diverted in working on the added plot.

CHAPTER FIVE

5.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Chapter five discusses summary of the findings on the study. This chapter also draws conclusions from the study. It also discusses recommendations for improvements and further studies.

5.1 Summary of Findings

This study analyses smallholder farmer perception and decision to adopt SLMPs in Wa East and Lawra Districts. This study was driven by the need to use SLMPs for ensuring sustainable and guaranteed yields in midst of unpredictable weather changes in Ghana particularly the vulnerable Northern Regions and African at large. This will also provide policy direction for stakeholders so as to enhance food security in the country and the sub region. Smallholder farming dominates the agricultural sector in Ghana. It provides livelihood for majority of the population. Knowledge of the perception and adoption issues will help provide agriculture, environmental and social policy options that will reduce challenges associated with adoption.

Tools required for the application of animal manure, compost and minimum tillage cost and profitability issues are important information for adoption. The demand as measured by the perception and socio economic as well as field characteristics of smallholder farmers also contribute significantly to the adoption of SLMPs.

This study therefore evaluated an entire adoption of animal manure, compost and minimum tillage for Ghana future policy on the adoption of these SLMPs particularly in the Upper West Region. Descriptive analyses were first carried out to examine the demographic characteristics of smallholder farmers within the study Districts, Wa

East and Lawra. This was followed by an analysis of the tools required for carrying out animal manure, compost and minimum tillage.

The profitability analysis which uses partial budget analysis was carried out, followed by respondents' perception of animal manure, compost, minimum tillage and finally, the regression of factors that have influence on respondents' choice of animal manure, compost and minimum tillage.

Majority (75%) of smallholder farmers in the Wa East and Lawra Districts used bicycles, sacks and head pans to enable them carry and apply animal manure on their fields. This set of tools were estimated to cost an average of GH¢ 449.18. The study also found about 75% of smallholder farmers in the study districts, required shovels, wheel barrows, bicycles, sacks, weedicides and head pans to ensure complete preparation and application of compost on their fields. These tools were estimated to cost an average of GH¢467.56. About 87.2% of respondents in the study districts required knapsack sprayers and weedicides for the application of minimum tillage. The tools used in the application of minimum tillage were estimated to cost an average of GH¢131.73. The average cost of tools for the application of the three practices ranges from a minimum average of GH¢ 131.73 to GH¢ 467.56. This amount appears to be a substantial amount of money to the smallholder farmer and therefore needs interventions to enable the smallholder farmer acquire tools for the application of these soil fertility enhancing practices.

It has been estimated that, the application of animal manure will result in net returns of GH¢448.2 equivalent to $97.4 per acre per season under cereal crops production compared to GH¢15.3 when the farmer is not applying animal manure. Average output was estimated to be 11.9 bags per acre for and 4.9 bags for maize and sorghum respectively where a bag is equivalent to a cocoa sack (100Kg for maize and 105Kg for sorghum). This profit value will rise to GH¢558 with a correspondent increase in output price by 11.8%. Profit will however reduce to GH¢407.1 with an 11.8% rise in input prices, where 11.8% is the annual inflation rate for the year 2017 by Ghana Statistical Service.

The study also estimated net returns of GH¢327.7 equivalent to $71.2 per acre per season with the application of compost compared to when the farmer was not applying compost. This was expected to increase to GH¢366.1 following 11.8% increase in output price. It was however expected to reduce to GH¢226.7 with an increase in input price by 11.8%.

The net returns for minimum tillage was GH¢98.2 equivalent to $21.3 under cereal crop production compared to GH¢15.3 ($3.3) when the farmer was not applying minimum tillage. The returns were expected to increase to GH¢109.89 with an increase in output price by 11.8%. In the event of 11.8% rise in input price, the net returns were expected to reduce to GH¢86.51.

The demand for animal manure, compost and minimum tillage was measured by the perception of the smallholder farmers on the respective practices under study. Smallholder farmers in the study districts had positive perception in animals' manure ability to increase crop yield, reduce erosion, increase soil fertility and reduce cost of production. They however largely disagreed with the following statements; animal manure is complex to apply in the fields, leads to complete crop failure, expensive to apply on the field and incompatible with existing farming practices. This resulted in a positive perception index score of 5.23 implying that, farmers will demand for animal manure, given the required resources, all other things being equal.

The study also found positive, farmers' response to the ability of compost to increase yield, increase the fertility of soils, prevent erosion and reduce cost of crop production. But the farmers were negative in their responses to compost complexity on the field; leads to complete crop failure, very expensive to apply and incompatible with existing farming practices. Compost therefore scores a perception index of 4.94 implying that, farmers have good perception towards compost and would want to apply it, given the necessary resources.

Minimum tillage equally revealed similar responses as found in animal manure and compost. Minimum tillage in a nutshell, scores a perception index of 3.94, meaning that, farmers have good perception for minimum tillage ability to address yield increases, maintain fertility, prevent erosion and also reduce cost of crop production.

In a whole, farmers have good perception towards all the three practices under study as they each score a positive perception index. The implication is that, respondents have agreed to the potentiality of animal manure, compost and minimum tillage to increase yield and their income.

5.2.1 Factors Affecting the Adoption of SLMPs

This study considered some socio economic and plot characteristics that affected the adoption of SLMPs. Among the factors considered, are years of experience in farming, access to extension service, access to ready market, farm size, household size, total number of animals, member of farmer association, perceived profitability, fertility status of fields and cost of production per acre.

The principal factors that affected the probability of adopting animal manure adoption are; number of years of experiences in farming, total number of animals the farmer own, access to extension service, access to ready market, household size and perceived profitability.

The probability of adopting compost was mainly affected by the number of years of experience in farming, total farm size, number of farm animals the farmer own, household size, access to extension service and cost of production per acre.

The study also found principally that, number of years of experience, total number of animals the farmer has, access to ready market and household size influenced probability of adopting minimum tillage.

The probability of simultaneously adopting animal manure and compost only was significantly affected by number of years of experience in farming, total number of animals the farmer own, household size, cost of production per acre and access to ready market.

The probability of jointly adopting animal manure and minimum tillage only was greatly affected by total number of animals the farmer own, number of years of experience, access to extension service, perceived profitability and access to ready market.

The probability of adopting compost and minimum tillage only was largely affected by number of years of experience, number of animals the farmer own, farm size, household size and access to extension service.

The probability of jointly adopting all the three practices was heavily influenced by number of years of experience, number of animals the farmer owns, access to ready market and being a member of a farmer association. These factors itemized in each of the categories were significant in 1%, 5% or 10% levels.

5.3 Conclusions

The study was conducted in the Lawra and Wa East districts of the Upper West Region. This study analysed smallholder farmers' adoption decision on animal manure, compost and minimum tillage in Wa East and Lawra District. The study took into consideration the tools used, profitability and perception of the practices. The study used partial budget analysis in analysing the profitability. The study also used Likert scale in estimating the perception and its indexes. Multinomial logit analysis was used in arriving at factors influencing small holder farmers, adoption behaviours.

The found some minor differences with regard to the tools used for the application of animal manure and compost. But majority of the respondents used sacks and head pan to gather and convey animal manure and compost to the field. The other tools needed could be hired or borrowed from other people. Minimum tillage was largely applied with a knap sack sprayer and weedicides. The study also indicated that, it will cost the farmer an average of GH¢ 449.2, GH¢467.56 and GH¢131.73 to procure these tools mentioned for animal manure, compost, and minimum tillage application respectively. But these tools could be used over several years.

The profitability of animal manure was estimated as GH¢448.2 per acre per production season for animal manure compared to GH¢15.3. The profitability of compost was GH¢327.5 per acre per production season compared to GH¢15.3 when the farmer was not applying compost. Minimum tillage was equally profitable to apply on the fields as it yielded a net profit value of GH¢98.2 per acre per production season compared to GH¢15.3 when the farmer was not applying minimum tillage. These margins were subject to changes depending changes in either input or output price.

The perception on animal manure, compost and minimum tillage is high among smallholder farmers in Lawra and Wa East Districts of Upper West Region. This led to perception index scores of 5.23, 4.93 and 3.94 for animal manure, compost and minimum tillage respectively. The index scores show that, the respondents were willing to apply animal manure, compost and minimum tillage, holding all other factors constant. Respondents were more willing to apply animal manure, followed by compost and then minimum tillage as showed in the perception index scores. The more positive the index score, the greater the demand for the practice.

The adoption behaviour of small holder farmers on animal manure is affected by economic and social factors. The adoption behaviour of respondents on compost was as well affected by economic, social and farm characteristics. Minimum tillage adoption behaviour was affected by economic and social factors.

Also, the simultaneous adoption of animal manure & compost only, animal manure & minimum tillage only and compost and minimum tillage were significantly influenced by economic and social factors. The joint adoption of all the three practices was influenced by economic and social variables rather plot characteristics.

5.3 Recommendations

On the examination of the findings made, the following recommendations were made to improve upon the adoption of SLMPs. These recommendations will go a long way to improve upon smallholder farmers' adoption behaviour as well as productivity.

- Smallholder farmers should come together in groups to acquire tools for collective use in their respective communities for the application of the respective SLMPs. This will go a long way to relieve smallholder farmers of the initial cost burden in the application of the respective SLMPs.
- Upgrading the capacity of extension personnel could help bridge knowledge gap and for that matter improve upon the efficiency of extension delivery and increased famers' productivity options.
- It is also recommendation that smallholder farmers should form associations for the marketing of their produce. This will ensure guaranteed market prices for their produce and hence, increase and sustain profit margins. Further

studies into the long term profitability levels (2-4 years) cumulative, should be carried out to provide adequate information on profitability of SLMPs.

- Demonstration farms by stakeholders in all farming communities should be encouraged, for other farmers to learn more about SLMPs and hence trigger adoption. The risk associated with the adoption of these SLMPs should also be probed into to uncover the risk of adopting these SLMPs. This will facilitate policy direction aimed at addressing the risk factors to encourage adoption.
- Further studies into the environmental benefits of animal manure application, compost and minimum tillage is recommended to facilitate well-defined policy direction. I further recommend studies into the effect of agro ecological factors and climate factors that affect SLMPs adoption. Finally, it is recommended that, any food production policy should inculcate SLMPs adoption to enhance sustainable productivity increases.

REFERENCES

ACDEP. (2010). *Networking for Development in Northern Regions.* Wa: Word Press. Org.

Adesina, A., & Baidu-Forson, J. (1995). Farmers' perceptions and adoption of new agricultural technology: evidence from analysis in Burkina Faso and Guinea, West Africa . *Journal of Agricultural Economics*, 1-9.

Akudugu, A. M., Guo, E., & Dadzie, K. S. (2012). Adoption of Modern Agricultural Production Technologies by Farm Households in Ghana: What Factors Influence their Decisions? *Journal of Biology, Agriculture and Healthcare*, 1-14.

Allmaras, R., Schomberg, H., Douglas Jr, C. L., & Dao, T. H. (2000). Soil organic carbon sequestration potential of adopting conservation tillage in the US croplands. *Journal of Soil and Water Conservation*, 365-373.

Amsalu, A., & de Graaff, J. (2007). Determinants of adoption and continued use of stone terraces for soil and water conservation in an Ethiopian highland watershed. *Journal of Ecological Economics*, 294-302.

Arellanes, P., & Lee, R. D. (2003). The Determinants of adoption of Sustainable Agriculture Technologies: Evidence from the Hill sides of Honduras. *25th International Conference of Agricultural Economists (IAAE)* (pp. 693-699). Durban: Document Transformation Technologies.

Asiamah, R., & Dedzoe, C. D. (1999). Plinthisation-A threat to agricultural production. *Ghana journal of agricultural science*, 223- 227.

Audi, R. (2003). *Epistemology: A contemporary introduction to the theory of knowledge.* New York: ROUTLEDGE.

Baldwin, R. K. (2006). Crop Rotations on Organic Farms. *Center for Environmental Farming Systems*, 1-16.

Behera, K. U., & Sharma, R. A. (2007). *MODERN CONCEPTS OF AGRICULTURE.* Delhi: Indian Agricultural Research Institute.

Belderbos, R., Carree, M., Diederen, B., Lokshin, B., & Veugelers, R. (2004). Heterogeneity in R&D cooperation strategies. *International Journal of Industrial Organization*, 1237-1263.

Bhattcherjee, A. (2012). *Social Science Research: Principles, Methods, and practice.* Florida: Textbooks Collection.

Cambridge University Advanced Learner's Dictionary. (2018, May 21). *Cambride University Press*. Retrieved from Cambridge University Press Website: https://dictionary.cambridge.org de Janvry, A., Fafchamps, M., & Sadoulet, E. (1991). Peasant Household Behaviour with Missing Markets: Some Paradoxes Explained. *Journal of Economics*, 1400-1417.

de Janvry, A., Fafchamps, M., & Sodoulet, E. (1991). Peasant household behaviour with missing markets: Some paradoxes explained. *Journal of economics*, 1400-1417.

DFID. (2001). *Bridging Knowledge Gaps Between Soils Research And Dissemination In Ghana.* Bangor: University of Wales.

DFID. (2004). *Agricultural Sustainability*. UK: DFID.

Diao, X., & Sarpong, D. B. (2007). Cost implication of Agricultural Land Degradation in Ghana: An economywide, multimarket model assessment. *International Food Policy Research*, 1-34.

Donkoh, A. S., & Awuni, A. J. (2011). Farmers' Perceptions and Adoption of Improved Farming Techniques in Low-Land Rice Production in Northern Ghana. *Fourth Tokyo International Conference for African Development (TICAD IV).* Tokyo: Coalation for Africa Rice Development.

Edwards, S., & Araya, H. (2011). *How to make and compost.* Rome: FAO.

EPA. (2002). *National Action Programme to Combat Drought and Desertification.* Ghana: Environmental Protection Agency.

FAO. (2009). *Food Security and Agricultural Mitigation in Developing Countries:Options for Capturing Synergies.* Rome: FAO.

FAO. (2011a). *Sustainable Land Management Practice, Guidelines and Best Practices for Subsaharan Africa Field Application.* Rome: TerrAfrica Partnership.

FAO. (2011b). *Climate-Smart Agriculture: A Synthesis of Empirical evidence and mitigation benefits from improved cropland management.* Rome: FAO.

Farouque, G., & Takeya, H. (2007). Farmers' Perception of Integrated Soil Fertility and Nutrients MANAGEMENT FOR SUSTAINABLE Crop Production: A Study of Rural areas in Bangladesh. *Journal of Agricultural Education*, 111-122.

Gebremedhin, B. (2004). ECONOMIC INCENTIVES FOR SOIL CONSERVATION IN THE EAST AFRICAN. *13th International Soil Conservation Organisation Conference* (pp. 1-4). Brisbane: International Livestock Research Institute (ILRI), Addis Ababa, Ethiopia.

Gittinger, P. J. (1984). *Economic Analysis of Agricultural Projects.* Economic Development Institute, The world Bank.

Grabowski, P. P. (2011). Constraints to the adoption of Conservation Agriculture in the Angonia high lands of Mozambique: Perspective from small holder hand-hoe farmers. *Michigan State University*, 9-96.

Greene, H. W. (2002). *Econometric Analysis.* New Jersey: Pearson Education Inc. Retrieved from ACDEP Secretariat.

GSS. (2005). *Population and Data Analysis Report: Socio-economic and Demographic Trend Analysis* . Accra: Ghana Statistical Service.

GSS. (2012). *Summary report of final results on 2010 population and housing census.* Accra: GSS.

GSS. (2013). *2010 Population & Housing Census, Regional Analytical Report, Upper West Region.* Accra: GSS.

GSS. (2014). *District Analysis of 2010 popoulation and Housing Census.* Lawra: Ghana Statistical Service.

GSS. (2017). *Statistical Bulletin, Consumer Price Index.* Accra: Ghana Statistical Service.

Gyasi, E. A., Karikari, O., Kranjac-Berisavljevic, G., & Von-Vordzogbe, V. (2006). *Climate Change Vulnerability and Adaptation Assessment Relative to Land Management in Ghana.* Accra: United Nation Framework Convention on Climate Change.

Hall, V. R. (2010). *Intermediate Microeconomics, A New Modern Approach* . New Delhi: East West Press Private Limited.

IAASTD. (2009). *Agriculture at a cross crossroads-Volume V, Sub saharan Africa* . Washington DC: Island Press.

Inckel, M., de Smet, P., Tersmette, T., & Veldkamp, T. (2005). *The preparation and use of compost.* Wageningen: Agromisa Foundation .

Juma, M., Nyangena, W., & Yesuf, M. (2009). Production Risk and Farm Technology Adoption in Rain-Fed, Semi-Arid Lands of Kenya . *Environment for Development*, 9-22.

Kassie, M., & Zikhali, P. (2009). Sustainable land management and Agricultural Practices in Africa: Bridging the gap between research and farmers. *Brief on Sustainable Agriculture* (pp. 1-11). Gothenburg, Sweden: United Nations.

Kassie, M., Jaleta, M., Shiferaw, B., Mmbando, F., & Muricho, G. (2012). Plot and Household-Level Determinants of Sustainable Agricultural Practices in Rural Tanzania. *Environment for Development*, 1-40.

Kassie, M., Zikhali, P., Manjur, K., & Edward, S. (2009a). Adoption of Organic of Organic Farming Technique: Evidence from Semi-arid region of Ethiopia.

Environment for Development (pp. 1-9). Washington DC: Resources for the Future.

Kassie, M., Zikhali, P., Manjur, K., & Edwards, S. (2009b). Adoption of sustainable agriculture practices: Evidence from a semi-arid region of Ethiopia. *Narural Resource Forum*, 189-198.

Kim, K. S., Tiessen, K., Beeche, A., & Kamatari, A. (2011). Cattle manure management in Rwanda – A case of Girinka cow beneficiaries in the district of Ngoma . *Rwanda Journal of Agriculture Sciences*, Volume 24.

Kothari, R. C. (2004). *Research Methodology: Methods and Techniques.* New Delhi: New Age International (P) Limited.

Kpieta, B. A., & Bonye, Z. S. (2011). LAND AS A "GOD": THE GENDER DIMENSIONS OF ITSWEALTH CREATION AMONG THE DAGAABAS IN NORTH-WESTERN GHANA. *European Scientific Journal*, 109-131.

Kumar, R. (2011). *Research Methodology: A step by step guide to beginners* . New Delhi: SAGE Publications India Pvt Ltd.

Leary, R. M. (2001). *Introduction to behavioral research methods.* United State of America: Pearson Education Company.

Mafongoya, P., Jiri, O., & Phophi, M. (2016). Evaluation of Tillage Practices for Maize (Zea mays) Grown on Different Land-Use Systems in Eastern Zambia. *Sustainable Agriculture Research*, 1-10.

Melaku, D. N., Bayu, W., Tesfaye, S., & Sommer, R. (2014). Current and residual effects of compost and inorganic fertilizer on wheat and soil chemical properties. *Nutrient Cycling In Agroecosystems*, 357-367.

Mgbenka, N., & Mbah, N. (2016). A REVIEW OF SMALLHOLDER FARMING IN NIGERIA: NEED FOR TRANSFORMATION. *International Journal of Agricultural Extension and Rural Development Studies*, 43-54.

MoFA. (2011). *Agriculture in Ghana: Facts and Figures.* Ghana: Ministry of Food and Agriculture.

Morris, L. M., Tripp, R., & Dankyi, A. (1999). *Adoption and Impacts of Improved Maize Production Technology:A Case Study of Ghana Grain Development Project.* Mexico, D F: International Maize and Wheat Improvement Center (CIMMYT).

NEPAD. (2013). *African Agriculture, tTransformation and Outlook.* Johannesburg: NEPAD.

New Jersey Department of Agriculture. (2001). *Partial Budgeting: A Financial Management Tool.* New Jersey: USDA. NorthEast Region, Sustainable

Agriculture for Research and Education in Cooperation with Rutgers Cooperative Extension of Salem County.

Newman, W. L. (2014). *Social research Methods: Qualitative and Quantitative Approaches.* London: Pearson Eduction Limited.

Ngoc Chi, T., & Yamada, R. (2002). Factors affecting farmers' adoption of technologies in farming system: A case study in OMon district, Can Tho province, Mekong Delta. *Omonrice 10*, 94-100.

Ngoma, H., Mulenga, P. B., & Jayne, S. T. (2016). Minimum tillage uptake and uptake intensity by smallholder farmers in Zambia. *African Journal of Agricultural and Resource Economics*, 249-262.

Nhemachena, C., & Hassan, R. (2007). *Micro-Level Analysis of Farmers' Adaptation to Climate change in South Africa.* Washioton D.C: International Food Policy Research Institute.

Nkala, P., Mango, N., & Zikhali, P. (2011). Conservation Agriculture and Livelihoods of Smallholder Farmers in Central Mozambique. *Journal of Sustainable Agriculture*, 757-779.

Nkegbe, A. (2013). Inegrated Natural Resource Management in the Upper West Region of Ghana. *3rd Africa – Asia Drought Adaption Forum* (pp. 1-32). Xinjiang - China: Environmental Protection Agency.

Odendo, M., Obare, G., & Salasya, B. (2011). What factors influence the speed of adoption of Soil fertility management technologies? Evidence from Western Kenya. *Journal of Development and Agricultural Economics Vol. 3(13)*, 627-637.

Odhiambo, J. O., & Magandini, N. V. (2008). An assessment of the use of mineral and organic fertilizers by smallholder farmers in Vhembe district, Limpopo province, South Africa. *African Journal of Agricultural Research*, 357-362.

Owusu, V., & Anifori, M. O. (2012). Assessing Consumer Willingness to Pay a Premium for Organic Food Product: Evidence from Ghana. *International Association of Agricultural Economists Triennial Conference* (pp. 1-13). Foz do Iguacu, Brazil: International Association of Agricultural Economists (IAAE).

Owusu, V., & Anifori, O. M. (2012). Assessing Consumer Willingness to Pay a Premium for Organic Food Product: Evidence from Ghana. *International Association of Agricultural Economists Triennial Conference* . Foz do Iguacu, Brazil: International Association of Agricultural Economists (IAAE).

Pandey, I. M. (2002). *Financial Management.* New Delhi: Vikas Publishing House Pvt. Ltd.

Pender, J. (2009). *The World Food Crisis, Land Degradation and Sustainable Land Management: Linkages, Opportunities and Constraints.* International Food Policy Research.

Pretty, J. (2006). *Agroecological Approaches to Agricultural Development.* Ottawa: Rimisp-Latin American Center for Rural Development.

Pretty, J. (2006). *Agroecological Approaches to Agricultural Development.* Ottawa: World Bank.

Quansah, C., Safo, E., Ampontuah, E., & Amankwah, A. S. (2000). Soil fertility erosion and the associated cost of NPK removed under different soil and residue management in Ghana. *Ghana Journal of Agriculture*, 33-42.

Raj, A., Jhariya, K. M., & Toppo, P. (2014). Cow Dung For Ecofriendly and sustainable productive Farming . *International Journal of Scientific Research*, 201-202.

Salami, A., Kamara, B. A., & Brixiova, Z. (2010). *Smallholder Agriculture in East Africa: Trends, Constraints and Opportunies.* Tunis: African Development Bank.

SDSN. (2013). *Solutions for Sustinable Agriculture nd Food Systems.* New York: SDSN Secretariat.

Shiferaw, A. B., Okello, J., & Reddy, V. R. (2007). Adoption and adaptation of natural resource management innovations in smallholder agriculture: reflections on key lessons and best practices. *Journal of Environment, Development and Sustainability*, 601-619.

Snijders, P., Onduru, D., Wouters, B., Louis Gachimbi, L., Zake, J., Ebanyat, P., . . . van Keulen, H. (2009). *Cattle manure management in East Africa: Review of manure quality and nutrient losses and scenarios for cattle and manure management.* Wageningen: Wageningen UR Livestock Research.

Sserunkuuma, D. (2005). The Adoption and Impact of Improved Maize and Land Management Technologies in Uganda. *Journal of Agricultural and Development Economics* , 67-84.

Sustainet EA. (2010). *Technical Manual for Farmers and Extension Service Providers: Conservation Agriculture.* Nairobi: Sustainable Agriculture Information Initiative.

Teklewold, H., Kassie, M., & Shiferaw, B. (2012). On the joint estimation of multiple adoption decisions: The case of sustainable agricultural technologies and practices in Ethiopia. *International Association of Agricultural Economists (IAAE) Triennial Conference, Foz do Iguaçu, Brazil*, (pp. 1-36). Brazil: international Association of Agricultural Economics.

Tey, S. Y., Li, E., Bruwer, J., Abdullah, M. A., Cummins, J., Radam, A., . . . Darham, S. (2012). Adoption rate of sustainable agricultural practices: A focus on Malaysia's vegetable sector for research implications. *African Journal of Agricultural Research*, 2901-2909.

United Nation. (2009). *The contribution of sustainable agriculture and land management to sustainable development.* New York: Division for Sustainable Development.

WFP. (2011). Country Programme Ghana 200247 (2012-2016). *Executive Board Second Regular Session* (pp. 1-26). Rome: World Food Organisation.

Wikipedia. (2018, May Monday). *Perception*. Retrieved from Perception website: https://simple.m.wikipedia.org

Wikipedia. (2018, Monday). *Tools and Equipment (Disambiguation)*. Retrieved from Tools and Equipment Website: https://en.m.wikipedia.org/wiki/tool

Woodfine, A. (2009). Using Sustainable Land Management Practices to Adapt to and Mitigate Climate Change in Sub-Saharan Africa. *TerrAfrica Regional Sustainable Land Management*, 1-78.

World Bank. (2006a). *Environmentally and Socially Sustainable Development Department, Africa Region.* Ghana: World bank.

World Bank. (2006b). *Sustainable Land Management: Challenges, Opportunities and Trade Offs.* Washington DC: International Bank for Reconstruction and Development.

Yu, L., Harley, M. T., Kliebenstein, J., & Orazem, P. (2011). Testing for Complementarity and Substitutability Among Multiple Technologies: The Case of U.S. Hog farms. *Iowa State University, Iowa.*, 1-37.

APPENDIXES

Appendix A: Questionnaire

Department of Environment & Resource Management, Faculty of Integrated Development Studies, University for Development Studies - Wa Campus. Please kindly answer the questions below if applicable. Every bit of information provided shall be use purposely for research and shall be treated with the strictest confidentiality.

Community..District..

Region..Date...

Part: 1Personal Information

1. Gender: 1. Male [ ] 0. female [ ]
2. Experience in farming……………………………………..Mobile................................
3. Marital status: 1. single [ ] 2. Married [ ] 3. Widowed [ ] 4. Divorced [ ] 5. separated [ ]
4. Level of education none: 1. Basic [ ] 2. Secondary [ ] 3. Tertiary [ ] 4. Non formal [ ]
5. Religion: 1.Christianity [] 2. Islam [] 3. Traditionalist [] 4. Others specify...
6. Ethnicity: 1.Sisaala [ ] 2. Dagaaba [ ] 3. Lobi [ ] 4. Waala [ ] 5. Others specify...
7. Do you do other job(s) that earn you salary outside your farm? 1. Yes [ ] 2. No [ ]
8. Where do you work off farm..?

Part 2: Objective 1(Tools and Equipment for practices)

9. Which practices do you carry out on your field? 1. Animal manuring [ ] 2. Composting [ ] 3. Minimum tillage [ ] 4. Mulching [ ] 5. Crop rotation [ ] 6. Green manuring [ ] 7. Agro forestry [ ] 7. Legume intercrop [ ] 8. Stone bonding [ ]. Others specify....................................
10. Thick as appropriately the practice and the corresponding resources needed to carry it out

Animal manure appl　　Minimum tillage　　Composting

Shovel [ ]	Shovel [ ]	Shovel [ ]
Knapsack sprayer [ ]	Knapsack sprayer [ ]	Knapsacksprayer [ ]
Wheel barrow [ ]	Wheel barrow [ ]	Wheelbarrow [ ]
Bicycle [ ]	Bicycle [ ]	Bicycle [ ]
Sacks [ ]	Sacks [ ]	Sacks [ ]
Weedicides [ ]	Weedicides [ ]	Weedicides [ ]
Labour [ ]	Labour [ ]	Labour [ ]
pick axe [ ]	pick axe [ ]	pick axe [ ]
others [ ]	others [ ]	others [ ]
Estimated Cost……………	**Estimated Cost………..**	**Estimated Cost………**

Part 3: Objective 2 (Profitability Analyses)

a. **Productions**

11. Production cost under normal farming activities. #Acreage…..Farm Name……………

Activity	**No. Of people/acre**	**Man days**	**Wage rate/day (wf)**	**Wage rate (wof)**
Clearing of vegetation/ploughing	AMF…AMH… AFF…AFH… MCF…MCH… FCF…FCH…	AMF…AMH… AFF…AFH… MCF…MCH… FCF…FCH…	AMF…AMH… AFF…AFH… MCF…MCH… FCF…FCH…	AMF…AMH… AFF…AFH… MCF…MCH… FCF…FCH…
Stumping	AMF…AMH… AFF…AFH… MCF…MCH… FCF…FCH…	AMF…AMH… AFF…AFH… MCF…MCH… FCF…FCH…	AMF…AMH… AFF…AFH… MCF…MCH… FCF…FCH…	AMF…AMH… AFF…AFH… MCF…MCH… FCF…FCH…
Burning of thrash	AMF…AMH… AFF…AFH… MCF…MCH	AMF…AMH… AFF…AFH… MCF…MCH	AMF…AMH… AFF…AFH… MCF…MCH	AMF…AMH… AFF…AFH… MCF…MCH

	… FCF…FCH…	… FCF…FCH…	… FCF…FCH…	… FCF…FCH…
Cost of seeds/planting material	AMF…AMH … AFF…AFH… MCF…MCH … FCF…FCH…	AMF…AMH … AFF…AFH… MCF…MCH … FCF…FCH…	AMF…AMH … AFF…AFH… MCF…MCH … FCF…FCH…	AMF…AMH … AFF…AFH… MCF…MCH … FCF…FCH…
Sowing /planting	AMF…AMH … AFF…AFH… MCF…MCH … FCF…FCH…	AMF…AMH … AFF…AFH… MCF…MCH … FCF…FCH…	AMF…AMH … AFF…AFH… MCF…MCH … FCF…FCH…	AMF…AMH … AFF…AFH… MCF…MCH … FCF…FCH…
Fertiliser cost				
Transport cost				
Cost of fertiliser application	AMF…AMH … AFF…AFH… MCF…MCH … FCF…FCH…	AMF…AMH … AFF…AFH… MCF…MCH … FCF…FCH…	AMF…AMH … AFF…AFH… MCF…MCH … FCF…FCH…	AMF…AMH … AFF…AFH… MCF…MCH … FCF…FCH…
Irrigation	AMF…AMH … AFF…AFH… MCF…MCH … FCF…FCH…	AMF…AMH … AFF…AFH… MCF…MCH … FCF…FCH…	AMF…AMH … AFF…AFH… MCF…MCH … FCF…FCH…	AMF…AMH … AFF…AFH… MCF…MCH … FCF…FCH…
Weeding	AMF…AMH … AFF…AFH… MCF…MCH …	AMF…AMH … AFF…AFH… MCF…MCH …	AMF…AMH … AFF…AFH… MCF…MCH …	AMF…AMH … AFF…AFH… MCF…MCH …

	FCF…FCH…	FCF…FCH…	FCF…FCH…	FCF…FCH…
Harvesting	AMF…AMH … AFF…AFH… MCF…MCH … FCF…FCH…	AMF…AMH … AFF…AFH… MCF…MCH … FCF…FCH…	AMF…AMH … AFF…AFH… MCF…MCH … FCF…FCH…	AMF…AMH … AFF…AFH… MCF…MCH … FCF…FCH…
Chemicals Q'ty				
Chemicals Applied	AMF…AMH … AFF…AFH… MCF…MCH … FCF…FCH…	AMF…AMH … AFF…AFH… MCF…MCH … FCF…FCH…	AMF…AMH … AFF…AFH… MCF…MCH … FCF…FCH…	AMF…AMH … AFF…AFH… MCF…MCH … FCF…FCH…
Others	AMF…AMH … AFF…AFH… MCF…MCH … FCF…FCH…	AMF…AMH … AFF…AFH… MCF…MCH … FCF…FCH…	AMF…AMH … AFF…AFH… MCF…MCH … FCF…FCH…	AMF…AMH … AFF…AFH… MCF…MCH … FCF…FCH…

NB: AMF=Adult Male family, AMH:Adult male hired, AFF:Adult female family, AFH:Adult female hired, MCH:Male child family, MCH:Male child hired, FCF:Female child family, FCH:Female Child hired

12. Production cost under animal manure application #Acreage……………………

Activity	**No. Of people/acre**	**Man days**	**Wage rate/day (wf)**	**Wage rate/day (wof)**
Gathering of manure	AMF…AMH… AFF…AFH… MCF…MCH… FCF…FCH…	AMF…AMH… AFF…AFH… MCF…MCH… FCF…FCH…	AMF…AMH… AFF…AFH… MCF…MCH… FCF…FCH…	AMF…AMH… AFF…AFH… MCF…MCH… FCF…FCH…
Cost of manure				
Cost of	AMF…AMH…	AMF…AMH…	AMF…AMH…	AMF…AMH…

transporting manure to farm	AFF…AFH… MCF…MCH… FCF…FCH…	AFF…AFH… MCF…MCH… FCF…FCH…	AFF…AFH… MCF…MCH… FCF…FCH…	AFF…AFH… MCF…MCH… FCF…FCH…
Application of manure	AMF…AMH… AFF…AFH… MCF…MCH… FCF…FCH…	AMF…AMH… AFF…AFH… MCF…MCH… FCF…FCH…	AMF…AMH… AFF…AFH… MCF…MCH… FCF…FCH…	AMF…AMH… AFF…AFH… MCF…MCH… FCF…FCH…
Quantity Applied				
Others	AMF…AMH… AFF…AFH… MCF…MCH… FCF…FCH…	AMF…AMH… AFF…AFH… MCF…MCH… FCF…FCH…	AMF…AMH… AFF…AFH… MCF…MCH… FCF…FCH…	AMF…AMH… AFF…AFH… MCF…MCH… FCF…FCH…

13. Output from animal manure application. #Acreage……………………

Cereal Crops grown	**Estimated output in bags without animal manure**	**Estimated output with animal manure**	**Type of bag** (cocoa bag=1, maxi bag=2, small bag=3

14. Production cost under composting

Activity	**No. Of people/acre**	**Man days**	**Wage rate/day (wf)**	**Wage rate/day (wof)**
Compost pit	AMF…AMH	AMF…AMH	AMF…AMH	AMF…AMH

	… AFF…AFH … MCF…MCH … FCF…FCH …	… AFF…AFH… MCF…MCH … FCF…FCH…	… AFF…AFH… MCF…MCH … FCF…FCH…	… AFF…AFH… MCF…MCH … FCF…FCH…
Gathering of compost material	AMF…AMH … AFF…AFH … MCF…MCH … FCF…FCH …	AMF…AMH … AFF…AFH… MCF…MCH … FCF…FCH…	AMF…AMH … AFF…AFH… MCF…MCH … FCF…FCH…	AMF…AMH … AFF…AFH… MCF…MCH … FCF…FCH…
Transport cost	AMF…AMH … AFF…AFH … MCF…MCH … FCF…FCH …	AMF…AMH … AFF…AFH… MCF…MCH … FCF…FCH…	AMF…AMH … AFF…AFH… MCF…MCH … FCF…FCH…	AMF…AMH … AFF…AFH… MCF…MCH … FCF…FCH…
compost application	AMF…AMH … AFF…AFH … MCF…MCH … FCF…FCH …	AMF…AMH … AFF…AFH… MCF…MCH … FCF…FCH…	AMF…AMH … AFF…AFH… MCF…MCH … FCF…FCH…	AMF…AMH … AFF…AFH… MCF…MCH … FCF…FCH…
Quantity applied:				
Others	AMF…AMH	AMF…AMH	AMF…AMH	AMF…AMH

	… AFF…AFH… MCF…MCH … FCF…FCH…	… AFF…AFH… MCF…MCH … FCF…FCH…	… AFF…AFH… MCF…MCH … FCF…FCH…	… AFF…AFH… MCF…MCH … FCF…FCH…

15. Output from composting

Cereal Crops grown	**Estimated output in bags without animal manure**	**Estimated output with animal manure**	**Type of bag** (cocoa bag=1, maxi bag=2, small bag=3

16. Production cost under minimum tillage

Activity	**No. Of people**	**Man days**	**Wage rate/day (wf)**	**Wage rate/day (wof)**
Clearing of vegetation	AMF…AMH … AFF…AFH… MCF…MCH … FCF…FCH…	AMF…AMH … AFF…AFH… MCF…MCH … FCF…FCH…	AMF…AMH … AFF…AFH… MCF…MCH … FCF…FCH…	AMF…AMH … AFF…AFH… MCF…MCH … FCF…FCH…
Weedicides quantity				
Application of weedicides	AMF…AM H… AFF…AFH …	AMF…AMH … AFF…AFH… MCF…MCH	AMF…AMH … AFF…AFH… MCF…MCH	AMF…AMH … AFF…AFH… MCF…MCH

	MCF…MCH … FCF…FCH …	… FCF…FCH…	… FCF…FCH…	… FCF…FCH…
Others	AMF…AM H… AFF…AFH … MCF…MCH … FCF…FCH …	AMF…AMH … AFF…AFH… MCF…MCH … FCF…FCH…	AMF…AMH … AFF…AFH… MCF…MCH … FCF…FCH…	AMF…AMH … AFF…AFH… MCF…MCH … FCF…FCH…

17. Output from minimum tillage

Cereal Crops grown	**Estimated output in bags without animal manure**	**Estimated output with animal manure**	**Type of bag** (cocoa bag=1, maxi bag=2, small bag=3

Part 4: Objective 3 (Knowledge and Perception studies)

The following are statements that relate to the specific SLMPs, you are requested to provide your level of agreement by selecting from 1 to 5 under the appropriate column of the table below. Where 1=strongly agree, 2= Agree, 3= Indifferent 4= Disagree 5= strongly disagree.

18. Animal manure

Animal manure increase crop yield	
Maintain the fertility of the soil	
Control/prevent erosion of the soil	
Reduce cost of crop production	
Animal manure is very complex to use on the field	
Animal manure can lead to complete crop failure	
It is very expensive to apply on the field	
It is not compatible with existing farming practices	

19. **Composting**

Composting increase crop yield	
Maintain the fertility of the soil	
Control/prevent erosion of the soil	
Reduce cost of crop production	
composting is very complex to use on the field	
Composting can lead to complete crop failure	
It is very expensive to apply on the field	
It is not compatible with existing farming practices	

2.0 Minimum tillage

Minimum tillage increase crop yield	
Maintain the fertility of the soil	
Control/prevent erosion of the soil	
Reduce cost of crop production	
Minimum tillage is very complex to use on the field	
Minimum tillage can lead to complete crop failure	
It is very expensive to apply on the field	
It is not compatible with existing farming practices	

Part: 5aObjective 4 (Socio-economic and household characteristics)

20. Do you get assistance from agricultural extension agents? 1. Yes [ ] 2. No [ ]
21. If yes to (21), how many hours per week? 1. (1-3) 2. (4-5) 3. Others [ ]
22. Do you get ready market for your produce? 1. Yes [ ] 2. No [ ]
23. If yes to (23), where do you dispose the produce? 1. Farm gate [ ] 2. Market center [ ]
24. If market center, how many kilometers from the farm/store...
25. What is the size of the plot in acres? ....

26. Do you often encounter pest and disease problems on the plot? 1. Yes [ ] 2. No [ ]

27. If yes to (27), which of your plot(s)..

28. How many people live in your household?

Males <15years	Females < 15years	Males >15years	d. females > 15years

29. Do you often get fertilizer timely? 1. Yes [ ] 2. No [ ]

30. If no to (30), what are the challenges to your timely acquisition of fertilizer?

....

....

....

31. How many livestock do you have?

Cattle	Sheep	Goats	Pigs

32. How many poultry birds do you keep?

Fowls	Guinea fowls	Ducks	Turkeys	Others

33. Is the amount of rainfall on your plot satisfactory? 1. Yes [ ] 2. No [ ]

34. If no to (34), what is your response when rainfall is not satisfactory...?

35. Are you a member of any farmer association? 1. Yes [ ] 2. No [ ]

36. If yes to (36), what does the association mainly do...?

37. Do you think you are making profit in your farming as a business? 1. Yes [ ] 2. No [ ]

38. If no to (38), why...

39. Which farming system do you practice on your farm? 1. Mixed cropping [ ] 2. Mixed farming [ ] 3. Mono cropping [ ]4. Land rotation [ ] 5. Crop rotation [ ] 6. Others specify...

Part: 5b Objective 4 (Plot Characteristics)

Location of farm	Example Kadinga zu	1…………	2………..	3…………
Size of farm (in acres)	3 acres			

Practice of SLMPs (in acres)	Yes[√] No [ ]	Yes[ ] No [ ]	Yes[ ] No [ ]	Yes[ ] No [ ]
SLMP practised (1=animal manure, 2=compost, 3=minimum tillage, 4=green manuring, 5=others)	1/3/5/…	…/…/…/…/	…/…/…/…/	…/…/…/…/
Tenure arrangement (1=owned, 2=rented, 3=family land 4=shared 5=others)	2			
Distance from residence to farm (km)	1.5km			
Time taken to walk to farm	30mins			
Usual transport mode (1=foot, 2=bicycle, 3=motorbike, 4=animal cart, 5=tricycle 6=others)	2			
Fertility status of plot 1. Highly fertile 0. Poorly fertile	0			
Fertilizer usage(1=yes 0=No)	yes			
Nature of the plot's terrain (1=sloppy, 2=gentle slope, 3=flat, 4=rocky, 5=other)	2			
Type of soil found on plot (1=sandy, 2=clayey, 3=loamy)	3			
Crops grown(1=maize, 2=sorghum, 3=millet,	Crop A...3 Crop B...2	Crop A…... Crop B…..	Crop A…... Crop B…..	Crop A…... Crop B…..

4=rice, 5=others)	Crop C…...	Crop C…...	Crop C…...	Crop C…...
Total output in bags(this refers to output used for all purposes including home consumption, sales, debt payment, stored and other uses)	Crop A8... Crop B6.. Crop C…...	Crop A…... Crop B….. Crop C…...	Crop A…... Crop B….. Crop C…...	Crop A…... Crop B….. Crop C…...
Type of bag(1=cocoa bag, 2=small fertilizer bag, 3=medium fertilizer bag, 4=maxibag)	Crop A 4 Crop B…1 Crop C…...	Crop A…... Crop B….. Crop C…...	Crop A…... Crop B….. Crop C…...	Crop A…... Crop B….. Crop C…...
Number of bags	Crop A..3 Crop B…4 Crop C…...	Crop A…... Crop B….. Crop C…...	Crop A…... Crop B….. Crop C…...	Crop A…... Crop B….. Crop C…...
Price per bag/unit of sale (GHC)	Crop A.90 Crop B160 Crop C…...	Crop A…... Crop B….. Crop C…...	Crop A…... Crop B….. Crop C…...	Crop A…... Crop B….. Crop C…...