UNIVERSITY FOR DEVELOPMENT STUDIES

THE DETERMINANTS AND EFFECTS OF MAIZE CROP AND LIVESTOCK INTEGRATION AMONG FULANI HERDSMEN IN MAMPRUGU-MOAGDURI DISTRICT, NORTHEN GHANA

BY

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DECLARATION

Student

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

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

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ABSTRACT

Crop-livestock integration is a risk coping strategy in the mixed farming system, which enhances conservation and sustainable agriculture. This study investigates the determinants and effects of maize crop and livestock integration among Fulani herdsmen in the Mamprugu-Moagduri District in the Northern Region of Ghana. Purposive sampling was used to select the study area while simple random sampling and stratified sampling were used to select the communities and respondents respectively. A total of 200 respondents was used for the analysis. The study used Heckman treatment effect model for the analysis. The study concludes that most agricultural practices adopted by the respondents were the use of weedicides (97.50%); land preparation by tractor (95%); dibbling (87.5%) and chemical fertilizer (87.5%). About 53% of the respondents adopted CLI. The probability of adopting CLI in the study area is high for the following categories of farmers: younger farmers; relatively large farm holders; farmers who have access to credit; farmers with small herd size; and farmers who adopted less inorganic fertilizers. Similarly, adoption of maize crop and livestock integration led to increased household maize output. Training is a major constraint to CLI adoption in the study area. The study recommends that Government policies and programmes should be geared towards facilitating improved access to production credit with minimum collateral and low interest rate to improve the adoption of crop-livestock integration. The youth and the relatively large maize farm holders should be targeted for support. Farm households should be encouraged to minimize inorganic fertilizer application and shift their attention towards crop-livestock integration. Public training should be enhanced to build farmers' capacity to adopt maize crop and -livestock integration.

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DEDICATION

I dedicate this work to the Glory of the Almighty God and my lovely mum, Mrs. Mary Zakaria.

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LIST OF ACRONYMS

SSA	Sub-Saharan Africa
CLI	Crop-Livestock Integration
FAO	Food and Agriculture Organisation
MoFA	Ministry of Food and Agriculture
FACS	Faculty of Agribusiness and Communication Sciences
IIRaCS	Institute for Interdisciplinary Research and Consultancy Services
DARE	Department of Agricultural and Resource Economics
UNDP	United Nations Development Programme
IWAD	Integrated Water Management & Agricultural Development
GSS	Ghana Statistical Service
GDP	Gross Domestic Product
CA	Conservation Agriculture
GH₵	Ghana Cedi
SKB	Sisili-Kulpawn Basin
NGO	Non-Governmental Organisations
DAAD	German Academic Exchange Service (German: Deutscher Akademischer Austauschdienst)

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Ghana is one of the middle-income countries in West Africa and has experienced impressive economic growth between 2010 and 2015. As at 2016, the per capita GDP of the country was US$ 149,723. Access to health care and education has also increased over the years and thus, making Ghana one of the few West African countries to be ranked as 'medium human developed country under the Human Development Index' (UNDP, 2016). Prior to these achievements, Ghana halved extreme poverty from 56.5% in 1992 to 24.2% in 2013 and thus, achieving one of the best records in sub-Saharan Africa (GSS, 2016). The contribution of agriculture to these milestones cannot be concealed, as the sector's contribution expanded marginally from a growth rate of 2.8 % in 2015 to 3.0% in 2016. Its share of GDP, however, dropped from 20.3% in 2015 to 19.1 % in 2016 (GSS, 2017). Specifically, the livestock sub-sector, contributes about 9% of the total agricultural GDP (MoFA, 2016).

Crop-livestock integration (CLI) in the mixed farming systems is an important pillar in African agriculture. It promotes food security and livelihood opportunities for hundreds of millions of people (Thornton and Herrero 2015). CLI contributes about 50% of global food needs. Specifically, in terms of cereals, about 41% of maize, 86% of rice, 66% of sorghum, and 74% of millet production are consumed globally and livestock provides about 75% and 60% of their milk and meat requirements respectively (Herrero et al., 2009). With the increasing population and reducing of agricultural land, CLI is crucial for ensuring a food secured society (Herrero *et al.,* 2010).

Crops and livestock integration, in which crops and livestock are raised on the same farm, occurs very widely in the tropics. Vast majority of the mixed crop-livestock farming systems are rain-fed, and cover large areas of the arid–semi-arid and humid–subhumid in sub-Saharan Africa (SSA) (Robinson *et al.,* 2011). CLI can be managed to contribute to environmentally sustainable intensification and risk management (Thornton & Herrero, 2015). Effective diverse interactions between various crop and livestock production in the mixed farming systems mitigate climate variability (Kristjanson & Thornton, 2004) as climate variability makes farmers vulnerable. Therefore, ensuring sustainable intensification and economically profitable CLI in the mixed farming system meets the welfare and environmental improvement goals of every economy (Place *et al*., 2003 & Makinde *et al*., 2007). For instance, improved and good way utilisation of organic manure from livestock has the prospect to ensure sustainable CLI for rural poor agro-pastoralists, since they often cannot afford to buy expensive chemical fertilisers (Bationo *et al*., 2004 & Makinde *et al.,* 2007) and other inputs.

Efficient management of crop and livestock integration in the farming system would not only contribute to income generation for households but also lead to higher crop and livestock productivity. It also promotes better environmental health via supplying nutrients to agricultural land without necessarily relying on external resources (Iiyama *et al*., 2007). These suggest that the interaction of crops and livestock activities in the agricultural sector should be a first step towards developing a more effective research and extension services.

One reason for which CLI is well suited is the mutual benefits to both crop and livestock. For example, livestock provides draft power to cultivate crop land and manure to fertilize the soil while the harvested crops or their residue are used in feeding the livestock.

CLI maintains the sustainable production system with the destroying the agricultural resource base (Thornton & Herrero, 2015). It promotes energy balance in the sustainability of farming systems hence, use energy more efficiently in production (Xu *et al.*, 2010). Crops and livestock production are highly complementary in the mixed farming system. Their complementarity has the potential to increase productivity of crops and livestock and thus improves rural farmers' living standard through increase in crop and livestock output (Kerr, 2002). It could also tend to increase smallholder farmers' consumption and sales of surpluses from crops and livestock output.

Like other parts of the continent, livestock rearing is vital in the smallholder farming systems in Ghana. Livestock serves as food and cash security to many, especially rural farmers. Livestock production is closely interrelated with crop production. For instance, it provides draft power for tillage, manure and carting of crop produce. Manure from livestock production is specifically important for conservation agriculture (CA). In recent times, the demands for organic products are increasing and the need for sustainable production with minimal damage to the environment and soil is also increasing. These are putting more pressure on agrarian communities into CLI. Although not new, the CLI is an effective innovation to increase farmers' resilience to climatic variability as well as address soil degradation resulting from poor agricultural practices that deplete the organic matter and nutrient content of the land. It is against this backdrop that scientists and policy makers emphasize CLI so that there is a holistic and more sustainable agriculture.

1.2 Problem Statement

Smallholder farmers in developing economies struggle to achieve food security by exploring and adopting agricultural innovations (Govereh & Jayne, 2003). CLI farming in the agriculture farming system is a key solution to problems of low productivity in the agricultural sector (Amani, 2005). This system of farming has been recognized as a key determinant to address rural and peri-urban household food insecurity and a tool for poverty reduction in less developed economies (Herrero *et al.*, 2007 & FAO, 2010) since it is an income generation activity. CLI minimized cost of production in agriculture by exploiting economies of scope (Chavas & Di Falco, 2012) and it is a cost saving production system to a level of 14% of farming crops and rearing livestock independently (Wu & Prato, 2006).

Agriculture in Ghana, especially Northern Ghana, faces the risk of soil infertility and land degradation. The challenge is how to increase agricultural productivity while at the same time preserving the natural resource base that supports agricultural production (Nkegbe *et al.,* 2011) for medium and long term. This is especially so with rising population growth that puts more pressure on arable land. Even though the Northern Region is one of the food baskets, it is among the poorest regions in Ghana (Nkegbe *et al.,* 2011). The region is characterized by low soil fertility, soil erosion and erratic rainfall leading to declining crop yield and animal production which affect the welfare of the farmers. It has been observed that one of the surest ways of overcoming the soil infertility problem, and therefore increase yield is the adoption of CLI (application of livestock (cattle) manure and use of maize and other crops residue in the mixed farming system).

CLI is among important means of achieving CA and hence the potential to increase agricultural productivity. Farmers who stand the chance of being able to adopt CLI are those who practice mixed farming in increasing crop and livestock productivity.

In the communities surrounding Sisili-Kulpawn river basin in the Mamprugu-Moaduri District, Fulani herdsmen are involved in maize farming in addition to rearing their own livestock (cattle) and/or indigenes' livestock. The Fulani herdsmen are traditionally not known to engage in residential agriculture. Indeed, they are mostly not considered in mainstream crop farming in Ghana. However, the situation has changed as they currently engage in crop farming especially maize cultivation in addition to pastoralism. This is thought to be providing an opportunity for CLI in the mixed farming to influence productivity. However, the production practices for that matter CLI of these "latecomers" in terms of crop and livestock production, the rationale for the adoption of CLI and the effects on maize output are not well understood. Similarly, factors that influence the adoption as well as the perceived benefits of CLI also remain unknown. An empirical study among these Fulani herdsmen to investigate the factors influencing the adoption of CLI and its effects on maize crop output would therefore be worthwhile. Furthermore, there is the need for a holistic assessment in order to explore the potentials of CLI farming systems in increasing maize output of Fulani herdsmen in the Mamprugu-Moagduri District in the Northern Region of Ghana.

The Integrated Water and Agricultural Development (IWAD) and Wienco Ghana Limited, in collaboration with the Ministry of Food and Agriculture (MoFA) have targeted to improve CLI in the mixed farming system at Mamprugu-Moagduri District in West Mamprugu in the Northern Region of Ghana. This is aimed at improving crop and livestock production to raise the food and income security situation of the crop and livestock farmers especially, among the Fulani herdsmen. Therefore, unearthing the potentials of CLI by using Fulani herdsmen as a case study is vital.

Ghana is an agrarian economy. About 90% of smallholder farmers' practiced CLI in the mixed farming system (Asante *et al.*, 2017). Conversely, the choices available to farmers to practice crops and livestock farming are inadequate due to scarcity of resources, especially the traditional factors of production (land, labor and capital). Also, the decision by farmers to go into CLI has been influenced by erratic rainfall, drought, high temperatures and floods (Griebenow & Kishore, 2009 & Ellis-Jones *et al*., 2012). The effects of these climate variability is reduction of crop yields and sometimes total crops failure (Asante *et al.*, 2017) making farmers more vulnerable. CLI has a mass effect on crops and livestock production (Ellis-Jones *et al.*, 2012; Ndamani & Watanabe, 2015), since pasture and crop residue are limited to feed livestock. These consequences leave resource-poor smallholder farmers in Ghana to be experiencing income instability and the outcome are food insecurity and poverty (Asante *et al*., 2017).

The role of CLI in the mixed farming has been established over the years (Little *et al.*, 2001; Joshi *et al.*, 2004; Yan *et al.*, 2010; Chavas & Di Falco, 2012; Kim *et al*., 2012; Tasie *et al*., 2012; & Ogundari, 2013). The role of CLI are classified into three, namely;

economic, social and agronomic (Johnston *et al.*, 1995). The economic benefits comprise seasonal stability of smallholder farmers' income to meet the basic needs such as education and healthcare. Most smallholder farmers are into CLI industry due to significant uncertainty that is inherent in agriculture (Chavas & Di Falco, 2012). CLI help smallholder farmers to adapt to the uncertainty in agriculture by optimizing income from a range of activities in agriculture (Asante *et al.*, 2017). The social benefits include more stable employment for smallholder farmers, youth in the rural areas and resources all over the year. The impact of CLI on social life is that it leads to sustainable income generation through efficient use of resources and exploitation of comparative advantage, as it has been recognized in India (Joshi *et al*., 2004). Agronomic benefits include CA, soil and water conservation management and other sustainable ways of agriculture farming. Furthermore, CLI reduces disease, weed and insect infestation. Similarly, it does not only reduce erosion, it improves soil fertility and structure; hence improves productivity (Caviglia-Harris, 2005; Iiyama *et al*., 2007; Mainik & Rüschendorf, 2010).

Despite the importance and significant role of CLI in managing production risks, income stability and soil improvement, among others, research to reveal the potentials of CLI in Northern Region, where poverty is high and rainfall patterns are noticeably changing, is limited. Admittedly, earlier studies focus on agricultural diversification and factors influencing income and livelihood diversification in the mixed farming systems (Knudsen, 2007; Iiyama *et al*., 2007; Lay & Schüler, 2008; Ibrahim *et al*., 2009; Fausat, 2012; & Senadza, 2012). For instance, Aneani *et al*. (2011) investigated the determinants of diversification of cocoa production and Asante *et al.* (2017) examined the determinants of farm diversification in integrated crop–livestock farming systems, both in Ghana.

However, little had done on agricultural practices, perceive benefits of CLI and the determinants and effects of CLI on maize crop output, using Fulani herdsmen as a case study. Hence, there is the need in a holistic approach to examine CLI and its effect on maize production as well as the perception of CLI among Fulani herdsmen in the Mamprugu-Moagduri District in the Northern region of Ghana.

1.3 Research Questions

The specific research questions to be addressed in the study are as follows:

1. What are the agricultural production practices adopted by the Fulani herdsmen in Mamprugu-Moagduri District?
2. What are the perceptions of Fulani herdsmen about CLI?
3. What are the adoption levels of CLI?
4. What factors influence the adoption of CLI among Fulani herdsmen in Mamprugu-Moagduri District?
5. What are the effects of adopting CLI on maize output of Fulani herdsmen?
6. What are the challenges facing the adoption of CLI by Fulani herdsmen?

1.3.1 Research aim and objectives

This study aimed to investigate the determinants and effects of maize crop and livestock integration among Fulani herdsmen in the Mamprugu-Moagduri District in the Northern Region of Ghana.

The specific objectives were to:

1. Explore the agricultural production practices adopted by the Fulani herdsmen;
2. Examine the Fulani herdsmen's perceptions of CLI in relation to application of livestock manure and use maize crop and other crops residue;
3. Examine the levels of adoption of CLI;
4. Analyze the factors that influence the adoption of CLI among Fulani herdsmen;
5. Determine the effects of adopting CLI on maize output of the Fulani herdsmen; and
6. Investigate the challenges Fulani herdsmen face in adopting CLI.

1.4 Justification

In northern Ghana, crop and livestock farming is the prime occupation of the populace. Most rural farmers regard crop cultivation as their main source of occupation for subsistence. Mostly, livestock is held in reserve as a minor occupation for risk diversification. There is much pressure on agricultural land as a result of urbanization and this has pushed farmers into crop and livestock integration farming. For this reason, the full integration of crop-livestock farming in the mixed faring systems, aimed at sustainable, environmentally friendly productivity, is crucial for the agricultural development in Ghana particularly Northern Region.

The rapid population growth and household level consumption are putting extraordinary demands on agriculture and natural resources. Over one billion people are chronically malnourished while our agricultural systems are concurrently degrading land, water, biodiversity and climate on a global scale (Foley *et al*., 2011). CLI has been identified as one of the mechanisms for reducing these menaces. However, agricultural production practices adopted by the Fulani herdsmen; the Fulani herdsmen perceptions of CLI; the determinants and effects of CLI on maize crop output as well as challenges Fulani herdsmen face in adopting CLI are limited in literature.

Unfolding the potentials of CLI in increasing maize production in the Mamprugu-Moaduri District of the Northern region of Ghana is relevant for policy planners and development agencies and academic as well. These will guide governments, Non-Governmental Organisations (NGOs) and other stakeholders in the agricultural sector in the design and programming of interventions to mitigate the effect of land degradation, climate change variability and poverty. In the academic domain, it contributes to the literature on the determinants of CLI and its effect on crop output in the mixed farming systems. It also contributes to the literature on the constraints farmers face for practising CLI

Also, researchers and extension service providers require feedback of the potentials of CLI from end users that have been practiced for long in the traditional way. Therefore, this study will provide feedback to future research, policy makers and policy implementers to improve integrated crop-livestock farming, design methods and disseminate these methods to the end beneficiaries which would improve sustainable agricultural practices and hence productivity.

1.5 Scope and Limitations

This study was conducted in West Mamprusi in the Mamprugu-Moagduri District in the Northern Region, Ghana. IWAD Irrigation Project is located in the Mamprugu-Moagduri District, specifically Yagba which is the District capital (Yagba is one of the New District in the Northern region). IWAD targeted to improve CLI in the mixed farming in the area to enhance agricultural productivity.

The study acknowledges that during the dry season, water bodies receive huge livestock of sedentary and migratory (nomadic herdsmen) Fulanis to access watering points and fodder for their livestock in the study area. Obviously, the livestock impacts negatively on the water bodies as well as on the agricultural land (FAO, 2017). Besides, nomadic herdsmen increase the risk of crops and livestock diseases outbreaks (Boateng, 2016). These increase general cost of production such as high veterinary costs and mortality rate. As nomads, they need to sustain their lives and they do so by engaging in maize cultivation in addition to the herding business and milk marketing (Boateng, 2016). The Fulani herdsmen therefore explored strategies to fully benefit from crop and livestock production by practising CLI. The effect of nomadic herdsmen, therefore merits keen study. However, such analysis is beyond the scope of this study. Instead the study focuses only on the sedentary Fulani herdsmen in the study area throughout the period of the study. Furthermore, the study is limited to only Mamprugu-Moagduri District in the Northern Region of Ghana. Institutions such as IWAD, as well as the indigenes engaged in crop and livestock production are not covered in the study.

1.6 Organization of Thesis

The thesis is organized into five main chapters. The first chapter captures the background to the problem under study and state the problem and research questions. Furthermore, it contained the main and specific objectives of the study; a justification for the study; scope and limitations, as well as how the study is been organized. The second chapter provided literature review, related to the study. The third chapter is devoted to the methodology where the theory, the study area, sampling techniques, mathematical and empirical bases of the study are explored. Whiles chapter four cover the results and discussion of the findings of descriptive statistics and treatment effect models, the final chapter cover the summary, conclusions and recommendations of the study. References and appendices to support this research then follow.

CHAPTER TWO

LITERATURE REVIEW

2. 1 Chapter outline

This chapter reviews literature on the determinants and effects on maize production. The specific sections include maize production, significance of livestock production, livestock and the environment, concepts of CLI and the role of policy in CLI. These are followed by the theoretical framework which comprises random utility and adoption/ diffusion of innovation theories. The chapter ends with the determinants of CLI in the mixed farming system and conceptual framework of the study.

2.2 Maize Production and Its Importance in Ghana

Maize is an important food commodity crop in Ghana. It accounts for more than 50% of the country's total cereal production (Ragasa *et al.*, 2014) and is grown in all agro-ecological zones (Akramov & Malek, 2012). Maize has been a dominant food crop in Ghana for several hundred years. Since the introduction of the crop into Ghana in the late 16th century, it has established itself as an important food crop in the country (Morris *et al.*, 1999). The Ghana government, Non-Governmental Organisations and other stakeholders have made major investments to improve maize productivity (Ragasa *et al.*, 2014). Regardless of these efforts, the average maize yield in Ghana is still low. For instance, the productivity of maize has been growing by only 1.1% per annum in Ghana. Maize productivity in Ghana averaged 1.2–1.8 metric tons per hectare, in 2012. This is far below the potential yield of 4–6 metric tons per hectare realised in on-station trials (Ragasa *et al.*, 2014). Poor agricultural innovation and or technology adoption (CLI), market participation, poor policies, agricultural research and extension services explain the persistently low productivity of maize in the country.

There is high demand for maize as result of the rapid population growth, urbanization and livestock sectors in Ghana (Ragasa *et al*., 2014). According to Hurelbrink & Boohene (2011), livestock, mainly the poultry industry's demand for maize, is estimated to grow by 10 % annually between 2000 and 2009 and would have exceeded 540,000 metric tons if birds feed a proper ration. Per capita consumption of maize, specifically white maize, grew only slightly from 38.4 kg in 1980 to 43.8 kg in 2011 (MoFA, 2012). Without maize productivity enhancements, Ghana's MoFA estimates that 267,000 metric tons of maize will be imported in 2015 to meet domestic demand (FAO, 2013). For this reason, the crop (maize) is regarded as the most important food security crop. The question is whether CLI leads to increase maize output which this current work seeks to answer.

2.3 The Significance of Livestock Production

The livestock sub-sector in agriculture in Ghana cannot be overlooked. Many products of livestock are consumed at the household level to reduce malnutrition. For instance, large quantities of livestock products such as meat, milk and other dairy products are imported each year to partially meet the demand and supply of animal protein of people (Ragasa *et al*., 2014). As in 2013, a total of 21,131, 16,728 and 16,953 for cattle, sheep and goats respectively, were imported into the country to meet the demand for meat and dairy products (MoFA, 2014). For instance, in 2010, the total amount of milk products imported into Ghana to meet the demand was 28,267.5 metric tonnes (Gidiglo, 2014). Furthermore, dairy products (milk, cheese and yogurt) are the second highest imported each year, representing 30% in 2013 into the country (MoFA, 2014).

Livestock rearing plays multiple purposes in agro-pastoral economy and social security. It is a livelihood strategy to farmers in Northern Ghana in addition to crop farming (Blench, 2006 & Adam & Boateng, 2012). The livestock rearing in the region is dominated by sedentary and migratory Fulani for whom livestock constitutes the sole means of livelihood. The total cattle population in the country is about 1,543,000 and its contribution to agricultural gross domestic product (GDP) is estimated to be GH₵ 1,832 (GSS, 2016). Currently, the demand for livestock is estimated to be 127,038 metric tons of which cattle share 21,221 metric tons in Ghana (MoFA, 2013).

Livestock production is a source of wealth generation, income enhancement and improvement in rural livelihoods (MoFA, 1990) as well as social status. It is another major sector in agriculture which is considered as having a potential for employment generation and poverty reduction for resource poor farmers (Picca, 2008 & Leonard, 2006). Livestock rearing increases household income, mostly for the resource poor farmers and food security in rural areas as well as insurance against food deficit during prolonged drought periods. It also aids farmers to purchase conventional inputs for crop cultivation (Asafu-Adjei & Dantankwa, 2001). Livestock rearing also serves as financial security during crop failure, economic stress, disasters, and ethnic conflicts (Terril, 1985).

The livestock production industry in Ghana is basically composed of small-scale enterprises such as cattle, sheep and goat production (Baiden & Duncan, 2008). Livestock, specifically cattle, provides draught power for tillage, manure and transport farm inputs in crop production. Livestock rearing is a method for poverty reduction strategy to smallholder farm households in the developing countries where the farmers are generally poor and have poor purchasing power for chemical fertilizers for soil fertility maintenance (Omolehin *et al*., 2007). It offers an opportunity to promote organic farming and conservation agriculture that aim to achieve adequate profits and sustainable level in production. Livestock and the environment interact with each other in production to meet human needs.

2.4 Livestock Production and the Environment

In Ghana, declining nature of agricultural ecological system need to be reverse. CLI is a prerequisite for an enhanced production both present and future generations and the maintenance of ecosystem integrity (MoFA, 2010). The interaction of the livestock and the environment has positive or negative impacts. The positive impacts comprise of improvement of soil fertility management linked with the use of livestock manure on agricultural land. CLI enhances biodiversity and serves as a potential for alternative use for energy. On the other hand, the negative impacts include water and air pollution, and damage of biodiversity related to overgrazing on the agricultural land.

Climate change and variability is a major threat to national agricultural development and it manifests in increasing levels of desertification in the Northern Savannah. It undermines the agriculture potentials and the economic viability of the Northern ecological zone and its capacity to contribute to national development (NDPC, 2014). The livestock sub-sector has not been well recognised as a contributor to global warming. But it is one of the most significant contributors to the most serious human-induced greenhouse-gases (Ragasa *et al.,* 2014). Random grazing of livestock, mostly by Fulani herdsmen and pastoralist in the Northern Savannah zones of the country reduces the carrying capacity of the rangelands and causes soil erosion and land degradation. It is estimated that a total of 26,307.5 hectares of grassland is destroyed through bushfire annually in Ghana (FAO, 2015). This discharges large volumes of carbon dioxide into the atmosphere thereby reducing additional forage available for livestock grazing (Ragasa *et al.,* 2014). Similarly, livestock farming shares water resources with people in some rural farming communities as a result of water scarcity. The outcome of this is water pollution. In addition, high temperature of the environment that pertains in the extreme north of the country impairs livestock production such as reproductive performance and health status (Ragasa *et al.,* 2014).

Insufficient and irregular rainfall pattern as a result of climate change affects forage and crop production, and ruminant/non-ruminant production. This could lead to shortage and high cost of feed. Methane gas produced in the digestive system of ruminants and to lesser extent non-ruminants as a result of enteric fermentation in Ghana in 2012 amounted to 380,680 gigagrams (FAO, 2015). Livestock farms which are sited within or near to settlements cause nuisance to the communities since the wastage emanating from the farms is not properly managed (Ragasa *et al.,* 2014). The consequence of this is environmental pollution and unhygienic environment in the communities. Hence, the environmental impact on livestock and vice versa can be mitigated by promoting CLI in the country and globally at large.

2.5 The concept of CLI and the role of livestock

Agricultural diversification can be regarded as the re-allocation of a farm's productive resources, such as land, capital, crops, animals and farm equipment to other farms. According to Petit and Barghouti (1992) agricultural diversification simply means the rotation of crops and animals on the farming land to meet the growing demand for food. Furthermore, agricultural diversification refers as growing alternative crops, rearing different kinds of animals to meet farm household demand (Joshi *et al.*, 2006). According to Asante *et al*. (2017) CLI simply refers to the production of more than one crop and livestock with available resources to increase productivity. It also refers to the combinations of crops and animals in agricultural production (Iiyama *et al.*, 2007). CLI which is use of livestock manure on farm fields and use of crops residue to feed livestock in the mixed farming system occurs interdependently rather than independently on the farm. For the purpose of this study, CLI is a mixture of crops and animal farming simultaneously in the same agricultural farmland. Application of livestock droppings (manure) to crops and the use of crop residue to feed livestock are one of the indicator of better integration. The survey was conducted based on if a farmer owned cattle and also used the crop residue to feed the animals as well as used the animals' droppings in the farm plots.

There are various ways of interactions between crops and livestock components of mixed farming systems during the intensification practice (Kristjanson & Thornton, 2004). Safeguarding sustainable intensification and economically profitable integration of crop-livestock farming to meet the wellbeing and environmental goals of people is vital (Place *et al*., 2003 & Makinde *et al.,* 2007). Efficient application of CLI would not only contribute to income generation but would also lead to higher crop productivity and better environmental health through nutrients recycling in the soil without relying on external resources (Iiyama, 2007). Hence, CLI is done to recycle resources efficiently.

CLI has been practiced by peasant farmers over centuries in Ghana. Smallholder farmers in the country have integrated their farming activities to include various food crops and local animals to increase productivity. According to Asante *et al.* (2017) there are some complementarities in this system of farming in Ghana. For example, crop residues or biomasses are mainly used to supplement livestock feeding, particularly during the dry season. Mostly, in regions where dryness is characterized by patches of sporadic bushfires like the Northern Region, the use of crop residues acts a significant role in livestock rearing in the dry season. Likewise, livestock manure is used as substitute for chemical fertilizer on most agricultural farmland in Ghana, especially among the rural poor.

The major crops integrated with livestock in Ghana are cowpea, groundnut, soybean, rice, millet, sorghum and maize (Asante *et al*., 2017). The category of animals in this system of farming are cattle, sheep, goats, pigs and poultry (Karbo & Agyare, 2002). The integration of these crops and animals in the farming systems improves income and food security. In terms of income security, cattle, goats, sheep and poultry are highly marketable and can easily be converted into money to support household expenditure while some of the animals and the crops are consumed at the household level to balance the nutritional requirements. The demand for animals is high during festival periods because these category of animals are used for socio-cultural purposes during festivals and other traditional events (Asante *et al.* 2017). Conversely, the priority to handle a particular kind of animal of farm household varies and also depends on their capacity to manage the animals. For example, a classic farmer in the mixed farming in Ghana keeps at least sheep, goats or cattle, or combination of these animals, in addition to the cultivation of the major cereal and leguminous crops. The main purpose of cultivating the cereal and leguminous crops are consumption at the household level, but the crop residues are used to feed animals after harvesting (Asante *et al*. 2017). Therefore, crop cultivation and livestock rearing should not be treated independently in agricultural production system. Hence, specialization in agricultural production should be shifted towards crops and livestock integration.

2.6 The Role of Policy on CLI

Sound policy and institutional framework play significant role in influencing crop-livestock and environment interactions by offering incentives for sustainable utilization of natural resources (Gumpta, 1995 & Mearns, 1996). Policy and technological opportunities have been used to enhance environmental protection among crop-livestock farmers in India (Cornner, 1996).

Governments and civil society organizations have a role to play to ensure economic agents such as smallholder farmers practice CLI through sensitization and education on the importance of CLI in sustainable agricultural farming. Policy should gear towards investment in crop and livestock production to mitigate the climate variability effect on agricultural productivity. Policy should also target protection farm households' property rights such as land ownership and use, access to farm inputs, agricultural extension services, production credit and stability of farm output prices. These promote adaptation and adoption of a new technology.

2.7 Theoretical Framework

The random utility, adoption and diffusion theories form the theoretical framework of the study.

2.7.1 Random utility theory

The Random utility theory is all about 'choosing an alternative that is best with respect to a person beliefs and desires of the alternatives (Anand, 1993). Anand (1993) stated that utility theory plays a greater role in decision to make a choice. Another way to present utility theory is about maximizing utility subject to the 'attributes' of an agent or rather than decision maker. There are many theories about utility including the one by Ben-Akiva & Lerman (1985). Ben-Akiva & Lerman (1985) categorize utility theory into two possible ways which include: constant utility and random utility respectively.

Constant utility refers *to* the utilities where alternatives are fixed. In this approach, the decision maker chooses the alternative with the highest utility, but it is assumed that there are choice probabilities involved. The random utility is the opposite to that of the constant utility (Wittink, 2011).

The random utility theory, which is equivalent to consumer theory, is used for this study. There are three hypothetical assumptions made in choice theory or random utility theory (Wittink, 2011). First, the attraction or utility towards an innovation varies across individuals as a random variable. In Thurstone's Law, it is discriminal dispersion and assumes it is normal. Hence, using the term utility, is being consistent with economic theory. Second, the consumer chooses an innovation if the expected utility is high and this makes a consumer an economically rational being and third, the choice is a discrete occurrence. The implication is that choice is all-or-nothing. The consumer as a rational social being cannot abandon an innovation with expected high benefit and chose a low expected benefit. They will tend to adopt innovation (CLI) if the expected benefit is high or otherwise. Therefore, choice is not a continuous dependent variable.

Discrete choice models in economic lens are built on random utility theory (Train, 2007). An individual, as a decision maker, faces alternative choices and constraints in relation to the uptake of innovation. Decision agents, in this model are assumed to be utility maximizers confronted to choose among **j** alternatives (Train, 2007). In this case, each alternative is related to a diverse level of utility. Among the alternatives, individual i chooses the package with highest utility taking into account constraints they face including their budget constraint (Mas-Colell *et al.*, 1995). In this study, farmers will adopt an innovation (CLI) when they perceive that the utility is much greater than if they do not adopt it (i.e. when they do the crop production and animal rearing independently).

Indirect utility in the consumption theory measures the maximum utility that a decision agent achieves offering a specified price level and constraints (Mas-Colell *et al.*, 1995). Hence, indirect utility is the basis for analysis in the study. Following the random utility theory, indirect utility has two components which include: a deterministic component and a random (unobservable) component. This can be presented as:

$U_{ij} = V_{ij} + \varepsilon_{ij} \quad where \; V_{ij} = X\beta_{ij}$ …………………………………………..2.1

V_{ij} is the deterministic utility related with individual i and alternative j, X is a matrix of independent variables with the corresponding parameter vector β to be estimated, and ε_{ij} is the random component. The exogenous variables (X), describe socioeconomic characteristics of household and these are identical across alternatives for an individual but vary between individuals. The probability that individual i desires alternative j over k because it provides higher utility is presented as:

$\mathrm{Pr}ob(U_{ij} > U_{ik}, \; \forall_{ij} \neq k) = \mathrm{Pr}ob[(U_{ij} - U_{ik}) > (\varepsilon_{ik} - \varepsilon_{ij}) \; for \forall_j \neq k]$ …….2.2

According to Greene (2012), if the error terms are independently and identically extreme value distributed with Gumbel (i.e. type 1 extreme value) distribution

$F(\varepsilon_{ij}) = e^{-e^{-\varepsilon_{ij}}}$ ………………………………..2.3

Then equation 2.3 is transformed into a probability that an individual i goes for alternative j as:

$\mathrm{Pr}\,ob(Y = j / X) = \exp(X\beta) / \left[\sum_{i=1}^{j} \exp(X\beta) \;\; where \; j = 1, 0 \right]$ ……………………2. 4

The decision of the individual is best described by the utility index (Y^*) for two alternatives and can also be presented as:

$Y^* = X\beta_{ij} + \varepsilon_{ij}$ ……………………………………..………. 2.5

Where $Y = \begin{cases} 1 \, if \; U_{ij} \geq U_{ik} \\ 0 \; otherwise \end{cases}$.

Here, y = 1 is designated as an individual household who adopts CLI and y = 0 describes an individual household who does not adopt CLI.

Equation (2.4) is estimated by means of maximum likelihood procedure to determine how various factors affect the likelihood of adopting CLI.

2.7.2 Adoption and diffusion innovation theory

One of the major objectives of the study is to examine the factors influencing farmers' decision to practice CLI. One cannot discuss adoption of CLI without diffusion and innovation concepts. Diffusion and innovation have a direct link to adoption of any technology (in this case CLI). Hence, this section highlights the adoption and diffusion of agricultural innovation theories. The major theories reviewed are concept of innovation/technology, adoption and diffusion, perceived attributes of innovation, the S-curve and rate of adoption, adoption process and adoption categories.

2.7.2.1 Innovation and technology

Innovation is not just conceiving ideas but the process of translating the new ideas into enhance productivity. The process of incubating and hatching an idea to create goods and services to uplift productivity refers as innovation. On the other hand, technology is the application of scientific knowledge to increase productivity. Technology simply refers to an innovation that is perceived as new and executed that helps to increase productivity (Roberts, 1988 & Edosomwan, 1991). This means that innovation and technology can be used interchangeably. Innovation such as CLI methods has been known to the farmers for centuries. Perhaps it has only been improved by researchers and disseminated back to the farmers. Farm households should also be self-motivated to adopt the innovation to increase agricultural productivity.

2.7.2.2 Adoption and diffusion of innovation

Adoption simply refers to the decision to accept and practice a new technology fully by a farmer or consumer based on their utility, while and diffusion is used to describe how technology or innovation spreads to the end beneficiaries in a society (Feder *et al.*, 1985). In other words, while adoption refers to the stage or steps in which technology is carefully chosen for use by an individual or an organization, diffusion refers to the stage in which the technology spreads to general use and application through a particular channel. Improving agricultural innovation like CLI and diffusion it to farmers enhances the innovation adoption.

Generally, there are quite a lot of disciplines that have looked at adoption and diffusion in different dimensions. For instance, sociologists describe technology adoption and diffusion as full acceptance of technology through a particular media channel often referred to as communication networks. In economics, technology adoption and diffusion are defined in relations to profitability (Abdallah *et al.,* 2014). Researchers including McConnell (1983), Norris & Batie (1987), Ellison & Fundenberg (1993), Marra *et al.* (2001), and Swinton & Quiroz (2003a; 2003b), had highlighted the economic theory underlying farmer behaviour in decision-making over adoption and diffusion of technologies. Production theory was used in adoption and diffusion of innovation where a farmer's main objective is to maximize profit (McConnell, 1983). Norris & Batie (1987) also used household model based on utility maximization for adoption and diffusion of technology.

The decision to use an innovation such as CLI, is not one event but it involves a gradual process (Das-Gupta, 1989). In some other circumstances, especially with environmental innovations farmers may hold awareness and knowledge but because of other socio-economic and institutional factors affecting the adoption choice stages, adoption does not fully materialize (Ray, 2001). In this case, adoption of innovation in farmers' farm environment is not permanent (Das-Gupta, 1989). The implication is that the determinants of the uptake of agricultural technology such as CLI are location and time-specific. Donkoh and Awuni (2009) also explained that adoption of technology takes place only in long run equilibrium when a farmer has complete information about the technology and its potential benefits. In this case, full adoption and potential benefits of CLI could be realized if farmers have full information about CLI and its potentials.

Formerly, adoption and diffusion of technology were undertaken by rural sociologists to examine how humans react to technology uptake (Feder *et al.*, 1985). Their studies serve as a foundation for economics and for that matter econometrics studies. Some rural sociologists who studied adoption and diffusion behaviours of human attitude were Ryan & Gross (1943) and Rogers (1962). Some of the studies on economics and econometrics of technology adoption were conducted by Mansfield (1961 & 1968) and Griliches (1957). For instance, Mansfield (1961, 1968) conducted an empirical study on "technical change and the rate of imitation" and "industrial research and technological innovation" while Griliches (1957) conducted a study on adoption of hybrid corn by "exploring the economics of technical change". These studies gave a better preliminary idea for examining the progress and development in technology diffusion theory. Nevertheless, what these studies jointly had in common was that in most developed and developing countries, diffusion of technology was an S-shaped. The implication is that anytime a technology is first released, only a few farmers adopt it. As time goes on, the number of potential adopters' increases and later declines, causing the rate of adoption to fall. At this point, the technology adoption would have reached its threshold point. In most cases, the ceiling is reached before all the agents (in this case, CLI farmers) would have adopted the technology (Donkoh & Awuni, 2009). For those who did not make decision to adopt, there may be several socio-economic and institutional factors that influenced their decision to adopt and the rate of technology adoption among economic agents (rate of diffusion) initially increases and finally decreases, the curve taking an S-shape.

2.7.2.3 Perceived attributes of innovation and rate of adoption

Rogers' (2003) model of the diffusion of innovations was influenced by the work of Ryan and Gross (1943) who studied the adoption of hybrid seed technology in two Iowan farm communities in the United States. Since this study, the diffusion of innovations theory, and specifically Rogers' model of adoption and diffusion, has spread across many disciplines in terms of technology uptake. Researchers who study the adoption of innovations behaviours often utilized Rogers' (2003) "diffusion of innovations" model to get the understanding on how innovation adoption occurs (Oliver and Goerke, 2008; Tabata & Johnsrud, 2008).

The attribute of an innovation is a piece of information or inherent characteristics of the innovation in relation to the field of study. Rogers (1983) identified five attributes of innovations, which are said to be mutually exclusive and universally relevant to all units in a society. These attributes include relative advantage, compatibility, complexity, triability and observability. Twenty years later Rogers redefined the attributes of an innovation which includes relatively advantageous (over ideas or practices they supersede), compatible with existing values, beliefs, and experiences, relatively easy to comprehend and adapt, observable or tangible, and divisible (separable) for trial (Rogers, 2003). These perceived characteristics contribute to innovation is not different from CLI. These innovation attributes can either enhance adoption of CLI or dis-adoption of CLI.

Relative advantage simply refers to the extent to which an improvement of innovation is observed to be better in economic terms than the idea it naturally existed in an earlier history. According to Rogers (1983), the degree of relative advantage is habitually communicated in terms of economic profitability, social prestige, or other relevant economic benefits. The relative advantage of the innovation is important to adopters, even though the psychic and characteristics of the potential adopters also affect the sub dimensions of relative advantage. For instance, CLI has relative advantage in terms of soil fertility management and fodder for animals and this makes CLI widely practiced by farmers.

Compatibility of an innovation refers to a magnitude to which an innovation (CLI in this case) is perceived to be consistent with the existing values, norms, historical experiences and desire of potential users of innovation. Any innovation that is more compatible is less indeterminate to the potential adopter, and fits more closely with the individual's circumstances. Compatibility of an innovation assists individuals to be well informed of the new idea that it is regarded as familiar. Rogers (1983) maintained that an innovation can be compatible or incompatible with (1) sociocultural values and beliefs, (2) previously introduced ideas, and (3) client needs for the innovation. The more compatibility any innovation to potential adopters is, the greater the likelihood of its adoption (Rogers, 1983).

Furthermore, if a technology is perceived as difficult to be understood and used it is termed complex. Naturally, an innovation can be either complex or simple. Some innovations are simple to potential adopters whereas others are not. The complexity of an innovation, as perceived by members of a social unit, is negatively related to its rate of adoption even though research evidence is uncertain (Rogers, 1983).

Trialability of an innovation refers to an extent to which an innovation is practically demonstrated on a limited scale. An innovation that has been experimented in the social system environment is generally adopted more rapidly than innovations that are never experimented before (Rogers, 1983). The personal involvement in experimenting an innovation is a way to offer well-meaning to an innovation adoption. According to Rogers (1983), the trialability of an innovation, as perceived by members of a social system, is positively related to its rate of adoption. Gross (1942) and Ryan (1948) argued that earlier adopters of an innovation perceive trialability as more important than later adopters.

Finally, the extent to which the outcomes of an innovation are observable to individuals or society is referred to as observability. An outcome of an innovation is easily observed and conveyed or spread to others via communication networks. The observability of an innovation, perceived by members of a social group, is positively linked to its rate of adoption (Rogers, 1983). Agricultural innovation like CLI if practically observe by other farmers who are not practically involve in an innovation demonstration spread the innovation to their colleagues through farmer to farmer extension. This promotes adoption of the innovation. Hence, the perceived attributes of an innovation (CLI) are important factors influencing the rate of adoption of an innovation.

2.7.2.4 Innovation adoption process

Adoption process involves systematic steps in which an innovation is fully accepted and used by individuals or society to improve output in production. Hence, adoption of CLI occurs through a succession of communication channels over a period of time among the members of similar social characteristics in a society. In diffusion theory, decision-making to adopt CLI passes through five stages which outlined by Rogers (2003) as:

- Knowledge- The target group or individual is first exposed to an innovation (CLI) and must learn about it, but lacks information about the CLI. At this stage, the individual has not yet been inspired to find out more information about the CLI;
- Persuasion-The individual develops keen interest in the CLI and actively seeks related information/details. In this case, the target group must be persuaded on the value of the CLI;
- Decision-The individual takes the concept of the change and weighs the merits and demerits of adopting the CLI and decides whether to adopt or reject it. This stage

takes much longer time which makes uptake of an CLI by farmers very slow (Rogers, 2003);

- Implementation-The individual adopts CLI to a varying degree depending on the circumstances. During this stage, the individual also determines the usefulness of the CLI and may search for further information about it; and
- Confirmation –this is the stage the individual finalizes his/her decision to adopt and continues using the CLI or otherwise. This stage is both intrapersonal (i.e. may cause cognitive dissonance) and interpersonal, and it confirms that a group has made the right decision.

Later, Rogers (2003) changed the terminologies of the five stages of adoption into; awareness stage (the individual learns of a new CLI); interest stage (the individual develops an interest in the CLI; evaluation stage -the individual makes a mental application and seeks information about it; trial stage- (the individual tries the idea on a small scale in his/her own situation; and adoption stage-the individual uses the new or improved idea (CLI) continuously on a full scale. An individual might accept or reject CLI at any time during or after the adoption process.

However, the descriptions of the stages of adoption have remained similar throughout the editions.

2.7.2.5 Adoption categories and S-curve normality of adoption

Another important and influential idea discussed by Rogers (1962) is the concept of adoption categories. According to Rogers (1962), adoption category can be classified based on individuals within a social system and individual innovativeness. Rogers (1962) suggested that a total of five categories of adopters naturally emerge in diffusion research. Therefore, as indicated earlier, the adoption of an innovation resembles an S curve or bell-curve when plotted over an interval of time (Fisher, 1971). In the adoption theory, there are five categories of adopters which are: innovators, early adopters, early majority, late majority and laggards (Rogers, 1962).

The innovators are those who readily adopt an innovation and make up about 2.5% of any population. The innovators are willing to take risks and also have the highest social status in a community, Rogers (1962) lamented. They are financially stable, socially respected and have closest contact to scientific research centers or agents and have interaction with other innovators. Their risk acceptance allows them to adopt technologies that may ultimately fail. But their financial resources help absorb these failures (Rogers, 1962).

Early adopters make up approximately 13.5% of the population. These individuals in the population have the uppermost degree of opinion leadership among the technology adoption categories. Early adopters have an advanced social status, financial liquidity, attained higher educational level and are more socially advanced than late adopters. They are more discreet in adoption decision than innovators. They make careful decision about technology adoption which helps them maintain a fundamental communication position that helps increase productivity (Rogers, 1962).

Most people fall into Early Majority (34%) and Late Majority (34%) adoption categories. According to Rogers (1962), the early and late majority adopters of an innovation have average social status and do not often hold leadership positions in a society (Rogers, 1962). The late majority category adopts an innovation after the average participation in innovation project in a society. These individuals target an innovation with a high degree of uncertainty and after the majority of society have adopted the innovation. The late majority adopters typically have below average social status, little financial liquidity, in contact with others in late majority and early majority and little opinion leadership.

‘‘Laggards”, are those who resist an innovation until the better end and comprise of about 16% of the population. These individuals have an aversion to research change-agents. According to Rogers, laggards typically tend to be focused on “traditions”, and they have lowest social status, lowest financial liquidity, old age group among adopters. Laggards are only in contact with family and close friends. They are risk averse making them adopt an innovation in slow pace. The concept of adopter categories is important because it shows that all innovations go through a natural, predictable, and sometimes lengthy process before becoming widely adopted within a society (Rogers, 1962). The figure 2.2 illustrates adoption categories and rate of adoption. In the figure, the blue line represents successive groups of people adopting the new technology and its adoption rate while the yellow line shows the saturation level. In mathematical concept, the yellow curve represents as logistic function or cumulative function which expresses cumulative percentage of adopters over time. That is, it slows at the start, more rapid as adoption increases, then leveling off until only a small percentage of laggards have not adopted (Rogers, 1962).

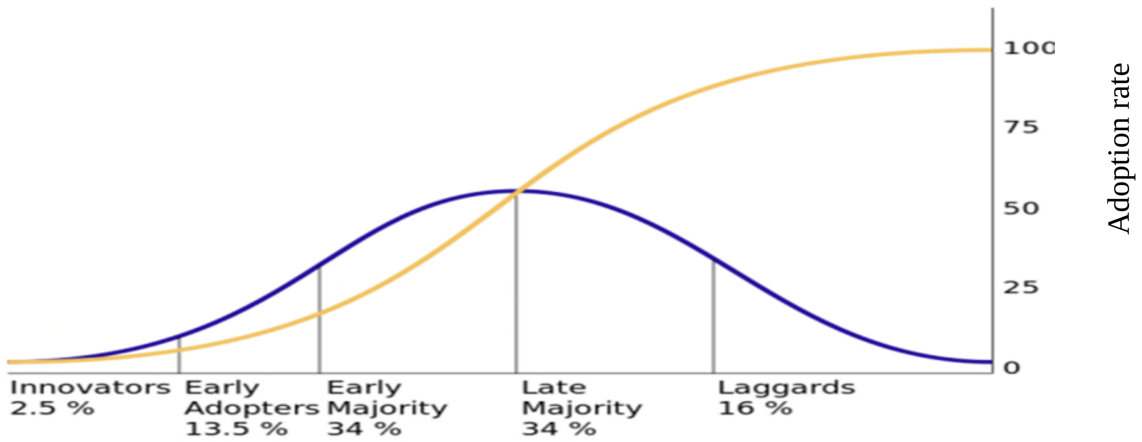

Figure 2. 1: The category and shape of adoption curve

Source: Rogers (2003)

2.8 Theoretical Underpinnings

There are many methodological techniques used to estimate agricultural diversification or other enterprise integration in business organization in a given time and space. Each technique has unique merits and demerits. Most of research methods employed many researchers for enterprise integration include Herfindahl index (HI), Ogive index and the Entropy index and its associated adjustments (Kelley *et al.,* 1995, Chand, 1996, Pandey and Sharma, 1996 & Joshi *et al*., 2006). In addition, Tobit, probit and Heckman two stage models have been extensively used to examine factors that influence technology adoption and the effects. This section provides a step-by-step explanation on how the objectives 3 and 4 were analysed respectively.

2. 8. 1 Herfindahl Index

The Herfindahl-Hirschman Index, better known as the Herfindahl Index (HI) is a statistical tool used to measure agricultural diversification and concentration of business (Rhoades, 1993). This statistical tool is widely used in measuring market concentration in the industrial organization sector (Scherer, 1980). However, it has been used as a measure of economic diversity in production (Tauer, 1992). The HI indicates the extent to which enterprise diversification in a particular economy is dominated by a few firms (Tauer, 1992). It simply refers to the sum of the squares of the enterprise diversification of a firm within production industry (Saxena, 2011). The HI can be simple, expressed as:

$$HI = \sum_{i=1}^{n} S_i^2 \qquad \text{…………………………………………….. 2.6}$$

where S_i is the share of enterprise diversification in the *ith* firm and *n* is the total number of enterprise diversification. That is number of crops and livestock integrating in the mixed farming system. The result is proportional to the average enterprise diversification, weighted by enterprise diversification. HI ranges from zero (0) to one (1). A zero value indicates specialization and a movement towards one shows an increase in the extent of enterprise diversification (Malik & Singh, 2002). The HI value increasing means that there is a more enterprise diversification and or integration whereas decreases indicate the opposite. Thus, the smaller the index value, the greater the specialization; and a bigger index value indicates greater diversification.

The advantage of HI is that more equal distribution of crops and livestock among a large number of farmers means higher level of economic or livelihood diversity. Also, its computation is simple. However, the limitation of this index is that it does not tell whether the total number of crops and livestock integration is increasing or decreasing. For instance, increased integration may come with a decrease in total crops and livestock productivity, which may not be a desired outcome. Another criticism of the HI highlights its potential to lead to wide measurement errors (Toby, 2014). Furthermore, HI is used when the enterprises are many but not limited to two alternative choices. It also fails to measure the effect of CLI on crop output. Hence, this statistical tool is not qualified to be used for analysis in this research work.

2.8. 2 Ogive and Entropy Indexes

Under the Industrial Organization Theory, a more diversified enterprise is assumed to be more competitive (Scherer, 1980) and so that of CLI. Farmers with greater numbers of crops and livestock engage in production that are associated with higher integration/diversity (Malizia & Ke, 1993). As a result of this, agricultural diversification ratios, such as the Ogive and the Entropy Indices have been used as measures of enterprise diversity (McLaughlin, 1930 & Tress, 1938). Ogive Index of enterprise diversification can be constructed as follows:

$$Ogive\ \ index = \sum_{i=1}^{n} \frac{(S_i - 1/n)^2}{1/n} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ 2.7$$

n is the sample size and S_i is the total number of crops and livestock in production. The more equally the number of crops and livestock in production is distributed among farmers, the greater the diversity (Rodgers, 1957). With the sample size, an equal distribution implies that S_i is equal to 1/N. The Ogive Index equals zero means perfect diversity and vice versa. Following Smith and Gibson (1988), the Entropy Index of Enterprise Diversification can be well-defined as:

Entropy index $= \sum_{i=1}^{n} S_i In\left(\frac{1}{S_i}\right) = -\sum_{i=1}^{n} S_i In(S_i)$ ……………………………… 2.8

Where In is the natural logarithm and n and S_i are as defined. The Entropy measure compares the existing agricultural diversification among farmers to proportional distribution. Higher Entropy Index values mean better diversification, while lower values mean more specialization in production. The minimum value of zero indicates maximum specialization and vice versa. Even though both Ogive and Entropy Indices yield similar economic activities in the interest of diversity to farmers, the Entropy Index is the more popular in measuring enterprise diversification.

The limitations of these indices are: (1) the inability of indicators to acknowledge certain qualitative characteristics of the agricultural diversification in agricultural sector such as livelihood diversification structure stability, the level of diversification differentiation, the height of entry barriers and operating cost among others. Furthermore, these indices do not include agricultural tradition, as well as features and objectives of farm managers (Maksimović &Kostić, 2012); (2) the value of farm household or farm characteristics may have different economic meaning in relation to agricultural integration (Maksimović & Kostić, 2012); and (3) this is only suitable for many enterprises. But in this study, there are only two enterprises involve, that is crop and livestock integration in the farming system Therefore, these indices are not appropriate for the analysis.

2.8. 3 Tobit Regression Model

In principle, the decision on whether to adopt any innovation can be either made jointly or separately. Tobit Model is used to estimate joint decision to adopt enterprise diversification (Keelan *et al.*, 2009; & Wan and Hu, 2012). According to Greene (1993), anytime two decisions (in this case adoption CLI) are made jointly, the best candidate in determining factors influencing adoption of CLI is Tobit Model. Tobit Regression Model assumes that all farmers deciding to adopt CLI and observation value of zero in the sample farmers is termed as "corner solution". But the decisions to adopt CLI are not jointly since farmers would first decide whether or not to adopt the CLI, and then decide the extent of adoption of CLI. According to Asante *el al*. (2017) using Tobit Regression Model to estimate the joint decision to adopt enterprise diversification (in this case CLI) separately, may lead to confounding policy implications. This would also lead to several counting of enterprise diversification (Waithaka *et al.*, 2007). The standard Tobit Regression Model assumes, other things been equal, that the dependent variable is censored at zero. The standard Tobit Regression Model is inappropriate if no censoring has occurred or if censoring has occurred both not at zero (Greene, 2005). Lin & Schmidt (1984) explained that this assumption has been condemned since a rational being make decisions at different stages at the same time. Using Tobit would yield bias estimates due to sample selection. Therefore, using Tobit Regression Model is not appropriate.

2.8.4 Probit Regression Model

Mostly, studies on adoption uses Probit or Logit Models to investigate the factors that affect the adoption of a new technology or innovation where the dependent variable (adoption) is binary. The Probit regression Model is one of the generalised regression models of binomial choice. For example, one may demand to know, the relationship between farm households' adoption or non-adoption of CLI and socio-economic and institutional factors influencing such adoption. Ideally, in the CLI, some households cultivate crops and rear livestock at the same time and also trade off the resources of the crops and the livestock within the system while others do not. This means that there are two categories of respondents. That is adopters and non-adopters, leading to a dichotomous response.

The Probit Regression Model (which is similar to Logit) allows for estimating these dichotomous decision-making with regard to technology adoption states. The aim of this Model is to estimate the probability that an observation with a particular characteristic falls into either zero or one. In Probit Regression Model, the adoption is unobservable, what we observe is the dummy variable which indicates whether a farmer adopts or does not adopt a given innovation (CLI). The Probit Regression Model assumes that a farmer's decision to adopt a technology depends on the utility index (Ii), that is determined by one or more explanatory variables such as extension, in such a way that the larger the value of the utility index the greater the probability of a farmer adopting a technology. Mathematically, the Probit/Logit can be presented as:

$$CLI\ (A_i) = \beta' X_i + \varepsilon_i \quad \text{……………………………….. 2.9}$$

Where A_i represents a dichotomous choice variable. Beginning with the dichotomous response variable A^* (utility index);

$$A_i^* = \beta' X_i + \varepsilon_i \quad \text{……………………………………….. 2.10}$$

Where X_i is a vector of independent variables that might influencing A_i, β' is a vector of parameters to be estimated and the ε_i is the stochastic term. In technology adoption, $A^*$is not virtually observed and instead a dummy variable is observed. This can be well-defined as:

$$A = \begin{Bmatrix} 1 \; if \; A_i^* > 0 \\ 0 \; if \; A_i^* \leq 0 \end{Bmatrix} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2.11$$

In terms of the respective probabilities, they $(A \; and \; A^*)$ represent $-\beta' X_i$ and $1 - \beta' X_i$ respectively. For this reason, $\beta' X_i$is no longer $E\left({}^{A_i}/_{X_i}\right)$as it indicated in OLS model but $E\left({}^{A^*}/_{X_i}\right)$. Based on equation 3.6 and 3.7, the probit model for adoption can be represented as:

$$prob(A = 1) = prob(\varepsilon_i > -\beta' X_i) = 1 - F(-\beta' X_i) \ldots\ldots\ldots\ldots\ldots\ldots 2.11$$

F is the cumulative distribution function of the stochastic term ε_i. Based on the probabilities given in equation 2.12, the likelihood ratio function (L_f) can be presented as:

$$L_f = \prod_{A_i=0} F(-\beta' X_i) \prod_{Y_i=1} [1 - F(-\beta' X_i)] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2.12$$

The probit model assumes that ε_i is normally distributed $[N(0, \;\; \sigma^2)]$, hence

$$F(-\beta' X_i) = \int_{-\infty}^{-\beta' X_i/\sigma} \frac{1}{(2\pi)^{1/2}} exp\left(\frac{-t^2}{2}\right) dt \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.13$$

From equations 2.11 and 2.12, $\beta' X_i / \sigma$ can be estimated as opposed to either $\beta_s \; or \; \sigma$ in predicting the marginal effects in the j^{th} of the socio-economic and institutional factors (X_i). Therefore, the following expression can be used:

$$\frac{\partial}{\partial x_{ij}}\Phi(X'\beta) = \phi(X'\beta)\beta_j \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \text{3.14}$$

2.8. 5 Sample election Bias

Sample selection bias which is also known as selectivity bias is a type of bias caused by choosing non-random data for statistical analysis. The bias exists as result of a flaw in the sample selection process, in which a subset of the data is systematically excluded due to a particular attribute. Selectivity bias is defined as when one or more regressors are correlated with the residual term (Ettner, 2004). According to Ettner (2004), the error term captures the effects of all omitted and imperfectly measured variables, any regressors that are correlated with the unmeasured or mis-measured factors end up proxying for them. According to Barnow *et al.* (1980), selectivity bias arises when assessing an intervention, the treatment (or control) status of the subjects is related to unmeasured factors which themselves are related to the program intervention outcome under study. They define the term selectivity bias as the potential mis-estimation of the impact of the treatment on the outcome. Relative to this present study, selectivity bias occurs when the decision to practise CLI is linked to unmeasured factors like farmers' "innate" ability and skills which are also related to their productivity. Sample selection has been well illustrated by Heckman (1979) and Smit (2003). The type of sample selection which is associated with this current study is lack of availability of information on all respondents' maize output, but the distribution of respondents over classes of the autonomous variables has followed in a selective manner.

Moving away from theory to practice, selectivity bias may arise due to two situations: (1) a researcher can observe maize output values for adopters of CLI and not for non-adopters of CLI and (2) the maize output for adopters and non-adopters can both be observed in this case, but the selection of the respondents by the investigator in both cases may follow an unrestricted pattern and not by random. The implication of this is that maize farmers who adopt CLI may have unmeasured factors that are related to their productivity.

In CLI, the researchers seek to ascertain the true effect of crop and livestock integration on maize output. Sample selection is a problem when examining effect of CLI on crop output. If adoption variable is added directly into the substantive equation (equivalent to output function) as an independent variable, the parameter estimates would end up been biased (Heckman, 1976). This means that the real impact of CLI on maize output would not be ascertained. For instance, when farmers who practise CLI realize more output than their counterparts (non-practitioners), one cannot conclude that it is due to the practise of CLI that the adopters achieved more output. It could happen that they are already efficient and skillful in production. According to Adzawla *et al.* (2016) adopters of innovation are different from their counterparts (non-adopters) in several ways and if socio-economic characteristics of farmers are related with their output, then the effect of the innovation on output would be overvalued.

Furthermore, supposed after estimation of the output equation, it was realised that the output value of adopters was higher than non-adopters, other things being equal. What is the justification that practising CLI has made the former better-off and not the fact that they have inner ability and special characteristics like skills more than the latter? Hence, it is significant to accurately correct for selectivity bias so as to be able to ascertain the real effects of CLI on maize crop output. Several similar techniques proposed in which the problem of sample selection bias could be corrected depending on the objective being examined (Heckman, 1979). The Heckman Treatment Effect is one of the model suggested by other researchers (Mal *et al.*, 2012, Yirga & Hassan, 2013).

2.8. 6 Heckman's Two Stage Model

Heckman's (1979) Two Stage Model is an estimator proposed to account and correct for sampling bias in research work. The first stage estimates the probability of adopting CLI and the second stage estimates the effect of CLI on maize output. It assumes that different sets of policy variables can be used in the Two Stage Estimation Model. It is very imperative to know that at least one of the explanatory variables in the first equation is excluded in the second step equation for identification purpose (Maddala, 1983). Generally, the structure of the regression for the first equation (Selection equation) can be expressed mathematically as:

$$A_i = \beta_0 + X\beta_i + \varepsilon_{1i} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2.15$$

Where A_i is the observed value of the latent variable, adoption, X for socioeconomic factors, β_i are the parameters to be estimated and ε_{1i} is a two-sided error term with normal distribution, $N(0,\ \sigma_v^2)$.

The Heckman First Stage Equation is used to estimate a selection equation and the predicted estimated values are used to form a selection control factor (λ). This control factor (λ) correspond to the Inverse Mills Ratio (IMR) which serves as an additional regressor in the substantive (maize output) equation. IMR is the ratio of the probability density function over the cumulative distribution function of a distribution. This then makes it possible to ascertain the real effect of CLI on maize output since sample selection has been corrected. Likewise, the other drivers of maize output are freed from the effects of the unmeasured factors and therefore the coefficients are unprejudiced (Smit, 2003). Measuring the effect of CLI on maize output can be expressed as:

$$Y_i = \beta X_i + \pi A + \varepsilon_{2i} \quad \text{……………………………..2.16}$$

Where Y_i is maize output; X_i is the vectors of farm inputs; β is vector of parameters to be estimated; the A is dummy variable (A=1 if the farmer adopts CLI or 0 otherwise); and ε_{2i} is the two sided error term with mean zero and constant variance. The π measures the effect of CLI on Y_i. The variable A is not exogenously determined since the decision of an individual to adopt CLI is based on self-selection. Hence, using OLS to estimate equation (3.13) gives bias and inconsistent results since the CLI interaction effects is measured with observed and unobserved personal attributes. Also, the assumption of constant variance of OLS is violated. Following Maddala (1983), the general model is presented as:

$$\left.\begin{array}{ll} y_{1i} = X_i\beta_1 + u_{1i} & (for\ adopters\ of\ CLI \\ y_{2i} = X_i\beta_2 + u_{2i} & (for\ non-adopters\ of\ CLI \\ A_i^* = Z_i\alpha = \varepsilon_i & (adoption\ decision\ function) \end{array}\right\} \quad \text{………………… 2.17}$$

Where $A_i = 1\ iff A_i^* > 0$ or $A_i = 0\ iff A_i^* \leq 0$. The observed y_i can be defined as $y_i = y_{1i}\ iff\ A_i = 1$ and $y_i = y_{2i} = iff\ A_i = 0$ with the $Cov(u_{1i}, u_{2i}, \varepsilon_i)$ equal $\begin{bmatrix} \sigma_{11} & \sigma_{12} & \sigma_{1\varepsilon} \\ \sigma_{12} & \sigma_{22} & \sigma_{2\varepsilon} \\ \sigma_{1\varepsilon} & \sigma_{2\varepsilon} & 1 \end{bmatrix}$. With each adopter of CLI with characteristics X_i and Z_i, the output of adopters and non-adopters can be computed to examined the effect of CLI. That is $E(y_{2i}|A_i = 1)$. The output for adopters under the normality assumption can be express as;

$$y_{1i} - E(y_{2i}|A_i = 1) = y_{1i} - X_i\beta_1 + \sigma_{2\varepsilon}\frac{\phi(Z_i\alpha)}{\Phi(Z_i\alpha)} \ldots\ldots\ldots\ldots\ldots\ 2.18$$

Where ϕ_i and Φ_i represent the probability density function (PDF) and the cumulative distribution function (CDF) respectively of the standard normal distribution calculation.

To measure the effect of CLI on maize output the conditional expectation of ε_{2i} for adopters needs to be assessed as suggested by Maddala (1983). Therefore, the expected benefit of CLI for adopters is presented as;

$$E(y_{1i}|A_i = 1) - E(y_{2i}|A_i = 1) = X_i(\beta - \beta) + (\sigma_{2\varepsilon} - \sigma_{1\varepsilon})\frac{\phi(Z_i\alpha)}{\Phi(Z_i\alpha)} \ldots\ldots\ 2.19$$

The effects of CLI on maize output is measured by the summation of the equation 2.19. According to Heckman (1979), it is only when this is done, that one can assess/evaluate the wholesome effects of technology adoption (CLI). It also frees the other explanatory variables in the output equation from unmeasured factors such as the farmer's innate ability. Therefore, Heckman treatment effect model, is used for this study which briefly discussed below.

2.9 Empirical review of the Determinants of Agricultural Diversification

A lot of research has been conducted in developed and less developed countries to examine socio-economic and institutional factors affecting the decision to practice CLI. Different objectives and methodologies have been used to achieve the objectives of such studies.

Fisseha (2010) examined the determinants, challenges and prospects of dairy production and marketing in Mekelle City in Ethiopia. Fisseha (2010) used the ordinary least square econometric estimation technique to identify determinants that affect dairy production. Fisseha (2010) concluded that dairy production was strongly and significantly affected by use of improved feed, demand for milk, number of cross breed milking cows, frequency of getting training, access to production credit and education of the household heads. Also, shortage of feed and its high price, access to production credit and absence of processing industry were the most important challenges of dairy production and marketing in the area.

The Tobit model was used to assess the degree of crop diversification and the factors influencing crop diversification among the farm households at Dundwa Agricultural Camp of Zambia (Dube *et al.,* 2016). In their study crop diversification was positively influenced by gender of household head, production of cash crops by the household and household investment in basic farming tools. However, farmer's age, total farm size, access to agricultural markets and total area cultivated negatively influenced crop diversification. The conclusion drawn was that increasing capacity building of female headed households in farm decision-making and promoting household investment in basic farming implements are measures that promote crop diversification.

A logistic model was also employed by Ali (2010) to evaluate the effect of agricultural diversification on smallholder's income in Pemba Island, Tanzania. It was aimed at identifying the determinants of agricultural diversification among smallholder farmers, and also to examine and compare competitiveness for some selected crops having the potentials for diversification and to determine how farmers allocate resources for optimal farm's net returns. Ali (2010) concluded that farm size, education, off-farm income and extension services had a positive relation to probability of adopting agricultural diversification, while experience was negatively related to the likelihood of farmers' adopting agricultural diversification.

Furthermore, Rehima *et al*., (2013) investigated the determinants of crop diversification using data on the three stage randomly selected 393 farm households in Southern Nations and Nationalities Peoples' Regional (SNNPR) of Ethiopia. The Heckman two stage model was used to estimate separately the farmers' decisions and level of diversification. Socio-economic and institutional factors that were identified to be affecting crop diversification were gender, education and trade experience, membership in cooperatives, resource ownership, features of the land owned, access to extension services and transaction costs. Rehima *et al*., (2013) recommended that in order to promote agricultural diversification, government and stakeholders should promote female participations, invest in both formal and informal education of the farmers, provide incentive for extension workers and improve the extension system. Also, strengthening agricultural inputs and agricultural research particularly, generating agro-ecology based technologies and disseminating them to farmers should be enhanced.

Similarly, Yirga and Hassan (2013) employed Heckman two stage models to investigate the determinants of inorganic fertilisers use in the mixed crop-livestock farming systems in the central highlands in Ethiopia. Indicators that were found to be significantly affecting inorganic fertilizers and intensity of inorganic fertiliser use in the mixed crop-livestock farming were educational level of household head, herd size, number of farm plots owned, land tenure, access to credit, extension service, agro-ecology and manure use. They concluded that policies to promote both adoption and intensity of use of inorganic fertilisers need to focus on factors that influenced farmers' behaviour to use inorganic fertilizer.

Abro (2012) used the Generalized Least Square (GLS) technique with fixed-effect model to examine the determinants of crop diversification towards high value crops in Pakistan using panel data (1980 to 2011). He found that the factors that might be responsible for the farmer's participation in crop diversification were length of roads, per-capita income, fertilizer application and availability of water. The study advocated that crop diversification was needed from low value to high value crops and from single crop to multiple crops and from agriculture production to production with processing and value additions. Abro (2012) also, recommended that in developing technologies for promoting crop diversification, countries must give greater attention to the development of technologies that would facilitate the agricultural diversification particularly towards intensive production of fruits, vegetables and other high value crops that would increase the income and generate effective demand for food.

Principal component analysis was employed by Iiyama *et al*. (2007) to analyse crop-livestock diversification (CLD) patterns in relation to income and manure use in Kenya. The study also examined the factors influencing the adoption of CLD. The study revealed that education, farmer based groups, proximity to training centre, and household size were key factors influencing the adoption of CLD. It was also established that, farm households that own improved cattle breed and grew fruits trees were found to earn higher incomes and applied more organic manure.

Sichoongwe *et al.* (2014) analysed the determinants and extent of crop diversification among smallholder farmers in Southern Province of Zambia. The researchers used secondary data from the Central Statistical Office of Zambia. By using a double-hurdle model, farm size, fertilizer quantity, distance to market and the type of tillage mechanism adopted were found to have a strong influence on farmer practices of crop diversification. The researchers therefore suggested the need for governments to formulate policies that would enhance farmers' access to and control over land, improved access to agricultural implements like ploughs and markets for their produce.

Fausat (2012) used multiple regression analysis to achieve the objectives of the research topic; ''Determinants of income diversification in rural farming households in Konduga Local Government Area of Borno State, Nigeria''. He found that age, household size and ownership of assets influenced income diversification. Therefore, the study recommended that the presence of agricultural development institutions in rural communities would promote access to credit facilities and improve rural infrastructure in terms of provision of electricity and improving access to markets.

In Ghana, Akudugu *et al.* (2012) investigated the factors that influence farm households' modern agricultural production technology adoption decisions. By using a logit model they found farm area, projected benefits from technology adoption, access to production credit and extension services to have a great significant influence on technology adoption decision making. Based on these findings, they concluded that farm households' decision to adopt agricultural technology depends on farmers' socio-economic circumstances and institutional efficiency.

Obasi *et al*. (2016) evaluated the determinants of productivity and profitability of mixed farming enterprises in Imo State, Nigeria using multiple regression analysis technique. The outcome of the study showed that factors such as farm size and labour force affected productivity positively while education, fertilizer, expenditure on planting materials, veterinary services and cost of feed affected productivity negatively. Also, factors such as farm size, access to production credit and expenditure on feed affected profitability positively and conversely, education, household size and expenditure affected profitability negatively. Obasi et al. (2016) therefore concluded that mixed farming in Imo State was productive with livestock having a higher productivity index. They further recommended that the promotion of crop and livestock farming will make more farmers to invest in it and increase their production capacity.

Windle and Rolfe (2005) examined the determinants of agricultural diversification in Central Queensland of Australia, using the Nested Multinomial Logit model. They concluded that farmers' debt, age, education, dependence ratio, off-farm income, farm size, initial cost in production, net income, other crops grown and decreasing risk were the most socioeconomic and institutional factors influencing farmers to practice agricultural diversification.

Rahman (2008) used bivariate probit analysis to identify the factors that influence crop diversification in Bangladesh. Factors that were found to be statistically significant for influencing the adoption of crop diversification were farm asset, access to irrigation, cost of land for renting, education, farming experience, infrastructure status and off-farm income.

Asante *et al.* (2017) investigated the factors influencing farm diversification in the mixed farming systems in Ghana using Cragg two-step regression model. Factors found to be significantly affecting crop diversification were tillage plough, fertilizer, and portable road networks linking to communities. Socioeconomic and institutional factors that significantly influenced livestock diversification were credit, distance to market, market information, and portable road networks. The other socioeconomic and institutional factors that influenced farm diversification were household head age, gender, dependency ratio, off-farm income, land tenure right, value of farm assets, hired labour, area of farm land, family share labour, access to production credit, distance to market, extension service, income stability, access to the fertilizer subsidy, and crop residue used to feed animals. They found that farmers' decision to adopt agricultural diversification and the degree of diversification are distinct decisions which are affected by different sets of farm households and farm characteristics. The researchers therefore concluded that policy makers should be careful in the selection of factors and the methods for examining the agricultural diversification process to avoid confounding recommendations.

With these facts, it is convincing that socioeconomic and institutional factors are vital in examining CLI. However, the determinants of adoption of CLI depend on location and it is time-specific. Therefore, there is the need to update the status of the determinants of adoption of CLI for a policy formulation relevant to the study area and northern Ghana as a whole.

CHAPTER THREE

METHODOLOGY

3.1 Chapter outline

This chapter describes the various methodological approaches used for the study. The sections discuss the study area, livelihood activities in the study area, sampling technique, sampling technique and sample size, research ethical considerations, source of data and data collection and then data analysis and presentation respectively.

3.2 The Study Area

The study focused on ten (10) communities in the Mamprugu-Moagduri District in the Northern Region of Ghana. The Mamprugu-Moagduri District's capital is Yagba and the District was carved out of the West Mamprusi District in 2012. The selection was based on the presence of Fulani herdsmen. Yagba has been historically dominated by settled Fulani herdsmen who engage in crop cultivation, especially, maize for household level consumption. The Fulanis' are the largest nomadic group in the area, moving around with their livestock all year round. They engage in seasonal movement to have access to water and fodder for their animals. However, this seasonal movement could have adverse effect on crop cultivation as well as the environment. Fulani settlers who are professional herders rear their own livestock and that of indigenes who entrust their stock under their care.

Moreover, the Integrated Water and Agricultural Development (IWAD) Irrigation Project also known as Sisili-Kulpawn Irrigation Project (SKIP) is located in the communities to take advantage of potentials of the Sisili Kulpawn River Basin. The herding of the Fulani herdsmen could have impacts on the IWAD Irrigation Project as well as the community farmers' crop production and vice versa.

Mamprugu-Moagduri District is located within longitude 0°35′ W and 1°45′ W and latitude of 9°55′N and 10°35′N. It is bordered to the Builsa South District in Upper East Region and Sissala East District in the Upper West Region, West Mamprusi District to the west, North Gonja District, and Kumbungu District both in the south of the Northern Region. The strategic location of the District presents tremendous economic potentials especially crop cultivation and livestock rearing both in the rainy and dry seasons. The District is covered by flat and undulating terrain and its geology is made up of middle Voltain rocks which are suitable for rural community water supply.

The temperature of the District ranges from 30°C to 40°C per annum. Also, the average rainfall ranges from 1000mm to 1200mm per annum, lasting from May to October with August to September being the months of highest rainfall.

The District has a vast land mass which is suitable for crop cultivation given the sufficient water availability (Wit & Norfolk, 2014). It is also suitable for livestock rearing because of the land mass and green vegetation. There is also access to water due to the Sisili-Kulpawn River Basin. Figure 3.1 is a map of Mamprugu-Moagduri District showing the various communities sampled. The arrow shows from the Northern District Map to the study area and its communities. These communities include Yagba, Goriba, Loagri, Kubori, Kuuba, Jeri-Kantem, Gbima, Sakpaba, Prima and Kubugu.

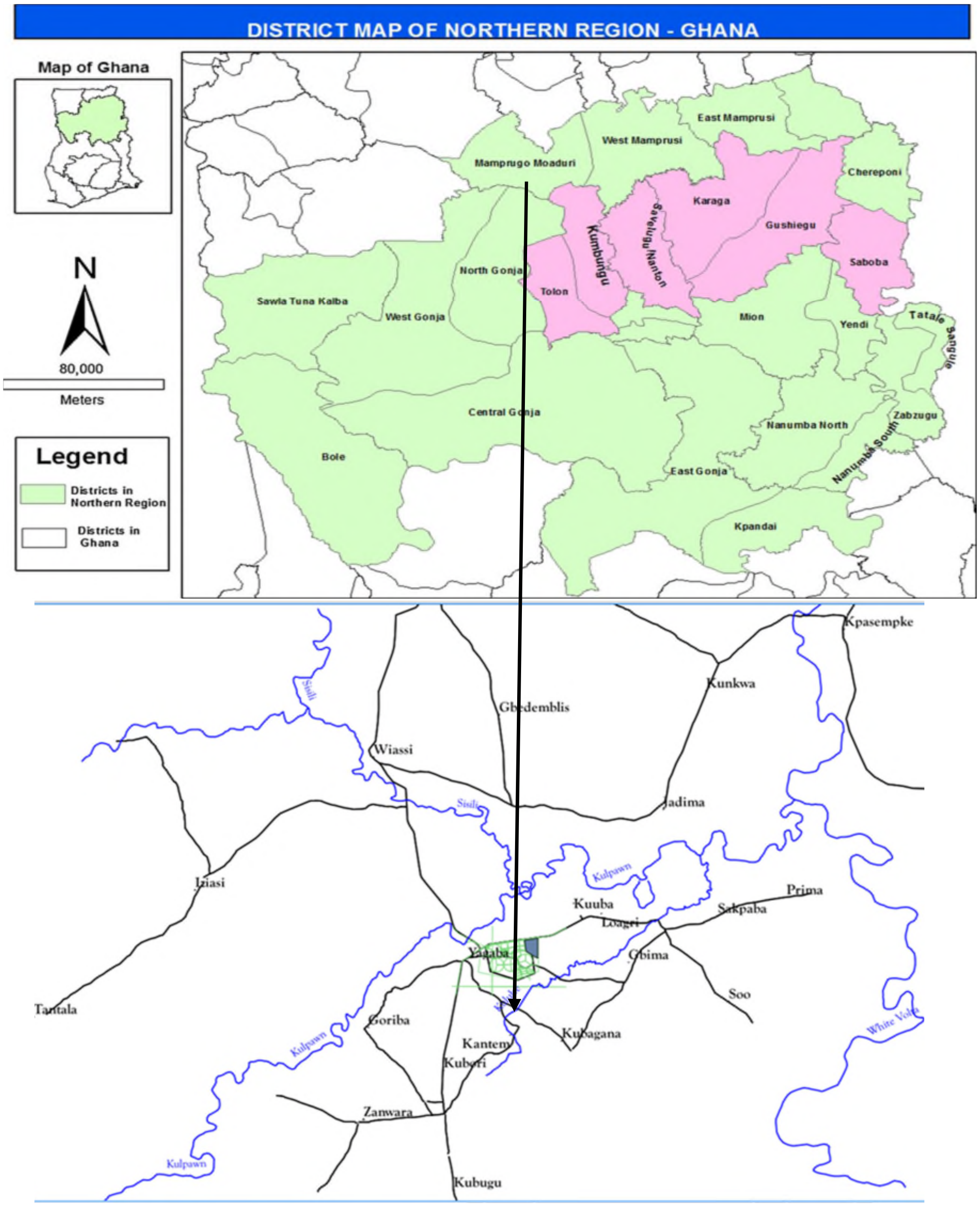

Figure 3. 1: District Map of Northern Region and the Study Area Map

Source: Adapted and developed by author using GIS country data from www.diva-gis.org and IWAD, 2013.

3. 3 Sampling Technique and sample size

The target unit of investigation for this study was Fulani households herding their own cattle and/or those of the indigenes and at the same time engaging in maize production in the selected communities in the Mamprugu-Moagduri District. Multistage sampling technique was used. In the first place the study area was purposively selected. A list of 21 IWAD intervention communities and non IWAD communities were obtained in IWAD and MoFA office in the District. In second stage, simple random sampling was used to select ten (10) communities by balloting. Simple random sampling technique entails that each member of the population has an equal opportunity of being selected as a subject. Lastly, proportional sampling was used to select adopters (100) and non-adopters of CLI (100) for the study (Table 3.1).

Table 3. 1: Procedure used in selection of Fulani households

	Name of community	Number of Fulani household sampled
IWAD operational area	Yagba	32
	Kubugu	16
	Loagri	13
	Kubori	24
	Goriba	15
Total		100
IWAD non-operation area	Sakpaba	40
	Prima	18
	Jeri-Kantem	8
	Gbima	13
	Kuuba	21
Total		100

3.5 Research Ethical Consideration

In the academic and social research, it is expected that researchers meet the acceptable ethical standards in social research. A researcher should be transparent, competent, honest, and monitor ethical guidelines in regard to research subjects.

Certainly, researchers face a range of ethical requirements and they must act professional and follow the standards for conducting a social research (Smith, 2003). An array of research ethical considerations towards a research must include the following: obtaining informed consent, confidentially, the right to privacy, preservation of anonymity (i.e. reporting in a way that will not link the subjects with the information provided), and avoidance of perception. Social subjects in participation in social research work need to be reassured that information offered will be summarized and reported in a way that their inputs will not be attributed to any one individual.

The American Psychology Association (APA) (2010) has established five recommendations to help researchers steer to clear an ethical difficulties namely: (1) inform prospective subjects what they will experience so that they can give informed consent to participate; (2) inform the subjects that they may withdraw from the study at any time they feel so not to participate; (3) minimise all destruction and discomfort for subjects to participate a research; (4) keep subjects' responses and behaviours confidential; and (5) presenting preliminary findings of the research after they have participated any research work.

This research meet all the requirements of ethical issues outlined above. The researcher was accompanied by the subjects' leader (Fulani community chief) in the study area. He also went further to seek permission from the community chiefs to conduct a research on behalf of the researcher to among the Fulani herdsmen in the study area. This gave the subjects confident to provide relevant information regarding the purpose of the study. Preliminary report especially the descriptive statistics were presented to the opinion leaders in the study area.

3.7 Source of Data and Data Collection

Primary data were solicited from the respondents by using a semi-structure questionnaire. The questionnaire was administered in the study area by the researcher through face-to-face interview that ensured respondents understood each question before offering authentic answers. The content of the questionnaire was structured to capture the following: household and farm characteristics; categories of settled Fulani herdsmen; how the Fulanis exchange resources as a source of livelihood; cattle herding and entrustment systems; mobility and grazing pattern of cattle; agricultural practices; cost of production (i.e. adoption of CLI); perceived benefits of about CLI; types of CLI and the bottlenecks of CLI that are likely to be affecting respondents to adopt the CLI. The questionnaire was pre-tested by the researcher in the Mamprugu-Moagduri District prior to the data collection. Questions with ambiguity, inconsistency and poor wording were identified and corrected. The pre-testing of the questionnaire ensured its reliability.

3.6 Data Analysis and Presentation

The data analyses involved descriptive and econometric techniques. In the following sections, the analytical procedure for each objective is provided below.

3. 6.1 Agricultural production practices adopted and farmers' perception of CLI

Objectives, one and two of the study sought to explore the crop and livestock production systems and to examine the farmers' perceived benefits/effects of CLI as practiced by the farmers, respectively. These were addressed using qualitative techniques. Descriptive analysis was employed to explore agricultural production practices adopted by the herdsmen farmers.

The Likert scale, was used to achieve objective two. The Likert scale in this study involved a five-point scale, namely: strongly agreed (5); agreed (4); undecided (3); disagreed (2) and strongly disagreed (1). From the responses, the mean values of each indicator were estimated. The implication was that the higher the mean values, the more positive confirmation of the attribute being described and the lower the value, the more negative the confirmation.

3. 7 Analyzing the Challenges to the Adoption of CLI

Farmers in the developing world continue to practise CLI in the mixed farming. Both the developed and developing countries have some levels of perceived benefits about CLI. For that matter, the respondents were made to indicate their perceptions or their extent of agreement/disagreement on some pre-determined indicators of CLI. The set of five (5) alternative reactions were available to the respondents by using Likert scale. The degree of agreement level was presented as strongly agreed (5); agreed (4); undecided (3); disagreed (2) and strongly disagreed (1). The implication of using Likert scale was that the higher the mean values, the more positive statement of the indicator being designated and the lower the value, the more negative the statement.

The Kendall's Coefficient of Concordance (W) was used to examine the challenges facing maize crop and livestock production. It is a statistical tool employed to rank a given set of challenges ranging from the highest to the lowest, and then measures the extent of agreement between the respondents regarding the challenges (Edwards, 1964).

Statistically, the Coefficient of Concordance (W) is expressed as:

$$W = \frac{n\left[\Sigma T^2 - (\Sigma T)^2\right]/n}{nm^2(n^2-1)} \quad or \; nT \Big/ nm^2(n^2-1) \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\; 3.1$$

Where: T is the sum of ranks for the variance being ranked;

m is sample size; and

n is number of variance being ranked.

The W is an index of ratio of the observed factors of the sum of ranks and the optimum possible variables of the sum of ranks. The optimum variables (T) are given by:

$$T = m^2(n^2-1)/12 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..\; 3.2$$

$$VarT = [\sum T^2 - (\sum T\,)^2/\text{n}] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..\; 3.3$$

The main idea behind the index is to compute the sum of ranks given to individual variable (challenges in CLI) ranked by respondents and then examine the variability of this sum. If the rankings are in total agreement, the variability among these sums will be at optimum. The challenges in CLI are ranked in descending order with the least score rank being the most serious challenge while the highest score is ranked the smallest challenge. The overall rank scores are then used to compute the Coefficient of Concordance (W) to measure the degree of agreement in the rankings. The W cannot exceed 1.00 and cannot be negative. Hence, it ranges from zero (0) to one (1). It will be zero when the ranks assigned by a respondent are the same as those assigned by other respondents and it will be zero when there is a maximum disagreement among the respondents.

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

F-ratio $F_c = (m-1) \times \frac{W}{(1-W)}$ ……………………………………….3.4

The degrees of freedom for the numerator (df) = $(n-1) - (2 / m)$………..3.5

The degrees of freedom for the denominator (df) = $(M-1)\{(n-1) - (2/m)\}$ ….3.6

The W was applied by Alhassan *et al.* (2008) to assess consumer preference for rice in Ghana. Similarly, Donkoh & Awuni (2011) used this method to investigate farmers' perceptions on farming practices which are crucial for increasing farm output and revenue for adoption of farm management practices in lowland rice farming in Ghana.

A Chi-square test was conducted to test for the significance of the mean responses of the pooled data. It is also a statistical tool used to test the association of variables in relation to an outcome (i.e. CLI).

3. 8 Conceptual Framework of CLI

A conceptual framework is a systematic and logically organised ideas which provides a focus for the integration and interpretation of research information (Lynham, 2002; Ager & Strang, 2008). It guides and provides direction for inquiry of information about adoption of agricultural innovation (CLI) that would aid policy maker to design and implement policies. In the farm environment, farmers are faced with various intertwined factors which influence their decision of choice to adopt agricultural innovation in other to maximize output. In this research work, the conceptual framework would briefly discuss the factors influencing farmers' decision to engage in CLI.

Basically, the key factors affecting the use of CLI in the mixed farming systems are presented in Figure 2.3.

Household characteristic factors such as farmer's age, dependent ratio (proxy for household size), experience, livestock ownership (herd size), crop residue storage, initial capital or cost, and migration all influence CLI.

Farm land characteristics that may influence CLI include farm size, farm distance to homestead, distance from homestead to watering point and livestock production systems. Farmers with large farm size are more likely to adopt CLI.

Institutional factors such as access to production credit, training on CLI, extension service, land tenure, off-farm activity and good road network affect farm enterprise integration.

Soil and manure management in the mixed farming systems are vital for practising CLI. The CLI offers great opportunity to improve soil fertility, hence sustainable agriculture. Soil and manure management that influences CLI include mulching, crop rotation, grazing reserves, manure, fertilizer and weedicide applications. Farmer's decision to practice CLI depends on access to livestock manure, livestock manure management and technical assistance.

The quantity of manure tends to rest on access to grazing land which is also affected by land tenure rights, as well as the availability of fodder. Moreover, manure application depends on the availability of transport to convey manure from livestock kraals to crop plots and the labour required to assist in this process. Arrangements based on mutual relationships can also be made for herders to confine the livestock for a specific period to graze and drop the manure directly on the crop fields. The efficient use of available nutrients for crop growth is equally dependent on careful management and timing of manure application in relation to sowing and weed management.

In addition, farmers' perception and security factors influence the uptake of CLI. The perception factors include climate change, soil fertility, soil erosion and general perception of CLI. In terms of security factors conflicts may influence CLI adoption negatively. Crop destruction by animals results in conflicts among farmers and Fulani herders. This creates social insecurity in a society. It would also cause pastoral farmers to move their livestock farther from home. The consequence is that it reduces the farmers' ability to fully practice CLI.

The outcome of agricultural technology adoption (in this case CLI) is to increase farm productivity. Other benefits of CLI include soil fertility improvement, climate change mitigation and availability of fodder. The long term impact of adopting CLI includes sustainable agriculture and reduction of poverty (improve welfare). Conversely, if farmers fail to adopt, the negative consequences are land degradation, environmental pollution, bushfire and scarcity of fodder for animals. The long term effect for not practising CLI includes food insecurity and malnutrition, manifestation of climate change and pest and diseases. All these affect crops and livestock production as well as human life.

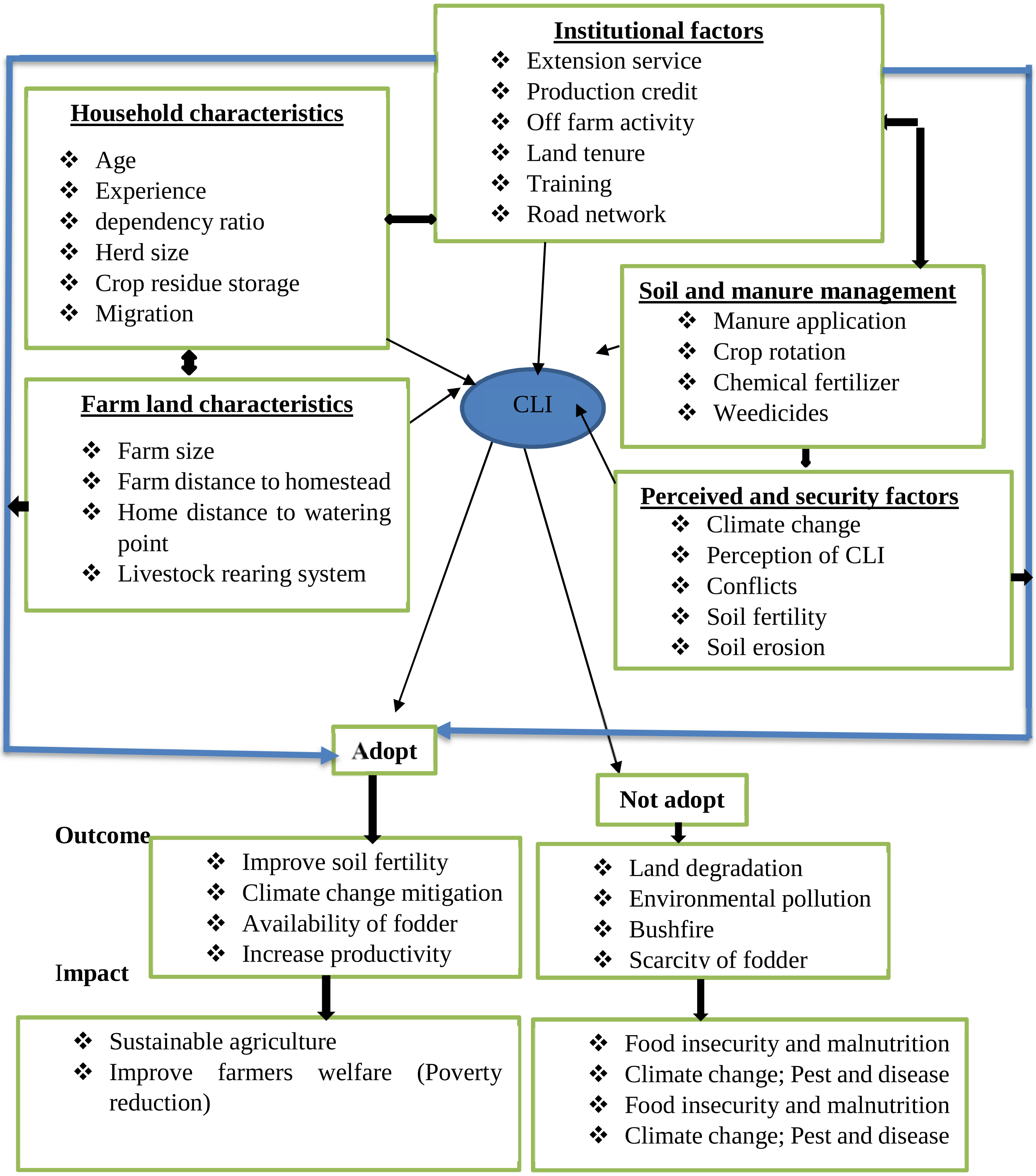

Figure 3. 2: Conceptual framework of the study

Source: Author's construction, 2017.

3.9 Heckman Treatment Effect Model

The Treatment Effect Model is equivalent to the Heckman two stage Model approach. The dissimilarity between the two however, is that in the case of the former, the treatment condition (thus CLI) is put into the substantive equation to measure the direct or real effect on output (Maddala, 2003). The treatment effect controls for the endogeneity and selectivity bias. The estimator includes residuals from the treatment model in the models for the potential outcomes, known as a control-function approach. Specifically, the treatment effect model is given as:

$$\mathrm{Y_i} = \mathrm{X'_i}\beta + \mathrm{A_i}\delta + \mathrm{u_2} \text{ .... } 3.7$$

Where X_i' is a set of factors that influence maize output, δ measures the effect of CLI on maize output and $\mathrm{A_i}$ is as defined earlier. Estimating equation 3.7 with OLS may not give adequate outcome. Even if the model correctly specified, it may not actually measure the true effect of A_i. Estimating the effect of A_i on maize output by adding A_i directly into the output function using OLS estimation method will either overestimate or underestimate the effect of A_i on maize output. Treatment effect model have been used to correct this over or underestimation problem. Following Greene (2003) work, this model can be express as follows:

$$A_i^* = Y_i' + u_2 \text{..} 3.8$$

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

Nevertheless, u_1 and u_2 strongly are correlated. Hence estimating equation 3.8 without first estimating the treatment equation 3.18 is no longer possible since A_i in itself is influenced by some set of covariance. The two simultaneous equations can be express as follows:

$$E(Y_i|A_i = 1, X_i, \beta) = X_i'\beta + \delta + E(u_1|A_i = 1, X_i, \beta) =$$

$$Maize\ output(Y_i) = X_i'\beta + \delta + \rho\sigma_u\lambda(-Y_i'\gamma) \ldots\ldots\ldots\ldots\ldots 3.9$$

Where λ is the Inverse Mills Ration (IMR) which can be define as the ratio of the probability density function over the cumulative distribution function of a distribution. Mathematically, this can be express as follows:

$$\lambda = \frac{-\phi(Y_i'\gamma)}{1-\Phi(Y_i'\gamma)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.10$$

Where ϕ and Φ are as defined earlier, and $\Phi \cong \Phi(Y'_i\gamma)$, and u_3 is the two-sided error term with $N(0, \sigma_v^2)$.

These two step estimator provide a follow-up result of which accounts for the selectivity bias or treatment problem. It can be observed that in equation 3.10 is possible only if $A_i = 1$.

3.9.1 Empirical Model Specifications

This Section provides the empirical models estimated in this study. Adoption of CLI is the used maize crop and other crops residues to feed livestock and at the same time used livestock droppings as manure to fertilize the crop farm. On the converse, this means that a farmer who grows only crops or livestock or both but does not provide room for mutual benefit between the two farms is considered as a non-adopter. The regressand in this study is the decision to adopt of CLI, a dummy where $A = 1$ if a farmer adopts and $A = 0$, if a farmers does not adopt.

The empirical model (selection equation) for adoption of CLI is stated as:

$$A = \alpha_0 + \alpha_1 x_1 + \alpha_2 x_2 + \alpha_3 x_3 + \alpha_4 x_4 + \alpha_5 x_5 + \alpha_6 x_6 + \alpha_7 x_7 + \alpha_8 x_8 + \alpha_9 x_9 + u_1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; 3.11$$

Where X_1 is age; X_2 is age squared; X_3 is dependency ratio; X_4 is herd size ; X_5 is access to credit; X_6 is trade-off; X_7 is distance to watering points; X_8 is farm size; and X_9 is chemical fertilizer.

The empirical model for maize output (substantive equation) is expressed as:

$$y = \lambda_0 + \lambda_1 x_1 + \lambda_2 x_2 + \lambda_3 x_3 + \lambda_4 x_4 + \lambda_5 x_5 + \lambda_6 x_6 + u_2 \ldots\ldots\ldots\ldots\ldots\ldots 3.12$$

Where X_1 is farm size; X_2 is seed; X_3 is labour cost; X_4 is weedicides; X_5 is chemical fertilizer; and X_6 is CLI. All the variables in 3.12 were log except CLI

Table 3. 2: Description of Socioeconomic Variables Used in the Study.

Variable	Description	*A prior* sign	
		Adoption	output
Age	Age of a farmer in years.	+/-	
Dependants ratio	Number of people not working divided by the number of people working in the household.	-	
Herd size	Total number of cattle for farm household.	+/-	
Production credit	Dummy; 1 if farmer had access to production credit during the farming calendar; 0 otherwise.	+	
Distance to watering point	Measured in walking minutes from homestead to water source.	-/+	
Trade off	Dummy; 1 if farmer trade off cattle manure; 0 otherwise.	+	
Farm size	Size of household's maize plot in acres.	+	+
Fertilizer	Quantity of chemical fertilizer applied per acre in 50kg.	-	+
Input variables			
Seed	Quantity of maize seed used for cultivation in kilograms per acre.		+
Labour	Labour cost in GH₵ per acre.		-
Weedicide	Quantity of weedicide used in litre per acre.		+
CLI	Dummy; 1 if Fulani household use crops residue to feed livestock and at the same time using livestock droppings to fertilize crop farm; 0 otherwise.		+

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Chapter outline

This chapter presents the findings on socioeconomic characteristics of the subjects in the study area. It also includes the agricultural farming practices practiced by respondents; respondents' perception on CLI; determinants of CLI system; and effect of CLI system on maize output. The others are: the agricultural production practices adopted by the respondents; Respondents' perception of CLI on soil fertility and erosion control and the challenges Fulani herdsmen face in adopting CLI.

4.2 Demographic and Socioeconomic Characteristics

The descriptive statistics of demographic and socio-economic variables and adoption level of CLI by Fulani herdsmen are shown in Table 4.1. These include: age, dependence ratio, distance to water source, experience, farm size, herd size, trade-off, credit, fertilizer, seed, labour cost, weedicides and maize output.

Two integrated crop-livestock farming techniques were identified in the study area. These include using cattle manure in crop field and feeding cattle with crop residue after harvest. Based on this information, the CLI is categorized into adoption and non-adoption. Adoption of CLI means a farmer applied livestock manure into crop field and used crop residue to feed livestock. Non-adoption simply means a farmer either used livestock manure in crop field or used crop residue to feed livestock. By these definitions farmers who adopted CLI were 53% of the total respondents while 47% were non-adopters.

The average ages of adopters and non-adopters of CLI were 45 and 43 respectively. The overall average age for the pooled data was 44. This average age means that the respondents were within the economically active bracket and this could lead to effective work on the part of the farmers.

The dependency ratio for both adopters and non-adopters 7.26 and 6.84 respectively. Dependency ratio is the ratio of economic active labour force to the economic inactive labour force in a farm household. Mostly, households with a relatively large number of dependents turn to diversify their sources of livelihood to meet their basic needs, particularly in relation to increasing production and balance diet (Benin *et al*., 2004). However, households with small dependency ratio may not have the motivation to diversify their sources of livelihood due to insufficient household labor and other farm inputs such as fertilizer and tractor service.

The average distance to water source for cattle for both adopters and non-adopters of CLI were about 165.33 and 174.17 minutes respectively with the overall average of 170.1 minutes. The value of the t-test was statistically significant at 10%. Shorter distance to water source for farmers to water their animals makes it easier for farm households to diversify agricultural production. The mean experiences for the adopters and non-adopters of the CLI were 35 and 34 years correspondingly. Meanwhile, the overall mean experience in years was 34. This implies that adopters of CLI were more experienced in practicing mixed farming compared to the non-adopters. Farmers with more experience in CLI are likely to have more access to production resources and information, hence they are more likely to diversify in their source of livelihood.

The average total land holding (pooled) was 4.04acres, while 4.64 acres and 3.53 acres represents land holdings for adopters and non-adopters respectively. The total land holding was statistically significant (1%). This means that farmers with large farm sizes have high likelihood to practice CLI**.**

Table 4. 1: Demographic and socio-economic variable used in the study

Variables	**Adopter of (CLI)**	**Non-adopter of (CLI)**	**T test**	**Pooled**
Adoption level	**0.53**	**0.47**	**-**	**-**
Age (years)	45.07	42.14	-2.19**	43.49
Dependency ratio	7.26	6.84	-1.11	7.04
Herd size (no. of cattle)	74.71	89.56	1.83*	82.73
Credit (dummy, 1=yes, 0 otherwise)	0.49	0.36	-1.53	0.42
Trade-off (dummy, 1=yes, 0 otherwise)	0.38	0.25	-1.99**	0.31
Distance to watering point (minutes)	165.33	174.17	0.63	170.1
Farm size (Acre)	4.64	3.53	-3.10***	4.04
Fertilizer (Kg)	12.23	45.60	2.84***	30.25
Seed (Kg)	11.28	9.74	-2.07**	10.45
Labour cost (GHC)	38.50	22.28	-3.67***	29.74
Weedicide (Litre)	1.28	0.66	-5.35***	0.95
Maize output(Kg)	444.79	364.17	-2.29**	401.26

***, **, *, stand for values statistically significant at 0.01, 0.05, and 0.1 levels respectively.
Source: Author's Computation, 2016.

Herd sizes were adopters (79.4.) and non-adopters (89.56) with the overall mean of 82.73. Trade-off is the exchange of resources without necessarily buying the resource with cash. Some resources found to be traded off among respondents were cattle, goats, sheep, maize, millet, land, and among others. The percentages of respondents who traded off their resources were 38 and 25 respectively for adopters and non-adopters.

In addition, hired labour cost was considered since mixed farming is labour intensive. The farmers who practised CLI spent more cost on hired labour (GH₵ 38.50/ac) compared to their counterparts (GH₵ 22.28/ac) who did not practise CLI. In all, farmers spent averagely GH₵ 29.74/ac and the t-test was statistically highly significant (1%). Weedicides are used on farmland to control or minimise weeds infestation on crops. Farmers who practised CLI were found to apply more (1.28 litres/ac) weedicides than their counterparts (0.66 litre/ac). The overall litres of weedicides applied per acre were about 0.95, and it is significant at 1%. Also, the maize output for farmers who diversified and those who did not were 444.79kg/ac and 364.17kg/ac respectively with an average (pooled) of 401.26kg/ac. This means farmers who practised CLI had 80.62 Kg/ac additional maize output.

4.3 Cost of Producing Cattle and Maize in the Mixed Farming Systems

Cattle production, like any other business, involves cost. In this study the variable inputs identified in cattle production were salt lick, crop residue, drugs and related veterinary services. The minimum and maximum costs of salt lick were GH₵ 220.50 and GH₵ 960.00 respectively with a mean of GH₵ 154.15 per year. (Table 4.2) Also, the maximum amount used to buy crop residue to supplement cattle feed was GH₵ 3,000.00 with an average of GH₵ 189.03. In addition, Fulani households are very cautious of the health of their animals and as such, they invite veterinary personnel to treat or vaccinate their cattle when there is disease outbreak. The maximum cost for medical service and drugs was GH₵ 2,500.00

with mean cost of GH₵ 628.10. The cost of land preparation per acre by using farm tractor was GH₵ 45.00. This amount was flat across all farms.

Table 4. 2: Cost of production in adopting CLI

Indicator/GH₵	Observation	Mean	Std. Dev.	Min	Max
Salt lick/year	200	154.15	220.50	0	960
Crop residue/year	200	189.03	448.20	0	3000
Land preparation/acre	200	45.00	0.00	45	45
Hired labour/year	200	93.68	136.60	0	700
Fertilizer/year	200	30.25	127.59	0	1000
Weedicide/year	200	54.99	60.72	0	300
Cattle treatment/year	200	628.1	587.45	0	2500

Source: Author's Computation, 2016.

In every production, labour is paramount. Hence, the maximum cost of hired labour in practising CLI was GH₵ 700 per year with an average of GH₵ 136.60. Similarly, the maximum cost of chemical fertilizer and weedicide were GH₵1000.00 and GH₵ 300.00 with averages of GH₵30.25 and 54.99 respectively.

4.4 Classification of Subjects for Investigation

The Fulani herdsmen in the study environment are categorised into two. These are settled Fulani and migratory Fulani respectively. The classification of the Fulani's was based on the method of herding cattle and their interactions/relations with the community in the study area.

The settled Fulani herdsmen are those who have the permission of the community leaders to construct permanent houses, are involved in community decision making and herd their own cattle in addition to other farmers' cattle. They have close links with the indigenes and regard themselves as part of the community. These Fulanis are further classified into two as "new' Fulanis and "old" Fulanis. As the names suggest, the new Fulani herdsmen are those who settled recently while the 'old ones are those who have settled in the community for many years. The "new" Fulanis are not well integrated into the community as compared to the older Fulanis. This makes older Fulanis potent candidates for Fulani chief with the responsibility as an intermediary person between the Fulani herdsmen and the community chiefs and opinion leaders. For instance, in cases of conflicts between a Fulani and an indigene, the Fulani chief mediates with the community chief to resolve such conflicts.

The Fulani households herding their own cattle represent 26.42% and Fulani households herding their own and those for the indigenes represent 73.58% in the study area. This means that a large proportion of the Fulani households herd their own cattle and the indigenes as the cattle have been trusted into them. The study revealed that Fulanis who herd their own cattle and that of the indigenes have stronger relations with the community chief/members than Fulanis herding solely their own. In the case of the former, this relationship so exists because, these Fulanis are allocated land by the chiefs and their people making them feel accepted by the people of the community. However, Fulani households herding their own cattle contact the community chiefs directly for arrangement and agreement to be made before the community chiefs allocate land to them even before they settle. This type of Fulani herders first of all, pay in-kind by giving a cow to the chief to settle and this deal is renewed annually, which serves as security or insurance for the Fulani to settle for a long period or permanently in the community. The contract agreement between community chiefs and the Fulani herders are verbal and there is no legal document binding both of them.

Moreover, community cattle owners and the Fulani herders have better relations with one another than the community chief. This is because the cattle owners arrange for the Fulani to settle in the community and herd their cattle. The cattle farmers are responsible for the welfare of the 'Fulanis' and this includes food, healthcare, cloths, farm plots among many others.

On the other hand, the migratory Fulani herdsmen are temporary settlers who move from one place to another in response to seasonal fluctuations, especially during the dry season to have access to fodder and water for their cattle. The transhumant (migratory) Fulanis do not have any relationship with the settled Fulani and the community chief/members. Nonetheless, the chiefs tax the transhumant Fulanis with a cow each when they want to settle for a short period with their cattle. The transhumant Fulanis mostly come from Burkina Faso, Togo and Nigeria with large cattle grazing along the Sisili-Kulpawn River Basin and towards the southern part of Ghana. In terms of livestock management, the migratory Fulanis are hardly discovered by the community chiefs and elders as well as agricultural extension service personals in the study area. This supports the claim of Osken, (2000) in Burkina Faso that the migratory Fulani herders are not accessible and are difficult to discover by veterinary service personnel in a particular terrain.

The transhumant Fulanis are difficult to control and authorities have been unable to limit their random movement and transform them into agro-pastoralists (Osken, 2000). This transhumant Fulanis mostly arrive in the Sisili-Kulpawn River Basin after harvest (November-January) and return when it begins to rain (April-May). In the study area, there is no grazing site for cattle and therefore the herders move their cattle to graze the crop residues on the farms of community members. According to Osken (2000), the migratory Fulanis use the community wells and dugouts and their women sell milk to community members to meet the basic needs as they moved about. This type of settlement is not different from that in the Mamprugu-Moagduri District in the Northern Region. Therefore, the increase in the population of Fulanis with their cattle herders in the Mamprugu-Moagduri District leads to agricultural land and environmental degradation. However, it also improves soil fertility since the cattle droppings enrich the soil and reduce the workload (chemical fertilizer application) of the farmers.

4.5 Trade-off of Resources

A qualitative technique was used to explore the resources the respondents had and how they exchange the resources in the study area. Resource exchange is vital between Fulani herdsmen and the sub-chiefs or community chiefs for them to be granted the chance to settle in the study area. To integrate the Fulanis with the indigenes and other stakeholders, there is the need to know the resources the Fulani herdsmen possess and how they exchange these with other resources with the indigenes. Also, it is important to establish the resources that the Fulanis are lacking. This will serve as a pathway for integrating the Fulanis with the indigenes and other stakeholders to improve the livelihood of the Fulani. The security of livelihoods of Fulani herdsmen depends mainly on the health and wealth of their cattle (Fabusoroa & Sodiya, 2010) and other livelihood coping strategies. From the study, the resources the Fulanis have are human capital, cattle, cattle manure, sheep, goats and poultry while the resources they are lacking include land tenure right, fodder, education, and access to veterinary service. The trade-off of these resources among the Fulani community and others help to integrate Fulanis into society that promote access to land and pasture for grazing of their livestock (Fabusoroa & Sodiya, 2010).

The main resources exchanged between the Fulani herdsmen and the sub-paramount/ community chiefs are shown in the relations 1 and 2 (Figure 4.1). The sub-paramount/ community chiefs provide some resources, especially land to the Fulanis while the latter also provide cattle to the former. In this resource exchange process, the community chiefs act as an intermediate between the sub-paramount chief and the Fulanis. Prior to settling, the Fulanis have to provide some items either in cash or in kind to the sub-paramount chief and the community chief while the settled Fulanis herding their own cattle have to provide an agreed amount of money or a cow to the community chiefs or to the sub paramount chief yearly. In most cases, those Fulani herding their own cattle exchange a cow to the paramount chief to have access to land to settle and take care of their cattle. Since they are herding their own cattle without the indigenes of the community farmers' cattle they have to pay or offer a young cow to the paramount chief and the community chiefs to maintain the relationship to stay in the communities. The paramount chief is the custodian of the land and he has the right to allow or deny a Fulani to settle in the area. All the households of the indigenes; community chiefs and elders as well as the Fulani herdsmen are under the umbrella of the sub-paramount chief. The chiefs of the communities do not have the right to tax the Fulani except the sub-paramount chief. In this case, the sub-paramount chief chooses delegates in the palace to accompany the chiefs in each community to tax these Fulani herdsmen a cow every year. Negotiation of Fulani herdsmen among the Fulani community and other stakeholders is very important as it forms social relation to a collective action for securing land access and social security (Fabusoroa & Sodiya, 2010). However, the study revealed that there were no documented rules and regulations governing the payment of a cow to the paramount chief by the Fulanis in the study area.

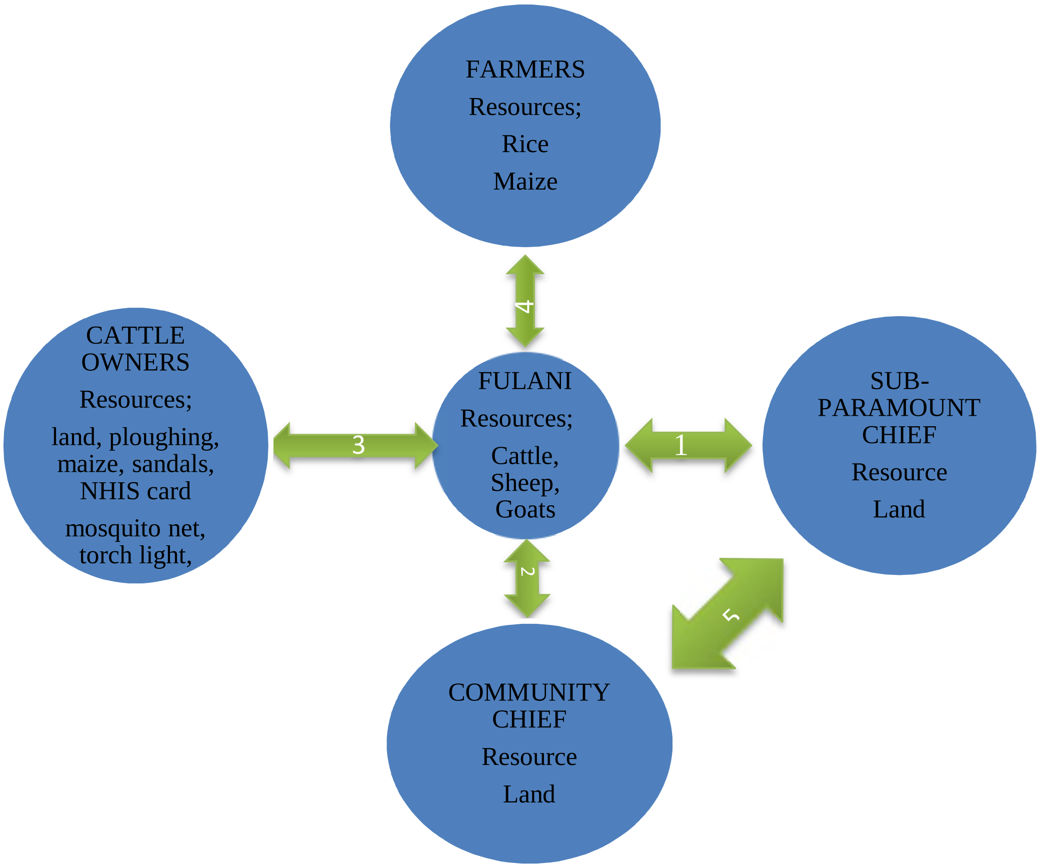

Figure 4. 1: Model of Trade-off of Resources

Source: Author's Construction, 2016

Relation 3 in Figure 4.1, shows the how the resources exchange between cattle owners (indigenes) and the Fulani herders. The Fulanis benefit from cattle owners when the latter contract the former to herd their cattle and or give land to the Fulani to farm. The cattle owner ploughs the land for the Fulani to cultivate maize every year. The cattle owners also provide some other resources to the Fulani such as farm produce (maize) in the lean season (July-September), mosquito net, a pair of sandals, torch light, and assistance in registering the Fulani household with the National Health Insurance Scheme (NHIS) to access healthcare. These are provided in exchange for herding the cattle by the Fulanis, but where necessary the cattle owner can also give cattle to the Fulani for some number of years to motivate them. The Fulanis benefit from milking of the cows which is part of the contractual agreement between the two where the income from the milk belongs to the Fulani. However, Fulani households herding the indigenes cattle tie or confine the animals in the cattle owner's farm plots to fertilize the soil.

Also, the relation 4 (Figure 4.1) explains the resource exchange between the Fulani herdsmen and the crop farmers. This exchange of resources between Fulani herders and the crop farmers is often not common in the study area. The study revealed that about 28 % of the Fulani herders exchange resources with farmers. This means that majority (72%) of the Fulani herders have never exchanged or attempted to exchange their resources with the crop farmers. The resources the Fulani and crop farmers exchange include cattle, sheep, maize and rice. Some of the Fulani herders exchange cattle and sheep for farm produce such as: maize and rice during the lean season to have enough food for their households. This trade-off always occurs in the early part of the rainy season. The main aim of these resources exchange is to improve the livelihood and welfare of those involved. Trade-off of resources is one such tool farmers used in order to deal with difficult economic and business times (Bazar, 2008).

However, there was no evidence of exchanging cattle manure in the study area which could mean that the herders use it on their own farms or the cattle owners' farms.

4.6 Drivers for Social Integration of Fulani

Qualitative method was used to gather information about the ways Fulanis get integrated into the s into the communities. The key people interviewed to achieve the objective were Fulani leaders and communities' chiefs. Effective integration is important in providing mutual benefits for both community indigenes and settlers (Fulanis). From the study, education and security are the major drivers that were mostly mentioned to be promoting social integration in the area. For example, both a Fulani's child and an indigene's child attend the same schools, interact and share ideas at school. Education creates a common platform for interaction, hence promotes social integration. Nonetheless, the educational status of Fulani households was very low. Although the Fulani households are aware of the importance of education, majority (97.5%) of their children were not in school. Only two children of the Fulani chief, representing 2.5% were found attending school in the study area. One of the Fulanis noted that:

We do not have a permanent place to settle, the community people can dismiss us at any time. If we get a permanent place to settle and our security is assured, it will give us the chance to enrol the children in school. If one Fulani does something wrong, the community people make general conclusion about all Fulani households.

Others are simply ignorant about the educational system in Ghana and have the notion that because they are foreigners, they have to pay huge sums of money for their children to have access to education. This was a statement by one of the Fulanis:

I have stayed here for about 20 years yet I do not know Ghana's basic education is free or less costly that is why I have not enrolled my children in school. No one informed me or advised me to enrol my children in school since I arrived in this community.

In addition to permanent settlement and cost, it was shown that Fulanis would enrol their children in school based on the achievement of certain objectives which include rules and regulation governing the Fulani and the indigenes communities; strong leadership among both groups; social acceptance in the communities; income security and access to information. The perception of permanent settlement is about allocating a particular area in the community to Fulanis to build permanent structures. In their view, this is a basic need that will empower them to be socially accepted or integrated into the community. Kamali (1999) also argued that the dimension of social acceptance is aliened to having a sense of belonging and satisfaction. With permanent integration, the Fulanis believe that they can have well developed rules and internal communication within the community. Since their incomes depend on cattle herding, income levels are expected to rise with strong social acceptance, ultimately leading to the strong desire for educating their children.

The relationship of social integration of the Fulani herdsmen and adoption of CLI could have positive impact in the short term as well as long term. Integration of the herdsmen into the Ghanaian society would lead to the sharing of human and agricultural resources.

In terms of human resources, there would be more labour force which is a potential to cub unemployment rate. It would also promote peace, unity and security in Ghana and beyond. Similarly, social integration would promote practises of good agricultural farming to mitigate against climate change.

4.7 Livelihood Strategies of the Herdsmen

Fulanis are well known traditionally as livestock herders and for other economic activities such as crop production, marketing of milk and the provision of farm labour. The major sources of income for the Fulani households are livestock production (cattle, goat, sheep and poultry), crop production and milk marketing in the study area. The major crop cultivated is maize and sometimes millet, they mostly practice mono-cropping. Vegetables cultivated are okra, kenaf, and pepper. These crops and vegetables are grown purposely for home consumption. The primary role of the Fulani women is to sell milk and milk products, especially cheese.

4. 8 Cattle Production and Entrustment systems

In Ghana, there are three main cattle production systems. These are intensive, semi-intensive and extensive production systems. The extensive system involves moving the cattle from the kraal to the bush for fodder and water. Under this system, the cattle choose the type of grasses to feed and the quantity fed depends on the availability of fodder in the area. The opposite is the intensive system where the cattle are housed and provided with feed and water. As such, the cattle are limited by the quantity of feed provided by the owner. A mix of both extensive system and intensive system is the semi-intensive system or semi-zero grazing system.

Table 4.3 shows the distribution of the cattle herding systems practised by the Fulanis in the study area. Majority (80%) practiced extensive system while the remaining 20% used the semi-intensive cattle production system. These production systems could be a potential source of conflict due to destruction caused to crops by the cattle.

Cattle measurement control is a method or measure employed to control unregulated movement especially during the night. Controlling cattle movements in the night prevents the animals from damaging farmers' crops. The inability to control cattle movement brings about conflict between Fulani households and crop farmers. Table 4.3 shows the management practices employed to control cattle movement in the night. The study shows that more than half (54.50%) of Fulani households did not employ any control measures to restrict the cattle movement at night. Moreover, about 41% of households constructed a wooden "Kraal" or fence to house and restrict or prevent the cattle movement at night. The Fulani households that employed the method of "leaving the cattle at a particular area and watching them throughout the night" was about 1.50%. Others used ropes with heavy wood to tie the horns of the cattle to prevent their movement and this represents 3%.

For sustainable peaceful coexistence between the Fulanis and the indigenes, the intensive cattle production system is appropriate and recommended although farmers in the study area did not practise this production system.

Table 4. 3: Cattle production systems

Livestock production system	**Frequency**	**Percent**
Extensive system	160	80.00
Semi-intensive system	40	20.00
Intensive system	0	0.0
Total	200	100
Measurement system	Frequency	Percent
Kraal	82	41.00
Tied with rope	6	3.00
Leave the cattle and watch them throughout the night	3	1.50
No control measurement at night	109	54.50
Total	200	100.00

Source: Author's Computation, 2016.

Entrustment is a process in which there is a mutual arrangement either formal or informal between a farmer and Fulani herdsman, in which the farmer gives his cattle to a Fulani to take care-of, for shorter or longer periods. The term "entrustment" also refers to herding contract (Osken, 2000). The latter is an integral part in the cattle husbandry management between the indigenous farmers and the Fulani herders in the study area. The study revealed that about 76% of the indigenous farmers entrusted their cattle to Fulani herdsmen in the area. A farmer can entrust his cattle to a Fulani herder for a period of time depending on the degree of relationship that exists between them. Cattle are great assets and a farmer needs to have full confidence in a Fulani herder before entrusting his wealth to him. A Fulani herder who has been entrusted can send the cattle to different geographical areas to have access to fodder and water for the animals whilst leaving his family behind as guarantee. The Fulani who has been entrusted with a farmer's cattle derives some benefits for herding the cattle. McMillan *et al.* (1993) cited in Osken (2000) simplified the benefits of entrustment for both the farmer and Fulani herder to include: efficient use of household labour, reducing the risks of stealing/theft, better care and management of livestock and reduction of the likelihood of conflicts between farmers and Fulanis over crop damage when the cattle are sent away. The Fulanis also benefits cattle manure which is used as fertilizer on crop land improves soil fertility as well as control soil erosion.

4. 9 Mobility and Grazing Pattern of Livestock

The mobility of Fulani herders and grazing routes of cattle in the study area have no regular patterns. There are no rules and laws governing animal husbandry and management practices. There are no grazing reserves for livestock rearing; hence they move randomly to get fodder and water for the cattle. The effect of the existing mobility and grazing patterns of cattle pose a potential threat to the irrigation investment and conflict in the area. The headsmen move to any area where there is fodder and water for the cattle; sometimes 6-7 km in the dry season.

Table 4.4 shows Fulani herdsmen's mobility pattern and number of times the cattle drink water per day in the area. The results showed that about 27% of the Fulani herders did not move to other geographical area(s) but stayed in the original communities and provided fodder and water for their cattle. These Fulanis are those the indigenous farmers entrust their cattle to, hence they have strong and good relations with the farmers. About 46% of the Fulani herders moved once (1) to different areas and stayed there for a period of time to access fodder and water for their cattle. Similarly, 24% and 4% of the Fulanis respectively moved twice (2) and thrice (3) to other areas for the same purpose of feeding their cattle. The movement of the Fulani herders to different areas is due to scarcity of water and fodder in a particular community they settled.

Table 4. 4: Mobility Fulani herders and frequency of cattle drinking water

Movement of Fulani herders/year	Frequency	Percent
Zero movement	53	26.50
Move once	91	45.50
Move twice	48	24.00
Move thrice	8	4.00
Total	200	100.00
No. of times cattle drink water/day	**Frequency**	**Percent**
Once a day	21	10.50
Twice a day	166	83.00
Thrice a day	13	6.50
Total	200	100.00

Source: Author's Computation, 2016.

In addition, 83% of the respondents sent their cattle to drink water two (2) times daily, whereas about 10.5% and 6.5% sent the cattle to drink water once and three (1) times per day respectively.

4.10 Management and Agricultural Farming Practices

Poor farming practices adopted by farmers could lead to soil erosion and environmental problems and consequently, a reduction in crop output.

The study revealed that 65% of the respondents used cattle manure in their crop land either by confining the cattle in the crop land or deliberately collecting and applying the manure on the crop land (Table 4.5). Livestock manure is key in practicing conservation agriculture because it has the capacity to improve soil structure and organic content of the soil, hence improve soil fertility in a sustainable way. Manure contains the major crop nutrients such as nitrogen and phosphorus that support crop growth. Smallholder farmers can save money by using manure as fertilizer. However, manure usage should be guided by a nutrient management plan that spells out how to balance crop needs with manure nutrient concentration levels. Appropriate use of manure as fertilizer minimizes nutrient pollution to water resources and helps improve healthy soils for crop development and functioning. Moreover, applying livestock manure on crop land improves soil organic matter. Organic matter advances soil structure and the soil's ability to retain water. A healthy soil improves crop yields and reduces soil loss from both wind and water erosion.

Majority (87.5 %) of the respondents applied chemical fertilizer on their maize plots, albeit complemented with cattle manure. This interaction increases agricultural land fertility compared to the sole use of manure or chemical fertilizer. About 12.5% did not apply fertilizer to their farm plots and this proportion of the farmers could be part of those who solely applied cattle manure as fertilizer.

Table 4. 5: Distribution of farming activities practiced by respondents

Manure use	**Frequency**	**Percent**
Yes	130	65.00
No	70	35.00
Total	200	100.00
Chemical fertilizer	**Frequency**	**Percent**
Yes	175	87.50
No	25	12.50
Total	200	100.00
Main land preparation methods	**Frequency**	**Percent**
Tractor	190	95.00
Hoe and cutlass	9	4.50
Bullock	1	0.5
Total	200	100.00
Mani sowing Method	**Frequency**	**Percent**
Dibbling	175	87.50
Others	52	12.50
Total	200	100.00
Weedicide use	**Frequency**	**Percent**
Yes	195	97.50
No	5	2.5
Total	200	100.00
Left crop residue in field		
Yes	185	92.50
No	15	7.50
Total	200	100.00

Source: Author's Computation, 2016

Tillage is a method of preparing land for crop cultivation by loosening the soil to absorb water and nutrients for crop growth using tractor services and hoe and/or cutlass. The result shows that 95% of the respondents employed tractor to plough/prepare their fields for cultivation. The use of tractor increases the efficiency of farmers. Only 4.5% and 0.50% used hoe and cutlass and bullock for land preparation respectively. The decline of using hoe and cutlass and bullock for agricultural land ploughing is due to modern mechanisations methods such as tractor for land preparation. Using tractor for land preparation increases farmer efficiencies in production, other things being equal.

In Ghana, sowing of seed is mostly done by dibbling/row planting, broadcasting or hoe and cutlasses by smallholder farmers. Approximately 87.50% of the respondents sowed their maize by dibbling/row planting. Dibbling reduces overcrowding of seedling and competition of space for crops. It also minimizes the nutrient competition between crop and weeds in crop fields. Sowing of seed by dibbling/row planting reduces weeds' infestation and also makes weeding in the field very easy for a farmer. It demands less labour for weeding compared to; other sowing methods such as broadcasting and random dibbling of sowing. About 12.50% of the respondents planted their maize by other methods, namely, broadcasting and random sowing by hoe and cutlasses.

Herbicides/weedicides are used in crop farms to control weeds infestation. The result shows that about 97.50% of the respondents sprayed herbicides/weedicides on their maize farms compared to their counterparts (2.5%). The areas where cattle are restricted in the farm to use their manure as fertilizer, weeds infestation is high as compared to the area where cattle are not restricted. Therefore, spraying herbicides/weedicides on crop fields helps reduce the effect of weeds on crops cultivated.

Finally, 92.50% of the respondents left the crop residue/biomass on the crop field without burning it. This means that the farmers recognized the importance of crop residue in agricultural production. Crop residues left on the crop field protects the soil from erosion and other environmental problems bushfire outbreak and air pollution. The crop residue/ also serves as fodder for livestock.

4.11 Fulani herdsmen's Perception of CLI

From Table 4.6, the chi-square estimates show that there is a statistical significance in the agreement among all respondents on each of the indicators designated. All the indicators were statistically significant at 1% level. This means that all the indicators designated have strong association with adoption of CLI. Thus farmers' perception about CLI influences its adoption. The computed mean value of improved soil fertility for adopters and non-adopters of CLI were 4.36 and 4.53 respectively. This means that adopters agreed and non-adopters strongly agreed that CLI improve soil fertility for maize and other crops cultivation. The pooled mean value was 4.45, implying that farmers generally agreed that CLI improve soil fertility. CLI saves farmers resources and reduces waste by recycling products within the farming system. It contributes to soil texture and fertility while being an economic incentive for cultivating multipurpose crops and rearing different animals. This increases farmers' productivity leading to increased welfare.

The second indicator is control of soil erosion. The mean values for adopters and non-adopters of CLI were 4.6 and 4.47 respectively (Table 4.6). This means that adopters of CLI have stronger perception that CLI have the ability to control soil erosion. The overall mean value was 4.53. This means that all the respondents strongly agreed that CLI have the ability to control soil erosion in the mixed farming. CLI contributes in reducing agricultural land degradation (erosion). CLI is a potential to sustainable agricultural farming. Animals' manure and urine encompass several nutrients such as nitrogen, phosphorus and potassium, and the solid fraction contains organic matter that is important maintaining soil structure and fertility (FAO, 2008). Hence, CLI, in the mixed farming systems, enhances farm output by intensifying nutrient and energy sequencing. The long term benefits of mixed farming depend to a large extent on proper adjustment of soils, plants and animals. Manure is one of the most important outputs from livestock production (FAO, 2016). According to FAO (2016), livestock are used to produce high-quality compost and that their integration into agriculture is essential to the sustainability of some of the most intensive cropping sequences in the world.

Furthermore, the mean perception values of reducing risk in production for both adopter and non-adopters of CLI were the same (4.20). This implies that farmers agreed that CLI helps them to spread risk in production process than if they solely depend on either crop farming or livestock production. (FAO, 2008).

In terms of perception on less chemical fertilizer needed on the field, adopters' perception was lower (2.88) compared to non-adopters (3.06), with overall mean value of 2.98. This means that farmers who practice CLI apply small quantities of chemical fertilizer as compared to their non-adopting counterparts. With the overall mean of 2.98, it means that farmers were uncertain whether CLI can lead to less chemical fertilizer application rate in their crop fields. Farmers are likely to use little inorganic fertilizer if engaged in CLI rather than practising specialisation in production. Farmers' dependency on external inputs is low and this permits them to be independent of the fluctuations in the economy if they practise CLI. CLI is a poverty-induced strategy to farmers. Resource-poor farmers go into CLI because of their low purchasing power; they cannot afford external inputs and have no alternative but to overexploit the environment (Slingerland, 2000). This leads to the reduction of cost of production, hence improving farmers' welfare.

In addition, the computed mean values of improved household welfare for adopters and non-adopters of CLI were 4.76 and 4.79 respectively with overall mean of 4.78. This means that both adopters and non-adopters strongly agreed that practising CLI leads to improved welfare. Thus CLI increases the productivity of crops and animals which leads to building wealth for farm households. As farm households' wealth increases it leads to increased household expenditure which is a good measure of human welfare.

Table 4. 6: Respondents' perception about CLI

Indicator	**Adopters**	**Non-adopters**	**Pooled**	**Chi-sq.**	**Sig.**
Perception	Mean	Mean	Mean		
Improves soil Fertility	4.36	4.53	4.45	277.25	0.000
Controls soil erosion	4.60	4.47	4.53	109.27	0.000
Reduces production risks	4.20	4.20	4.20	153.25	0.000
Requires less chemical fertilizer	2.88	3.06	2.98	154.20	0.000
Reduce cost of production	3.91	3.85	3.88	578.75	0.000
Improves household welfare	4.76	4.79	4.78	226.33	0.000
Reduce environmental pollution	4.17	4.11	4.14	278.95	0.000
Makes feed available for livestock throughout the year	4.27	4.06	4.16	137.80	0.000

Source: Author's Computation, 2016

Both adopters and non-adopters agreed that CLI reduces environmental pollution and also makes feed available to animals throughout the year. Crop and livestock integration is managed to minimize environmental damage and to maximize nutrient recycling for the crops. From literature (Nianogo & Thomas, 2004), large parts of the forest and trees are cut to let cattle graze and this often leads to degradation of the environment because of improper management. Likewise, the farmers agreed that CLI makes feed available for livestock throughout the year, especially dry season, more than the other farming practises. Crop residue uses, as feed, provides the energy and minerals that allow animals to stay healthy, grow, produce and reproduce among others. The types of feed used to feed livestock include straw from crops, grass, tree leaves and grains among others depending on the agro climatological conditions and on the mode of farming (FAO, 2008). Livestock in mixed systems in Ghana depends mainly on grazing on wastelands, fallowed croplands or distant grazing zones. Hence, there is the need to explore opportunities to use leaves from leguminous crops, or biomass from crops (green manure) that are grown. For instance, improved fallows, ley farming, crop rotation, among others can improve fodder availability to livestock. Regrettably, the feeding value of such straw and stover (i.e. crop residue) is low (FAO, 2008). Similarly, production of crops such as cereals and oilseeds yields two kinds of by-products that can be used as animal feed. These are the highly valuable grain and oilseed residues and the poor quality straws and stovers (FAO, 2008).

4.12 Factors Influencing the Adoption of CLI

The factors influencing the adoption of CLI were evaluated using the Heckman treatment effects model and the results are presented in Table 4.7. The treatment effect model provides the determinants of both CLI and maize output. The Wald chi^2 is 126.39 and statistically significant at 1% level. This denotes that the overall model is a good fit and the explanatory variables used in the two models (Heckman two stage models) were collectively able to explain the farmers' adoption decisions as well as output.

From the result (Table 4.7), all the independent variables, except dependency ratio, trade off and distance to watering point were significant in explaining adoption decision. While the age; credit; and farm size had positive effect on the probability of practising CLI: age square; herd size and fertilizer had negative effect on adoption.

The age and age squared variables had a positive and negative coefficients and were statistically significant at 5% and 10% respectively. The sign of the coefficients of age and age squared implies that the younger farmers have a higher probability of adoption than the older farmers. However, an increase in a farmer's age decrease the farmer probability of adopting CLI. In other way round, as, the farmer increase in age he/she reaches his/her economic productive threshold at some point reducing the probability of adopting CLI. At this turning point farmers' probability of adopting CLI decreases. This makes a farmer's age assume a quadratic function. In this study, the turning point where farmer ability to adopt CLI decreases is at the age of 51. At this age farm household heads economic productivity is declining and also tend to be a dependant. This may not influence or motivate farmer to adopt agricultural innovations like CLI which is labour demanding.

Herd size, had a negative impact in adopting CLI in the study area. It is statistically significant at 1%. This means that households who had large cattle are less likely to adopt CLI compared to household with fewer cattle. Crop production is being challenged by soil fertility. As a result, livestock manure is a major resource for crop farming. However, large size of cattle is difficult to manage and control with rural communities. This difficulty of managing large cattle makes farm household having cattle to transfer the cattle to remote areas because of scarcity of fodder, water and small land size. Large cattle can also cause environmental pollution which is harmful to human health. Also, in areas where there are many cattle there is conflicts as result of damage of crops and other properties caused by the cattle. Therefore, it is not surprising that farmers with less cattle herd would go into CLI as there is a higher probability of getting folder, land and water. Antony *et al.*, (2013) also found that the number of cattle in Tropical Livestock Unit (TLU) has negative effect in the amount of livestock manure use. However, it is contrary to Hailu *et al.* (2014) and Arslan *et al.* (2013).

Credit has positive effect on the probability of adopting CLI. The coefficient of the credit is statistically significant at 1%. Meaning that farm households who have access to production credit have higher probability to adopt CLI. During the field work, it was observed that there was no microcredit source available to farmers in the study area. However, there were non-formal sources (i.e. friends and relatives) which helped the sample farm households to purchase animal drugs and other inputs. This finding is also in agreement with the finding of Abdulai and Huffman (2014).

Farm size had significant (positive) effect on the probability of CLI. It is statistically significant at 5%. The positive coefficient means that farmers with larger farm plots had high probability of adopting CLI. The positive sign of the coefficients of farm size variable meets the *a priori* assumption. The large farm size means that the farmer can manage both cattle and crops farming at the same time. In this case the larger the farm, the higher the probability of adopting CLI among farmers. Farmers with large land may adopt land-saving technologies such as mixed cropping, crop rotation, fallowing, zero grazing, among others, as an alternative to increased agricultural production. Literature have shown a positive influence of farm size on the adoption of new agricultural innovation. Researchers who reported a positive relation between farm size and adoption of agricultural technology include: Uaiene *et al*., (2009); Mignouna *et al*, (2011) & Signore, (2014). Uaiene *et al*., (2009) argued that farmers with large farm sizes were more likely to adopt a new technology as they can afford to devote part of their land to try new technologies unlike those with less farm sizes. In contrast, other researchers found negative relation between farm size and innovation adoption ((Mwangi & Kariuki, 2015; Bruce, *et al*., 2014).

The coefficient of inorganic fertilizer had negative influence on adoption of integrated crop-livestock diversification, and was statistically significant at 10%. The negative sign means that respondents who were not using fertilizer to supplement cattle manure in their crop fields tended to have high probability of adoption than those who used fertilizer in the study area. This is plausible considering the fact that farmers in the study area either use chemical fertilizer or inorganic fertilizer. Therefore, farmers who do not have the organic fertilizer would have to buy chemical fertilizer for their crop production. Also, having cattle gives the assurance of constant organic manure hence motivates such farmers into crop farming. Hailu, *et al.* (2014) had similar result in 'adoption and impact of agricultural technologies on farm income in Southern Tigray, Northern Ethiopia.'

Table 4. 7: Maximum likelihood of the determinants of CLI adoption

Variable	Coefficient	Standard Error	Z	P>|Z|
CLI				
Age	0.204**	0.088	2.30	0.021
Age squared	-0.002**	0.001	-2.24	0.025
Dependency ratio	-0.048	0.042	-1.12	0.262
Herd size	-0.004**	0.002	-2.10	0.036
Credit	0.459**	0.199	2.30	0.021
Trade off	0.117	0.229	0.51	0.610
Distance to watering point	-0.001	0.001	-1.11	0.268
Farm size	0.200***	0.056	3.57	0.000
Fertilizer	-0.966***	0.252	-3.84	0.000
Constant	-4.916	2.007	-2.45	0.014
Number of observations =	200			
Wald chi-square =	126.39***			

***, **, *, stand for values statistically significant at 0.01, 0.05, and 0.1 levels respectively.
Source: Author's Computation, 2016.

4. 13 Effect of CLI on Maize Output

The selection hazard (i.e. inverse mills ratio, λ) was statistically significant (5%) in Table 4.8, suggesting that there is evidence of a sample selection problem in estimating the CLI equation, hence justifying the use of endogenous treatment effect model. Therefore, the null hypothesis rejected the correlation of errors between the selection model and the outcome model of zero (Wooldrigde, 2006). Therefore, as the selectivity bias has been identified and corrected the estimated coefficients of the explanatory variables are free from the effects of unseen factors that correlate with the CLI.

This study also sought to estimate the effect of CLI on maize production. Table 4.8 shows that the adoption variable was statistically significant (1%) and positive, hence meeting the *a priori* expectation that the adoption of CLI is important for enhancing maize production in the area. This justifies support and calls for the adoption of CLI. Also, by implication the use of organic manure in crop production is vital. In recent times where consumers are raising concerns on the safety of foods due to high chemical use, this finding could be a good justification for policy support to encourage organic fertilizer usage. Also, considering the fact that cattle production, in addition, is a diversification strategy, farmers can use the income from cattle to subsidize crop production, hence the potential of increasing maize production. Integrated crop-livestock farming does not only enhance welfare of farmers and animals but also it is environmentally sustainable in production. The main target of CLI intervention is to boost crop and livestock production in order to accelerate the achievement of sustainable crop and livestock self-sufficiency. The opportunities for farmers to adopt CLI technology will be wider when efforts to increase productivity are also accompanied by efforts to improve quality and increase efficiency of inputs used. This finding is in agreement with the findings of Sserunkuuma (2005), Uaiene *et al*. (2009), Abdallah *et al.* (2014) & Bruce *et al*. (2014), that adoption of agricultural intervention technology had positive effect on output in production.

The results also show that that there was return to the scale of 0.926 in the maize production. The inference of this is that other things being equal, if all the variable inputs are jointly increased by 1%, the maize output would increase by about 93% which is an indication that quantities of other variable inputs in the production function exceed the scale efficient point. This means that crop and livestock farmers (Fulani herdsmen) in the study areas operated under decreasing return to scale. The finding is consistent with that of some developing agricultural countries (Binam *et al.*, 2008; Chirwa 2003; Solis *et al.*, 2009 & Ogundari 2013). The value of the return to scale also denotes that the farmers are operational in the first stage of production possibility curve. This means that farmers have the potential to increase their variable input in maize production needed for farm land/acre. Therefore, farmers need to scale-up their usage of farm land/acre in order to realize the maximum benefits from these inputs usage.

Moreover, from Table 4.8, it is revealed that the independent variables (farm size, labour cost and fertilizer) were statistically significant and also maintained their expected signs except seed, and weedicides. The expected positive signs of the variables imply that an increase in any of these variables will result in an increase in maize output, other things being equal.

Specifically, the coefficient of farm size was statistically significant (1%) and has positive effect on maize output. Holding other variables constant, if farm size increases by 100% it will lead to an increase in maize output by 89% approximately. The farm plot is the basic input in maize cultivation. The average farm size in the study area was 4 acres and this means that, the respondents allocated large portions of their land for maize cultivation.

The coefficient of labour cost is negative and statistically significant at 5%. Other things being equal, a 100% increase in labour cost per acre will lead to corresponding decrease in maize output by about 15%. Labour is an important indicator for adopting agricultural innovation. Literature has established that inadequate labour is a major setback to the adoption of an innovation and productivity. Valipour (2014 & 2015) observed that the reduction in rural farming population involved in agriculture signifies a decline in labour availability in the future. Hence, cost-effective innovations in terms of labour demand should be developed and disseminated to farmers in order to increase productivity.

Table 4. 8: Maximum Likelihood Estimates of treatment effect model: two step estimates

Variable	Coefficient	Standard Error	Z	P>|Z|
Maize output				
Farm size	0.888***	0.145	6.13	0.000
Seed	0.072	0.104	0.7	0.487
Fertilizer	0.103***	0.038	2.73	0.006
Labour Cost	-0.152**	0.060	-2.53	0.012
Weedicides	0.015	0.037	0.41	0.683
CLI	0.989***	0.324	3.05	0.002
Constant	5.522	0.246	22.41	0.000
Hazard lambda	-0.449**	0.196	-2.29	0.022
Rho	-0.60979			
Sigma	0.737047			
Return to scale	0.926			

***, **, *, stand for values statistically significant at 0.01, 0.05, and 0.1 levels respectively.
Source: Author's Computation, 2016.

The quantity of fertilizer applied was positively associated with output but it was not statistically significant. Recall that CLI also had a positive effect on output where it was justified that the livestock provides organic manure for maize production. Therefore, the joint effect of adoption of CLI and fertilizer in this model means that fertilizer is very essential for achieving higher maize output in the study area.

4.14 Constraints to CLI

The constraints to crop-livestock production and management identified include scarcity of water in the dry season, theft or stealing, animal and crop disease, scarcity of fodder in the dry season, high cost of production, lack/inadequate training, incompatibility with societal norms and values, land tenure problem and poor road network. Considering the study location where IWAD Irrigation Project is, these constraints will be more evident, but it will also have some advantages. For instance, some of the lands in the Mamprugu-Moagduri District are not being currently utilized for cropping but are regularly burnt during the dry season thereby reducing the availability of fodder in the area.

Climate change and variability also affects the availability of fodder and water for the cattle and other small ruminants. These factors would compel the herdsmen to adopt management strategies such as integrated crop-livestock farming which would maximise feed utilisation by livestock. The Fulani may in some instances begin to grow more rain-fed crops in order to produce grains for household consumption and utilise crop residues as cattle feed. The cultivation of dual purpose legumes for both human and livestock consumption could be encouraged as a package. Improved feeding techniques including the establishment of fodder banks are pathways for successful implementation of integrated crop-livestock diversification. However, the bottlenecks in cattle rearing which have indirect negative effect on CLI are discussed below.

The Kendall's Coefficient of Concordance (W) ranking shows the level of agreement between the rankings of the individual respondents. In this study, the most challenging variable was given the smallest value of one while the least challenging variable had the greatest value of four.

First of all, the mean value for inadequate and or lack of training with regard to crop-livestock production was 1.96. This was the first challenge that affected crop-livestock production management facing farmers in the study area. Training enhanced technology transfer and adoption of agricultural technologies (Stroebel, 2004). According to Atnafe *et al.* (2015) farmers that participated in crops and livestock training increased the probability of adoption agricultural technologies. Efforts to disseminate new agricultural technologies to the end users should be encouraged. Participating in farming training programme and visiting demonstration regarding CLI practices has impact on the adoption process of CLI (Mwangi & Kariuki, 2015). Farmers' participation in training thus influences their attitudes and thoughts making them more open, rational and able to analyse the benefits of the new technology.

The mean value for scarcity of water in dry season was 3.12, and this means that out of the nine challenges facing crop-livestock production and management, scarcity of water in dry season was ranked as a second major constraint to crop-livestock production. The inference is that any support to improve cattle production should target fodder bank management and agroforestry. Over the years it has been detected that fodder for livestock production has been a challenge due to climate change and the following excerpts support this assertion:

The fodder is a big problem because there is no green grass in the dry season for our cattle and even the dry grass usually is burnt by hunters and some of our people as well as the indigenes. Bushfire and less rainfall cause reduction in grass species and volume for the cattle and we have to travel long distances to access fodder/grass for the cattle. In the rainy season, there is problem accessing fodder because of farming activities. Some are in cattle routes are in farmers' farms which make it difficult to follow these routes to access grass for the cattle. There is no reserved land for cattle grazing in the community both in wet and dry season. This makes it difficult for us in cattle herding, since we do not know where to pass.

The mean value of disease affecting animals and crop affecting crop-livestock production was 3.77. This means that crop and cattle disease was third among the challenges facing crop-livestock production so support in terms of agronomy and veterinary services should be geared towards crop and livestock production. The diseases that usually attack the cattle are foot, mouth and heart diseases. Also, cattle stealing/theft and scarcity of water in the dry season had a mean of 4.28 and 5.94 respectively.

Similarly, with mean value of 4.23, poor road network was ranked fourth as a challenge facing farmers practising crop-livestock production. Poor road network linking the rural settings to the urban centres affects technology transfer and its adoption. It affects farmers to have access to technologies and farm input to increase production.

Table 4. 9: Challenges for crop -livestock production rank by respondents

Challenges	**Mean value**	**Ranking**
Inadequate and or lack of training	1.96	1st
Scarcity of fodder in dry season	3.12	2nd
Disease affecting animals and crop	3.77	3rd
Poor road network	4.23	4th
Theft or stealing	4.28	5th
High cost of production	5.74	6th
Scarcity of water in dry season	5.94	7th
Land Tenure problem	7.28	8th
Incompatibility with societal norms and values	8.67	9th
Kendall's coefficient of concordance (W)	0.612	
Chi square (df=8)	979.558***	
Observation	200	

Source: Author's Computation, 2016

High cost of production; incompatibility with societal norms and values and land tenure problem had a mean value of 5.74, 8.67 and 7.28 respectively. Inadequate budgetary allocation, limited infrastructure development, and inadequate livestock research (Befekadu & Berhanu, 2000 & Deressa, *et al.*, 2008) contribute to poor crop and livestock production. Other environmental or climatic factors such as flood, bushfire, tsetse fly infection, long dry season, soil degradation, deforestation, and illegal mining influence negatively on livestock production. Therefore, there is the need for Fulani herders as well as indigenes who possess cattle to adapt good management practices such as CLI in cattle rearing in order to improve cattle rearing business and these will improve their livelihoods.

The degree of agreement among the respondents is measured by the Kendal's W. A higher value shows the degree of agreement among the respondents of challenges facing in cattle production. The value of W was 0.63 and it is significant at 1% (Table 4.10). This implies that generally, there is about 63% level of agreement among the respondents on the challenges they face in cattle production.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Chapter outline

This chapter presents the summary of the research findings as well as the conclusions and recommendations. The chapter has three sections. The first section highlights the summary of the findings of the whole study while the second and third sections cover the conclusion and recommendations emerging from the findings respectively.

5.2 Summary

Many peasant farmers in SSA countries sustain their livelihood by adopting CLI. The real and the best known strategies form of CLI is when crop residues are used to feed the livestock and the excreta and or manure from the livestock are used to fertilize the land for crops' production. The modern organic farming systems rest on CLI. Conventionally, CLI has been used worldwide. CLI is essential for the livelihood of farmers, and for that matter the production of food crops and livestock to meet human needs of crops and livestock products. Usually, CLI has been practised for long, and both developed and developing economies are exploring the advantages of CLI. Therefore, the study aimed to explore the potentials of CLI in increasing maize production of Fulani herdsmen in the Mamprugu-Moagduri District of the Northern Region of Ghana. Specifically, it sought to examine the Fulani herdsmen's perception of CLI on soil fertility and erosion control (Objective 1); analyze the factors that influence CLI among Fulani herdsmen (objective 2); determined the effects of CLI on maize output of the Fulani herdsmen (objective 3) and explore some constraints to CLI adoption (objective 4).

This study was carried out in Mamprugu-Moagduri District in the Northern Region of Ghana where Fulani herdsmen are dominant. The Fulani herdsmen are traditionally and professionally herders of livestock at the same time and engage in crop production. The study used a total of 200 respondents. This was attained through a multi-stage sampling technique. A cross sectional data for 2015/2016 cropping season was used for the study. Primary information was solicited from the respondents using semi-structured questionnaire. Fulani herdsmen in the Yagba, Goriba, Loagri, Kubori, Kuuba, Jeri-Kantem, Gbima, Sakpaba, Prima and Kubugu formed the study units.

Descriptive statistics were used to achieve objectives one, two, three and six. On the other hand, estimating the effect of CLI on maize output of the Fulani herdsmen involved the estimation of a Treatment Effect model. This model allowed for the estimation of the factors influencing adoption of CLI and the pure effect of adoption on maize output.

The study revealed that about 26% of the Fulani herdsmen were solely herding their own livestock whilst the remaining (74%) were herding their own and that of the indigenes (mixed) livestock. The implication is that Fulanis are getting integrated into the Ghanaian society and more effort should be made to ensure full integration to eliminate or minimise conflicts between them and the indigenous farmers.

The first objective was to explore agricultural practices adopted by the Fulani herdsmen in the study area. The study established that some of the agricultural practices adopted by the Fulani herdsmen included use of weedicides (87.5%); land preparation by tractor (95%);

dibbling and chemical fertilizer used recorded 87.5%. Animal manure use on the crop field recorded the lowest (65%) among the agricultural practices adopted by the farmers.

Eight indicators were used to examine farmers' perceptions of CLI. The mean values were recorded as follows: improves soil fertility(4.45); , controls soil erosion(4.53); reduces production risks (4.20); requires less chemical fertilizer (2.98); reduce cost of production (3.88); improves household welfare (4.78); reduce environmental pollution (4.14) and makes feed available for livestock throughout the year (4.16). The Chi-square test at 1% significant level means that there was a general agreement in the responses provided.

A probit estimation of the factors influencing the adoption of CLI was conducted. The probability of CLI was high for the following: younger household farmers; household with less number of cattle; households having access to credit; farm households with large farm size; and farm households that use less chemical fertilizer. However, the reasons for non-adoption of CLI by were herding the cattle for indigenes and inadequate social security in the study area.

The study also found that CLI had a positive effect on the maize output of the farmers. What it means is that farmers who adopted CLI had a better maize output compared to the non-adopters of CLI. Also, while farm size and fertilizer contributed positively to increasing maize output, high labour cost lead to decrease maize output.

The bottlenecks affecting adoption of CLI as given by the farmers arranged in order of importance were as follows: Inadequate and or lack of training; scarcity of fodder in the dry season; disease affecting crop and livestock production; poor road network; or stealing;

high cost of production or adoption of CLI; scarcity of water in dry season; land tenure problem; and incompatibility with societal norms and values.

5.3 Conclusions

The study concludes that most agricultural practices adopted by the respondents were the use of weedicides (97.50%); land preparation by tractor (95%); left crop residue on field; dibbling (87.5%); chemical fertilizer (87.5%) and manure (65). About 53% Fulani herdsmen adopted CLI. The probability of adopting CLI in the study area is high for the following categories of farmers: younger farmers; relatively large farm holders; farmers who have access to credit; farmers with small herd size; and farmers who adopted less inorganic fertilizers.

Similarly, the adoption of CLI leads to increased maize output. Other factors that lead to increased maize output are large farm size and the adoption of inorganic fertilizers. High labour cost however is detrimental to increased output. Training is a major constraint to CLI adoption in the study area

5.4 Recommendations

Given that the adoption of CLI leads to increased output, both government and civil society organisations should support the farmers to embrace CLI adoption. The youth and the relatively large maize farm holders should be targeted for support. Also, since credit leads to high probability of CLI adoption, the farmers should be supported to have access to credit. Similarly, since high labour cost leads to smaller output, the farmers should form

FBOs so that they can support one another on their farms to cut down labour cost. Lastly, training opportunities in CLI should be given to the farmers to enhance their skills so as to increase adoption.

The study used cross sectional data. This provides a picture of CLI adoption and its effects within one season and at a relatively smaller geographical area. Future research should use panel data so as to give a wider and long term picture of CLI adoption and its effects.

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LIST OF APPENDICES

APPENDIX 1: QUESTIONNAIRE

University for Development Studies, Tamale-Ghana
Faculty of Agribusiness and Communication Sciences
Department of Agricultural and Resource Economics

I am an MPhil student in the University for Development Studies. As part of requirement of my degree, I am carrying out a research on the determinants and effects of maize crop and livestock integration among Fulani herdsmen in Mamprugu-Moagduri district, Northern Ghana. The aim of this research is to explore the potentials of maize crop and livestock integration in increasing maize productivity of farm households. I therefore kindly request your participation in the research by answering the following questions to fill this academic gap. Your privacy is assure and your response is sorely academic purpose. Thank you**.**

I ………………………………… accepted to be respondent in this research.

Name of interviewer………………………………… date......../……/2016

Community name………………..

Section A: Household and socio-economic Characteristics

1. Age of respondent ……………………….
2. Sex of the respondent (1) Male (2) female
3. Current marital status (1) married (2) single (3\0 \divorce (4) Widowed/Widower
4. Are you the household head? (1) Yes (2) No
5. Educational status (1) No formal education (2) Primary (3) JHS/Middle School (4) SSS/SHS (5) Tertiary
6. Number of years in formal education ………………………………
7. Please, fill the table below on your current household size
8. Total number of people in the household …………………………..

Age category	Number of people
Less than 15 years	
Between 16-35 years	
Between 36-65 years	
Above 65 years	

9. Experience in agricultural diversification in years ……………………
10. How many crops have you cultivated last season? …………………….
11. How many animals are you currently rearing? ………………………….
12. Do you engage in off farm activity? (1) Yes (2) No
13. If yes, total annual income of the activity ……………………………..
14. Do you own land (1) Yes (2) No
15. Size of the farm land …………………acres
16. Do you share family labour in agricultural diversification? (1) Yes (2) No
17. Do you have access to credit for production? (1) Yes (2) No

18. What is your perception about importance of production credit in integrated crop-livestock farming? (1) Less important (2) Important (3) Very important
19. Distance from home to market………………….minutes
20. Distance from homestead to farm ……………….minutes
21. Distance from home to watering point …………………minutes
22. Access to agricultural extension service (1) Yes (2) No
23. If yes, number of time extension service personnel visit……………………..
24. Do you have stable income from agricultural diversification (1) Yes (2) No
25. Did you used plough tillage in the last season in your farm plot? (1) Yes (2) No
26. Access to good road network (1) Yes (2) No
27. What quantity of fertilizer did you used to apply to your farm last season?...……….kg
28. Are you a beneficiary of fertilizer subsidy policy last season? (1) Yes (2) No
29. Have you store crop residue? (1) Yes (2) No
30. Do you feed you livestock with crop residue? (1) Yes (2) No
31. Do you belong to farmers association? (1) Yes (2) No
32. If yes, number of years ………………………………….
33. Have you ever had any training on agricultural diversification? (1) Yes (2) No
34. Do you participate in irrigation the last farming season?(1) Yes (2)No
35. Do you have mobile phone (1) Yes (2) No
36. Do you have radio (1) Yes (2) No

Section B: Livestock production system and manure use

37. Type of cattle rearing system (1) I own all my cattle (2) I own some (3) I don't own any
38. In the case of 2 or 3 what arrangements, in terms of payment, do you have with the cattle owner?
……………………………………………………………………………………
39. How do you feed your cattle? (1) Solely fodder at home (2) Solely when they go out (3)Partly when they go out and when at home
40. How do you treat your animals when they are sick? Please tick where applicable. (1) Veterinary services (2) Traditional medicine (3) None

<u>Section C: Agricultural Diversification</u>

41. Fill the table below on agricultural diversification/integration strategies you practice.

Strategy	Response	Number of crops cultivated or animals rearing	If yes average annual income
Mixed cropping (Crops diversification)	(1)Yes (2) No		
Livestock diversification (animals rearing)	(1)Yes (2)No		
Crop–livestock integration	(1)Yes (2) No		

42. I would like you to answer the following questions related to your crop-livestock farming.

Item	Yes	No
Do you use your animals to plough your crop field directly or indirectly?		
Do you sometimes titter your cattle on your crop farms to fertilize your field?		
Do you feed your cattle with some of the straws or produce from your crops?		
Do you deliberately grow fodder to feed your livestock?		
Do you sometimes exchange manure with fodder from a friend?		
Do you sometimes exchange cattle, milk or other cattle products with land or farm produce from a friend?		

Section D: Perceive benefits of crop-livestock integration

43. What is your perception about practising integrated crop-livestock farming among farmers? (1) Increasing (2) Reducing (3) Undecided
44. Kindly indicate your level of agreement of the effect for practising integrated crop-livestock farming on the following (*5 being strongly agree and 1 being strongly disagree*)

Indicator	Level of agreement				
	5	4	3	2	1
Improve soil fertility					
Control soil erosion					
Reduce risk in production					
Less chemical fertilizer need					
Reduce cost of production					
Improve household welfare					
Reduce environmental pollution					
Feed available for livestock throughout the year					

Section E: Socio-psychology and Security

45. Do you see conflict between indigenes and Fulani herdsmen in this area? (1) Yes (2) No
46. If yes, what is the major cause of conflicts? (1) crop destruction (2) watering points (3) ethnic differences (4) grazing on farm land
47. What is your view in regard to your stability in this village in term of security? (1) Not secured (2) Sometimes secured (3) Always secured
48. What is the major source of insecurity in your view in this village? (1) Crop destruction (2) conflicts (3) Theft (4) Ethnic differences (5) inadequate feed and watering points

Section F: Characteristics of agricultural land

49. What is your perception level of your farm land soil fertility status? (1) Poor (2) medium (3) Fertile
50. What is the severity level of soil loss in your farm plot? (1) None (2) Light (3) Medium (4) severe

Section G: agricultural farming practices

51. Please indicate which of the following farming techniques you normally adopted on your maize farm and the how important they are to. Please also indicate any problem you are facing with respect to using them.

CA technique	Tick	Rank 1=Not very important; 2=Important;3 very important	Any problem
Manure application			
Crop residue/mulching			
Inorganic fertilizer			
Composting			
Crop rotation			
Row planting			
Dibbling			
Herbicides/weedicides			
Making ridges			
Minimum/zero tillage			
Cover cropping			
Intercropping			
Others			

Section H: Crop production and cost structure

52. I will like you to tell me the size of your maize farm in acres, what quantity of seed you normally plant, how many people work on your farm and the quantities/costs of fertilizers you use.

Cost Item	Quantity/Number	Per unit cost where application	Total cost/Number
Farm size in acres			
Seed			
Land preparation			
Household labour			
Hired labour			
Inorganic fertilizers			
Manure			
Insecticide			
Weedicide			
Others			

53. When you use the above inputs what level of maize output do you normally obtain and at what price?

Item	Qty 100kg	Unit price 100kg	Revenue
Quantity harvested in(100kg bag)			
Quantity sold (100 kg bag)			
Quantity consumed 100kg bag			

Section I: challenges for practising crop-livestock integration

54. What are some of the challenges for practising crop-livestock integration? Mention them according to the most challenge to least challenge problem.

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

Thank you very much for your time. Contact number…………………

Appendix 2: Check list for community chief interview

1. Name of the community: ……………………………………………….
2. Name respondent: ………………………………………………….
5. How many people own cattle within your community?
(a) 1-5 (b) 6-10 (c) 11-15 (d) 16 above
7. What is the size of the communal land within your community?
…………………………………………………………………………………………
8. How is the communal land distributed among the members of your community?
…………………………………………………………………………………………
9. How many Fulani settlement do you think are currently living in in this community?
…………………………………………………………………………………………
10. What is your opinion about the Fulani?
…………………………………………………………………………………………
11. How is the general relationship between the local Ghanaian community and the local Fulani community?
…………………………………………………………………………………………
12. How many heads of cattle do you own? ……………………………………
13. How many herders are working for you? ………………………………..
14. How do you pay the herders?
…………………………………………………………………………………………
15. What do you do when comes a new Fulani family arrives to your community?
…………………………………………………………………………………………
16. Which conditions do you arrange to the Family for settling?
…………………………………………………………………………………………
17. How the families pays the rent of the land?
…………………………………………………………………………………………
18. In which cases do you ask Fulani to leave the area?
…………………………………………………………………………………………
19. How you distribute the farming land between the Fulani during the rainy season?
…………………………………………………………………………………………
……………………………………………………………………………
20. How a Fulani household can get a bigger portion of land?
…………………………………………………………………………………………
21. Do they usually farm the same portion of land every year? (a) Yes (b) No
22. Do you involve the Fulanis in the decision-making? (a) Yes (b) No
23. How do you communicate with the Fulani?
…………………………………………………………………………………………
24. How you manage when the cattle invade or damage crops from a farmer?
…………………………………………………………………………………………
25. Do you have any relation with the migratory Fulani? (a) Yes (b) No.
If yes describe the type of relation.
…………………………………………………………………………………………
26. What do you know about the bushfires?……………………………………………

27. In your opinion, what ways can Fulani herdsmen be integrated in the Ghanaian?

…………………………………………………………………………………