UNIVERSITY FOR DEVELOPMENT STUDIES

TRADITIONAL AND WESTERN KNOWLEDGE SYSTEMS IN SMALLHOLDER AGRICULTURE: HARNESSING SYNERGIES AND COMPLEMENTARITIES FOR IMPROVED HOUSEHOLD FOOD SECURITY IN THE KASSENA NANKANA TRADITIONAL AREA, GHANA

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BY

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OCTOBER, 2019

DECLARATION

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

Michael Pervarah ……. ……

(Name of student) **Signature** **Date**

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.

Prof. Joseph Awetori Yaro ……..… …….

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ABSTRACT

The debate on integrating traditional and western knowledge systems remains a challenge in research and development practice. Some scholars and development practitioners have underscored the need for the two bodies of knowledge systems to work together to achieve sustainable agricultural development. However, what appears to be missing in the debate is how the two bodies of knowledge can be purposely integrated and the context in which integration can be successful. This study set out to investigate how socially differentiated smallholder farmers harness synergies and complementarities between traditional and western agricultural knowledge systems to improve household food security in northern Ghana. Using an exploratory sequential mixed method design, the study employed a three-phased approach entailing the use of focus group discussions, surveys and in-depth interviews to engage study participants in the Kassena Nankana Traditional Area. The findings showed that social differentiation among smallholder farmers has considerable influence in shaping the choice of smallholder farming systems with high resource-endowed smallholder farmers predominantly in lowland and bush farmlands blending relatively high proportions of western farming technologies such as tractor ploughing, herbicides, and chemical fertilizers driven by profitability associated with market-oriented production. On the other hand, the study found that low resource-endowed farmers predominantly utilizing compound farmlands, where the bulk of household food crops are cultivated, rely extensively on traditional farming methods such as hand weeding with hoe, use of animal manure, and use of own recycled seeds stimulated by the desire to attain household food sustenance. However, the study noted that the manner of integrating the two bodies of knowledge is neither sufficient to induce sustainable agriculture nor bring about any notable changes to household food security. For effective synergy in addressing emerging challenges of smallholder agriculture, the study recommends that both public and private extension agents adopt an endogenous model to knowledge integration and processes that draws on synergies between traditional and western agricultural knowledge systems to facilitate smooth innovation diffusion for sustainable household food security. The study recommends that the National Agricultural Development Policy Framework should recognize traditional agricultural knowledge as a useful tool for sustainable rural agricultural development.

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God is the only reason I have made it this far.

DEDICATION

To my lovely wife: Naomi and children: Sabina, Austin and Shantel

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LIST OF ACRONYMS AND ABBREVIATIONS

AAGDS	Accelerated Agricultural Growth and Development Strategies
ACDEP	Association of Church-Based Development NGOs
ADVANCE	Agricultural Development and Value Chain Enhancement
AMSEC	Agricultural Mechanization Service Centers
CAAP	Comprehensive Africa Development Programme
CSIR/SARI	Council for Scientific and Industrial Research-Savannah Agricultural Research Institute
DFID	Department for International Development
DOA	Department of Agriculture
DSG	Dry Season Garden
EPA	Environmental Protection Agency
FAO	Food and Agricultural Organization
FASDEP	Food and Agriculture Sector Development Policy
GAP	Good Agricultural Practices
GDP	Gross Domestic Product
GHS	Ghana Health Service
GMO	Genetically Modified Organism
GoG	Government of Ghana
GPRS	Ghana Poverty Reduction Strategy
GSGDA	Ghana Shared Growth and Development Agenda
GSS	Ghana Statistical Service
HIPC	Highly Indebted Poor Country

ICRA	International Center for Development Oriented Research in Agriculture
IITA	International Institute of Tropical Agriculture
KNE	Kassena Nankana East
KNTA	Kassena Nankana Traditional Area
KNW	Kassena Nankana West
MAHFP	Month of Adequate Household Food Provision
METASIP	Medium-Term Agricultural Sector Investment Plan
MESTI	Ministry of Environment, Science, Technology and Innovation
METSS	Monitoring Evaluation and Technical Support Services
MoFA	Ministry of Food and Agriculture
MSP	Multi-Stakeholder Platform
NAFCO	National Food Buffer Stock Company
NDPC	National Development Planning Commission
NEPAD	New Partnership for Africa's Development
NGO	Non-Governmental Organization
PFAG	Peasant Farmers' Association of Ghana
PID	Participatory Innovation Development
PSIA	Poverty and Social Impact Analysis
RELC	Research Extension Liaison Committees
RESULT	Resilient and Sustainable Livelihoods Transformation
SDG	Sustainable Development Goals
STI	National Science, Technology and Innovation
UER	Upper East Region

UN	United Nations
UWR	Upper West Region
VSLA	Village Savings and Loans Associations
WFP	World Food Programme

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

Agriculture is by far the major economic activity in sub-Saharan Africa and provides the main source of food, income and employment to the rural population (Fuglie & Nicholas, 2013). It is often argued that agricultural growth is particularly effective in reducing hunger, malnutrition and poverty in Sub-Saharan Africa (Schneider & Gugerty, 2011; WFP, 2012; Fuglie & Nicholas, 2013). Although agricultural productivity is increasing slowly, it is far below the needs of the continent (Block, 2014).Therefore, for the sector to make any significant contribution to address the regions' food insecurity and meet the needs of the growing population, much higher levels of agricultural productivity in a sustainable manner is required.

Ghana has a long history of initiatives to improve agricultural productivity of smallholder farmers. The Ministry of Food and Agriculture (MoFA) and other international and local NGOs have made substantial investments in food security initiatives with monumental donor support for agricultural transformation, particularly, in northern Ghana. However, it does appear that the efforts to improve food security in northern Ghana have not resulted in the expected outcomes. Some researchers and practitioners have argued that development interventions are not often rooted in African traditional knowledge systems and practices and do not address local realities and cultural meanings that shape their livelihoods and wellbeing (Haverkort, Apusiga, Millar, Shankar, Rist, & Delgado, 2012).

The conventional approach to enhance agricultural production and productivity usually consists of wholesale transfer of western technologies, knowledge and values from the global north to the global south which mainly seeks to transform agriculture in line with market rationalities. As a result, intense efforts are made to modernize agriculture by focusing on mechanization, promotion of mono-cropping, cash crops, use of hybrid seeds, inorganic fertilizers, agro-chemicals and capacity building in good agronomic practices (GAPs) and business development for farmers to take up "farming as a business".

Traditional knowledge systems which form the basis for local decision-making and problem-solving strategies for agriculture, healthcare, natural resources management, and other activities have been relegated in favour of western scientific agricultural technologies (Nnadi, Chikaire, & Ezudike, 2015).Very few initiatives in northern Ghana encourage the use of traditional knowledge and farming practices as measures to improve food production, food preservation, storage, pest management, livestock management, and local weather forecasting. Some traditional practices being promoted include composting and bunding at very low scale and adoption of such practices in communities where they were hitherto not practiced is low. Nonetheless, traditional farming practices remain resilient among smallholder farmers in northern Ghana. Given that traditional knowledge systems still form the main driving force in decision-making processes regarding land use, food production, learning and experimentation in rural areas, the question being asked is whether traditional farmer knowledge and skills can complement western agricultural technologies to improve agricultural production and productivity to enhance household food security among smallholder farmers in northern Ghana?

All too frequently, western science and traditional knowledge are represented as two different competing knowledge systems characterized by a binary divide (Agrawal, 1995; Briggs, 2005; Briggs, 2013). Western science is seen to be open, systematic and objective, dependent substantially on being a detached center of rationality and intelligence, whereas traditional knowledge is seen to be closed, parochial, unintellectual, primitive and emotional (Agrawal, 1995; Ellen & Harris, 2000; Herbert, 2000). It appears that recent empirical works have served only to emphasize the binary tensions.

The central argument of this thesis is that rather than the two bodies of knowledge being seen as separate and coexisting together and researchers dwelling so much on the binary debate, sustainable agricultural developments may be better served by a system that draws on the synergies and complementarities between traditional and western agricultural knowledge systems because both knowledge systems embody rich notions, practices and competitive advantages that can be harnessed to improve household food security among smallholder farmers.

This is against the backdrop of the fact that farmers rarely compartmentalize knowledge into such separate, self-contained entities, but rather they develop knowledge as something that is hybridized, mediated and local (Briggs, 2013). If a particular piece of knowledge works for a farmer, and it makes economic and socio-cultural sense, then it will be used, regardless of whether it is drawn from western science or some other source. Indeed, smallholder farmers are very much aware of the availability of modern technologies but are making conscious decisions to use particular methods which suit their own local circumstances.

It is in this light that this study investigated how smallholder farmers are harnessing the complementarities and synergies between traditional and western agricultural knowledge systems to improve household food security in the Kassena Nankana Traditional Area (KNTA) in the Upper East Region of Ghana. The focus on the KNTA is because it is one of the major agricultural hubs in northern Ghana (Kansanga, Kpienbaareh, Mason-Renton, Atuoye, Seno, Antabe & Luginaah, 2019). As a result of its centrality to agriculture production, the community has been a destination for piloting a number of modern agricultural initiatives including the Tono irrigation scheme (p.5). The significance of the current study therefore is in two folds. Firstly, it contributes to the discourse on knowledge integration to improve crop production in northern Ghana and reveals contextual constraints to inform extension delivery approaches for differentiated smallholder farmers. Secondly, it provides a deeper understanding of smallholder farming systems and the blend of farming practices to inform evidence-based policy advocacy and decision-making to effectively transform agricultural production in northern Ghana.

1.2 Problem Statement

Ghana has made significant development progress in the last decade and is often hailed as a success story in African development. However, national averages conceal severe regional disparities. Northern Ghana, which includes the Northern, Upper East and Upper West regions, is poorly endowed with natural resources and the income per capita of its population falls below the national average (Marchetta, 2011). These three regions have continued to record higher incidences of poverty, food insecurity and malnutrition. For instance, the Upper East region has majority of the severely food insecure (6.4%) followed by Northern (2%) and Upper West region (1.4%) (Alhassan, 2015; Nkegbe, Abu &

Issahaku, 2017). According to the World Food Programme Comprehensive Food Security and Vulnerability Analysis report, the Kassena Nankana Municipal and Kassena Nankana West District are among the five districts with the highest proportion of food insecure households in northern Ghana (WFP, 2012).

Food insecurity in northern Ghana is largely attributed to the general poverty levels and poor performance of agriculture (WFP, 2012). Decline in agricultural performance is mainly caused by poor soil fertility and rainfall variability (Derbile, 2010; Kombiok, Saaka & Sogbedji, 2012) resulting to poor crop yields and thereby posing a greater challenge for households' ability to attain food security (Alhasan, 2015; Nkegbe et al., 2017).

Low soil fertility in northern Ghana is partly blamed on continuous cropping system without any conservation measures. Some studies attribute the low soil fertility in northern Ghana to bush fires which usually occur annually during the dry season (Kombiok et al., 2012). In the case of soils in the Upper East Region, Kranjac-Berisavljevic, Boyorbor, and Obeng (1999) assert that the parent rock materials of the area are granites and that soils developed over them have a low inherent fertility status. Derbile (2010) recounts how most farmers in the Atankwidi basin in the Kassena Nankana District (KND) perceive that soils were relatively more fertile during the era of their fathers and grandfathers than they are today.

Rainfall variability is a major threat to the livelihood of smallholder farmers in northern Ghana. Most farmers assert that the current rainfall regime makes crop farming problematic. Their account reveals unfavorable intra-annual distribution which often leads to dry spells and drought in some months and high rainfall intensities in other months

during the rainy season (Derbile, 2010). These farmer perceptions of rainfall variability have been corroborated by several studies (Yaro, 2004; Derbile 2010; Kasei, Diekkrüger, & Leemhuis, 2010). Yaro (2004) observed that rainfall variability is the single most important vulnerable-imposing variable of the climate in the Kassena Nankana District of the Upper East Region.

There is much evidence to suggest that even when modern technologies and best practices are well proven and made available to smallholder farmers, achieving broad-scale adoption remains a formidable challenge (IITA/ELARD, 2013) because most smallholder farmers often return to their traditional farming practices by default after a period of intervention to scale up adoption. Although smallholder farmers are well aware of the existence of both traditional and western knowledge systems, little is known about how the two forms of knowledge systems are shaping smallholder farming practices in crop production in northern Ghana. This raises a number of relevant questions: Are the two knowledge systems operating independently of each other in smallholder farming systems? How are smallholders experimenting and/or applying both knowledge systems in crop production? How are smallholder farmers harnessing the synergies and complementarities between the two knowledge systems to improve household food security outcomes? What are the household food security situations of smallholder farmers who blend the two forms of knowledge systems?

Even though some researchers and development practitioners have underscored the need for the two knowledge systems to work together to achieve sustainable agricultural development, little documentation exist on how the two may interact (Sollitoe, 2010; Briggs, 2013). Over the years, some scholars have resisted knowledge integration on the

grounds that conceptual models and ontologies of traditional knowledge and conventional science are sufficiently distinct to make these knowledge systems incommensurable (Atran, 2001; Verran, 2001; Cruikshank, 2005) and that some forms of integration can have unintended and undesired consequences (Fox, Suryanta, Hershock, & Pramono, 2006). Other schools of thought support integration of traditional and western knowledge systems along several lines of argument (see Maffi, 2001; Nelson, 2005; Maffi & Woodley, 2012). However, what appears to be missing in the debate is how traditional knowledge and western knowledge systems can be usefully and purposely integrated and the context in which integration will be appropriate and effective to ensure smooth diffusion of innovation for sustaining agricultural production. But the question is how would this be achieved?

Consequently, the problem to be addressed in this study is that, the interface, association and interactions between traditional and western agricultural knowledge systems is largely unexplored in research despite a long history of agricultural extension and community development in Africa. Besides, it is unclear how smallholder farmers deal with the competition between the two knowledge systems, harness the complementarities and synergies between them, make trade-offs and rationalize their choices in blending the two systems for sustaining agricultural production and enhancing household food security. This is based on the premise that the two bodies of knowledge, in their different ways, are quite limited in their abilities to address sustainable agricultural production and may not be viable alternatives in themselves in the light of increasing challenges and complexities of development affecting smallholder farmers.

1.3 Research Questions

Main question

The main research question which guided the investigation was: How do smallholder farmers harness synergies and complementarities between traditional and western agricultural knowledge systems to improve household food security situation in the Kassena Nankana Traditional Area?

Sub questions

The sub-questions addressed in this study include:

a. How do smallholder farmers in the Kassena Nankana traditional area describe their farming systems and what factors influence differentiated smallholder farmers in their choice of farming systems?
b. How are differentiated smallholder farmers integrating traditional and western scientific farming practices and how are they rationalizing their decisions?
c. What are the drivers and challenges of knowledge integration and how do they affect diffusion of innovations?
d. How is knowledge integration affecting household food security outcomes of differentiated smallholder farmers?
e. In which ways can the two knowledge systems be purposely integrated to facilitate diffusion of innovations to achieve sustainable farming practices among smallholder farmers?

1.4 Research Objectives

Main objective

The main objective of the study was to investigate how socially differentiated smallholder farmers harness synergies and complementarities between traditional and western agricultural knowledge systems to improve household food security outcomes in the Kassena Nankana Traditional Area.

Sub objectives

The sub objectives were to:

a. Describe farming systems showing how social differentiations among smallholder farmers define their choice of farming systems.
b. Examine how differentiated smallholder farmers integrate traditional and western agricultural knowledge systems and how they rationalize their decisions.
c. Examine driving factors and the challenges associated with knowledge integration with special focus on diffusion of innovation.
d. Examine how knowledge integration affects household food security situation of differentiated smallholder farmers.
e. Recommend strategies for effective blending of the two knowledge systems to facilitate innovation diffusion for sustainable smallholder farming systems.

1.5 Significance of the Study

In Ghana, agriculture is predominantly on a smallholder basis and about 90 – 95 percent of farm holdings are less than 2 hectares in size (Chamberlin, 2008). The crops sub-sector alone contributes 78 percent to agricultural GDP (GSS, 2018) and remains the primary livelihood for majority of smallholder households in the study area (Derbile, 2010). The

Ministry of Food and Agriculture (MoFA) continues to promote the use of modern agricultural technologies in alignment with national policy and strategy framework of modernizing agriculture to increase crop production (MoFA, 2017). However, despite stern efforts by extension agents, achieving broad-scale technology adoption among smallholder farmers remains a challenge (IITA/ELARD, 2013) because many smallholder farmers are unable to afford the cost associated with improved agricultural technologies. Besides, the sustainability of agricultural initiatives beyond the project lifespan has also become a matter of concern to development practitioners. Therefore, there is an urgent need to ensure project relevance, sustainability and ownership of interventions in project beneficiary communities to drive sustainable local development and improve standard of living.

This study therefore, is part of efforts to contribute to agricultural development theory and practice in northern Ghana in four main ways:

1. The study contributes to knowledge integration frameworks on how to purposively integrate traditional and western agricultural knowledge systems to achieve sustainable crop production in the Kassena Nankana Traditional Area through the proposed knowledge integration model and process provided in chapter six.
2. The study reveals contextual issues affecting smallholder farming systems to inform the design of appropriate extension delivery approaches at the farmer level to achieve ownership, relevance and sustainability of development initiatives.
3. More importantly, the study contributes to the discussion on heterogeneous characteristics of smallholders showing how social differentiations influence their choice of farming practices and technologies and their relevance for targeting by government and development partners in promoting agricultural technologies.

4. The study provides a deeper understanding of smallholder farming systems and the blend of farming practices by differentiated smallholders to inform evidence-based policy advocacy and decision-making by government and NGOs to formulate agricultural policies that are responsive to the needs and aspirations of the social differentiations of farmers as discussed in chapter four to ensure inclusive agricultural development in Ghana.

1.6 Definition of Concepts

The parameters for this study look at how social differentiations of smallholder farmers are integrating traditional and western agricultural farming practices and technologies to improve household food security. In order to contextualize the issues discussed in this study, some key concepts may require clarification. I will present a brief clarification of concepts within the domain of the study and then provide a detail discussion later in chapter two. The concepts include the following: farming systems, traditional and western agricultural knowledge systems, knowledge integration, household food security, and smallholder farmers.

Farming systems: - this refers to the mix of agricultural activities, including methods of land preparation, input use, cropping systems, and practices used to achieve desired level of production. The study is biased towards the cropping aspects of farming systems and focused on the interior savanna zone. Consequently, compound and bush farming systems are of particular interest.

Traditional knowledge systems and practices: - this basically refers to the body of knowledge which is native to smallholder farmers. It focuses on knowledge, innovations

and practices of local communities, developed from experience gained over a period of time and adapted to the local culture and environment and transmitted orally from generation to generation. This study is particularly interested in traditional agricultural management practices and non-technical insights. By using the term 'traditional', the study emphasizes historical and intergenerational continuity in agricultural management practices. To this end, elements such as farmer knowledge and practices in soil fertility maintenance, multiple farms cultivation, cropping systems and strategies, adaptations to rainfall variability, and traditional weather forecasting knowledge are the focus of investigation. For non-technical insights, the study is interested in the wisdom, ideas, principles and the perceptions underpinning the choice of different blend of farming systems.

Western scientific knowledge/practices: - this refers to concepts, ideas, values, practices and technologies which are packaged as part of agriculture extension delivery and imparted to the minds of farmers by state and NGO extension agents who are largely trained in western scientific agriculture. The term is used to describe a wide range of farming practices which involves the use of agricultural equipment and technologies with the aim of obtaining highest yield possible and to get the highest economic profit possible. In pursuit of this goal, the production practices often employed include: intensive system of cultivation, monoculture, application of inorganic fertilizers, use of improved seeds such as hybrids and certified seeds, irrigation, mechanization, use of agro-chemical for pest and weeds control, and promotion of Genetically Modified Organism (GMO).

Knowledge integration**:** - In this study, knowledge integration refers to blending of proportions of traditional and western farming practices/technologies to increase crop

production and productivity. Key areas of integration of the two forms of knowledge systems include: Land preparation methods, soil conservation techniques, farm labour, types of crops, and postharvest management. The degree of knowledge integration was measured in the light of 'high or low' integration, where 'high' integration refers to a larger proportion of western farming practices being adopted relative to traditional farming practice while 'low' integration refers to a smaller proportion of western farming practices being adopted relative to traditional farming practice.

Household food security: - In this study, the notion of household is thought of as a domestic unit with autonomous decision-making regarding production and consumption where household income and food resources are pooled and allocated to maximize collective welfare and the head of the household is vested with the decision-making power over household resources. For the purpose of this study, household food security is conceptualized as a household's ability to command an adequate amount of staple grains all year round through own production or a combination of existing sources (Adapted from Omosa, 2006). The Months of Adequate Household Food Provisioning (MAHFP) indicator is adopted to measure household food access and availability. This indicator captures household's ability to ensure that food is available above a minimum level all year round (Bilinsky & Swindale, 2010). The MAHFP is usually used as a measure of food insecurity in a highly subsistence-oriented area where production is primarily for home consumption and households do not make significant sales or purchases in the market (Alhassan, 2015).

Smallholder farmers**:** - these are men and women who have direct and special relationship with the land and nature through the production of food. It refers to the category of male and female farmers with limited land and capital, low agricultural inputs and technology

use, low output production, inadequate access to labour and mechanization, poorly linked to markets, subsistence orientation, and more vulnerable to risk. Given that smallness has many dimensions, an important way of making distinctions within this group is through variations in landholding size, a key productive asset. Subsequently, landholding size was used as a key indicator of who is a smallholder farmer.

1.7 Scope or Delimitation of the Study

The study focused on how smallholder farmers harness the synergies between traditional and western knowledge systems to improve household food security in the Kassena Nankana Traditional Area. It focused on traditional knowledge systems related to crop production and biased towards the cropping aspect of farming systems. Even though the study is biased towards the cropping aspect of farming systems, it recognizes the key role livestock plays in household food security in northern Ghana. Consequently, the role of traditional knowledge system in livestock rearing was not within the domain of this study. Rather, the study covered traditional agricultural management practices and technologies used by smallholder farmers in crop production.

The target group is smallholder farmers who cultivate less than two hectares (Houssou, Johnson, Kolavalli, & Asante-Addo, 2016) in the study area. This category of farmers have become the target for most food security initiatives in northern Ghana due to the incidence of food insecurity and poverty in the area (Nkegbe et al., 2017). In terms of food security, the study focused on two components: availability and access with the understanding that the concept of stability also refers to both availability and access. The study does not cover food utilization but focused on household's ability to ensure that food is available all year round through own production or a combination of existing sources. To understand how

smallholder farmers are blending the two forms of agricultural knowledge systems to improve household food security in the area, the study adopted the exploratory sequential mixed method design to deal with the study limitations related to validity and reliability of the findings. Consequently, I ensured that the findings from the different sources of the study were integrated and reported accordingly to differentiate the sources and ensured that the reported views expressed by smallholder farmers are consistent with the consensual views or otherwise expressed by focus group discussants. Similarly, the views expressed by focus group discussants were validated by the views expressed by key informants who are deemed to be knowledgeable and experienced in the related subject matter.

Given that the study covered the kassena Nankana Traditional Area, the limitation of the study, just like any other study, was language barrier because the researcher is a native speaker of kasem but not the Nankani local language. Therefore, I relied on translators to translate from Nankani into English or kasem. In view of this, I sometimes felt that vital information was being missed especially when the translation appeared not detailed enough. To address this challenge, the information collected was triangulated by other respondents, who could speak kasem or English language.

1.8 Organization of the Thesis

This thesis consists of seven chapters within three main parts. In PART I (Chapters 1, 2 & 3), I provide an introduction to the current study, situate it in related literature and establish the research methodology. Chapter 1 outlines the background, problem statement, research questions and objectives and why the study is both necessary and timely. In chapter 2, I review literature and discuss the theoretical and conceptual frameworks to guide the enquiry. It sheds light on conceptual issues underpinning the study and reviews the

evolutionary process of farming systems that drive technology adoption and diffusion innovations theory which explains adoption decisions in agriculture and concludes with a conceptual framework that illustrates how traditional and western agricultural knowledge systems interrelate and draws on complementarities and synergies to improve household food security outcomes. Chapter 3 presents the methodology used for this study and provides justifications for mixed methods research design and proceed to describe the methods used to collect, present and analyze data.

In PART II (Chapters 4, 5, & 6), I present the results and analysis of how social differentiations of smallholder farmers are harnessing the complementarities and synergies between traditional and western agricultural knowledge systems to improve household food security. More specifically, chapter 4 discusses the general characteristics of the study participants, smallholder farming systems, social differentiations of smallholder farmers, and smallholder farming system constraints. Chapter 5 is in two parts. In the first part, I examine how differentiated smallholder farmers are blending farming systems and how they rationalize their decisions. The discussion focuses on knowledge integration on different farmlands, knowledge integration among differentiated smallholder farmers, and challenges of knowledge integration. In the second part, I examine how knowledge integration affects household food security situations of different smallholder farmers. The discussion highlights household food sources, knowledge integration and food security situation of different smallholder farmer, and copping strategies of different smallholder farmers. In chapter 6, I discuss practical strategies for integrating traditional and western agricultural knowledge systems to improve crop production and the mechanisms to support

effective integration process. The discussion centers on the process of knowledge integration and the mechanisms necessary to support integration in crop production.

In PART III (Chapter 7), I present summary, conclusions and recommendations.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Introduction

Literature review is crucial in research because it shows what research has already been done on any given subject, synthesizes previous scholarship, sharpens the focus of the research, and justifies the research methodology (Boell & Cecez-Kecmanovic, 2014). In this chapter, I review relevant literature to situate the study in theoretical context. To do this, I discuss the theoretical and conceptual issues arising from the problem definition. The discussion is in three sections. In the first section, I shed light on the conceptual issues of the study. Key concepts explored include: farming systems, traditional agricultural knowledge systems, western agricultural knowledge, household food security, knowledge integration, and diffusion of innovation. The section also examines agricultural development policy framework in Ghana to situate the discussion within a broader policy environment. The second section discusses the theoretical framework to guide the study. The theoretical framework focuses on the theories of evolutionary process of farming systems that drive technology adoption and its counterpart diffusion innovation theory which provides an explanation of the factors influencing adoption decision in agricultural production. The third section presents the conceptual framework which illustrates how the various concepts interrelate to produce household food security outcomes.

2.2 Farming Systems in Sub-Saharan Africa

Most of the people in Africa depend largely on the land for their living. In their struggle to sustain themselves and their families, farmers have had to find out for themselves what works under widely varying environmental conditions along the process of trial and error

in which balances were found between the human society and its resource base. According to Ruthenberg (1980), farming systems evolve as a result of an interaction of the physical, biological, and exogenous factors. Some scholars refer to farming system as a particular arrangement of farming enterprises (e.g. cropping, livestock-keeping, processing farm products) that emerged in response to the physical, biological and socio-economic environment and in accordance with the farmers' goals, preferences and resources (Shaner, 2019). Giller (2013) defined farming system as the complex of resources that are arranged and managed according to the totality of production and consumption decisions taken by a farm household including the choice of crops, livestock, on-farm, and off-farm enterprises. In this study, farming system is used to refer to a population of farmer households undertaking a mixture of agricultural activities and practices to achieve a desired level of production for households with broadly similar patterns of livelihood and consumption patterns, constraints and opportunities, and for which similar development strategies and interventions would be appropriate. Such system often shares similar agro-ecological and market access conditions.

Typologies are often used as tools for dealing with farming system heterogeneity. This is achieved by classifying farms into groups that have common characteristics, i.e. farm types, which can support the implementation of a more tailored approach to agricultural development. In farming systems classification, the following variables are often used: farm size, income, capital, labour, resource management, production characteristics, and household demographics (Righia, Dogliotti, Steganinic, & Pacinia, 2011). The United Nations Food and Agriculture Organization (FAO) identified 15 farming systems in Africa

based on drivers such as available land area, agricultural population, predominant livelihoods and the prevalence of poverty (Dixon, Gibbon, & Gulliver, 2001).

In a study to explore patterns of farming system diversity in the Savelugu-Nanton and Tolon-Kumbungu Districts in the Northern Region of Ghana, using the multivariate statistical techniques of principal component analysis and cluster analysis, Kuivanen, Alvarez, Michalscheck, Adjei-Nsiah, Descheemaeker, Mellon-Bedi and Groot (2016) observed six farm types, stratified on the basis of household, labour, land use, livestock and income variables, explaining the structural and functional differences between farming systems. Types 1 and 2 were characterized by relatively high levels of resource endowment and oriented towards non-farm activities and crop sales respectively. Types 3 and 4 were moderately resource-endowed with income derived primarily from on-farm activities. Types 5 and 6 were resource constrained, with production oriented towards subsistence (Kuivanen et al., 2016). Some studies have shown that the differentiating characteristics of farming systems are driven by site-specific opportunities and constraints that in turn are shaped by various factors beyond the household scale at the community, landscape, and regional levels (Yaro, 2010; Chapoto, Mabiso, & Bonsu, 2013; Tittonell, 2014). These differences influence the coping and adaptive strategies of farmers in the face of shocks and stresses, as well as their interest and capacity to take advantage of potential opportunities for the sustainable intensification of their farms (Yaro, 2010).

In Ghana, the major farming systems are based on the agro-ecological zones that essentially establish the system. They are as follows: bush-fallow systems, permanent tree crop systems, compound farming system, mixed farming system and special horticultural farming system (Botchie & Asuming-Brempong, 2003). Given that the study is focused on

the interior savanna zone and biased toward the cropping system aspects of the farming systems, two major farming systems such as bush-fallow systems and compound farming systems are of particular interest. In the Akankwiba basin in the Kassena Nankana District of northern Ghana, Derbile (2010) observed that multiple farms constitute a major feature of crop farming among majority of households. The study identified two major types of land holdings: the compound farm *(i.e. Sammani*) and bush-farm **(**moon). The *Sammani* is often the immediate surrounding farmland of the homestead and it is usually fragmented into several smaller plots for the cultivation of traditional and new crop varieties such as sorghum, early millet (*naara*), late millet (*zea*), and beans (*ʈɛa*). According to Briggs and Moyo (2012), the plots are deliberately fragmented to provide a hedge against risk. The second type of land holding is the bush-farm (*moom*) which he categories into two – nearby bush farm called *Boo* and usually located along streams, rivers banks or valley. The next bush-farm is a distance from the homestead and also referred to as *moom* (Derbile, 2010).

What appears to be missing is a flexible approach to typology construction that incorporates farmer perspectives to provide context and insight into how social differentiations among smallholder farmers define their choice of farming system.

African farming systems have evolved over many centuries in response to particular sets of environmental conditions and they are constantly changing in response to changing circumstances. Intensification of farming system has been noted as essential for agricultural transformation in many developing countries (Houssou et al., 2016). They assert that most farmers are transitioning from using hand tools to tractor plowing and from planting traditional and late-maturing crop varieties to early-maturing ones (Houssou et al., 2016). Apart from increasing farm sizes following continued mechanized technology use,

Kansanga et al. (2019) found significant change in the cropping pattern of smallholder farmers. They observed that majority of farmers have moved away from the cultivation of traditional staple crops such as pearl millet and sorghum bicolor to market driven crops mainly maize, rice and groundnuts (Kansanga et al., 2019).

Houssou et al. (2016) assert that farmers' decisions as to which crop to cultivate, how much to cultivate, and what methods to use depend on a combination of factors. According to them, these factors include the household's needs for staple foods (for example, maize); type and fertility of the farm plots; cash and input needs; and market forces. For instance, Maize cultivation is demanding with respect of nitrogen, phosphorus and soil organic matter, and for this reason it is cultivated mostly on virgin lands (Callo-Concha, Gaiser, & Ewert, 2012). Furthermore, the cultivation of sorghum, maize and millet is important for the provision of carbohydrates to the local diets and also straw for fuel and foliage to feed animals (Eguavoen, 2007). In the northern savannah of Ghana, millet and sorghum bicolor are central to social life. They are used in the brewing of 'pito' which is central to everyday life as food and for performing traditional rites such as pouring of libation during ceremonies (Lobnibe, 2018).

Cropping system is an important component of a farming system. Within the farming systems are two types of cropping systems being practiced in northern Ghana. These are multiple cropping and mono-cropping. Mixed cropping and intercropping are variations of multiple cropping and have the potential to utilize the soil more efficiently, resulting in greater production from a given unit of land (Wood, 2013). That notwithstanding, mono-cropping system has become more economically rewarding, partly because growth in agricultural subsidies tends to favor mono-cropping (MoFA, 2007). In a study to evaluate

the effect of combined use of improved soybean varieties, organic fertilizer and inorganic phosphorus on the yield of soybean, Abebe and Deressa (2017) concluded that continuous mono-cropping with one or two chemical fertilizer sources is one of the main causes of the gradual soil fertility depletion. But suggested that crop rotations with the integrated use of fertilizer sources could lead to soil fertility improvement.

2.2.1 Smallholder Farming Systems

Smallholder farming systems are perceived to share certain characteristics which differentiate them from large-scale and profit-driven enterprises (Chamberlin, 2008). Usually, policy-oriented discussions of smallholders often address this group in ways such as limited land and capital, high exposure to risk, low input technologies, and low market oriented (Lipton, 2005). However, not all smallholders are equally land constrained, market oriented, or vulnerable to risk (Chamberlin, 2008). Generally, there appears not to be a consensus on a definition of smallholders (Nagayets, 2005). For instance, Lipton's (2005) definition of a smallholder is based on whether or not most of the labour is performed by members of the family, while Dixon, Taniguchi, and Wattenbach (2003) suggest that the term smallholder relates to their limited resource endowment relative to the other farmers in the sector.

A recurring theme throughout the literature on small farmers in the developing world is the idea that "smallness" has multiple important dimensions. That notwithstanding, an important distinction with the groups is through variation in landholding size, a key productive asset. According to Chamberlin (2008), landholding size is perhaps the most direct and easily introduced indicator of who is a smallholder. Other studies have shown that land size correlates with holdings of livestock and other assets (Negash & Niehof,

2004). However, the Ghana Poverty and Social Impact Analysis (PSIA) argues that household assets and risk conditions better define smallholders than simple measures of landholdings (Asuming-Brempong, Alhassan, Sarpong, Kwadzo, Akoena, Sakyi-Dawson. Mensah-Bonsu, Ditchfield, Amegashie, Egyir, & Ashley, 2004). Moyo (2016) assert that access to arable land and average landholding sizes are decisive in defining and shaping the differentiated scale of family farm production.

Contemporary agrarian activists use the concepts of peasant household and smallholder household interchangeably. Some scholars assert that the concept “peasant” confused “persons” and “roles” and noted that rural cultivators constantly shifted in and out of a variety of roles, including wage laborer, squatter, and urban service worker (Edelman, 2013). Therefore, Edelman (2013) defines peasants as a man or woman of the land, who has a direct and special relationship with the land and nature through the production of food and/or other agricultural products. Yaro (2002) noted that peasants are a heterogeneous group of people engaged in multiple activities and with multiple characteristics.

Policy documents often refer to smallholders without explicitly defining the sector or distinguishing internal differences that extend beyond basic agro-ecologies (Chamberlin, 2008 According to Asuming-Brempong et al. (2004), the failure to differentiate between various livelihood contexts and production objectives has led to current policies that miss a large portion of the smallholder segment. Consequently, Chamberlin (2008) argues that distinguishing among the various commercial orientations and wealth characteristics of small farm households is important in designing inclusive interventions.

In Ghana, smallholders are considered to constitute 90-95 percent of farms (Asuming-Brempong et al., 2004) and "about 80 percent of total agricultural production" (Government of Ghana, 2003, p. 69). Therefore, smallholder classification becomes relevant to understand structural changes in farming systems and the effects of policy reforms (Emtage, 2004). According to Chamberlin (2008), the logical starting point for identifying priority policy interventions that target smallholders in a certain area would be to recognize important differences within and across that area's small-farm sector.

Typology of farmers are constructed to help those who are administering and designing development policies and programmes to analyze the functionality of farms and to provide a useful recommendation on techno-economic matters which will help to optimize farming operations (Emtage, 2004). There are two main approaches in the literature on typology development. These approaches are quantitative approach and qualitative approach (Righia, Dogliotti, Stefaninic, & Pacinia, 2011). The quantitative identification and characterization processes utilize multivariate statistical techniques and analysis and study diversity by using a finite number of variables to categorize farms. The qualitative approach focuses on identifying and describing what is typical for the different types of farmers instead of defining the boundaries that cause differentiation between groups (Emtage, 2004). Some studies argue that a more flexible approach to typology construction, for example through incorporation of farmer perspectives, might provide further context and insight into the cause, consequences and negotiations of farm diversity (Kuivanen et al., 2016). In this current study, the approach used is largely qualitative drawing on key variables from the literature to inform discussions with participants in focus group

discussions for validation and exploration of further variables. The output from the discussion was used to design questionnaires for a survey.

Using wealth ranking, the Ghana Poverty and Social Impart Analysis (PSIA) defines five categories of smallholders in Ghana: large-scale commercial farmers; small commercial farmers; semi-commercial farmers; non-poor, complex, diverse, risk-prone farmers (Chamberlin, 2008). Yaro (2002; 2009) classified peasants using wealth ranking scheme into four wealth groups: the rich, the better-off, the medium poor, and the ultra-poor. The "rich" groups are mostly people who have large acres of fertile lands, inherited cattle from parents and grandparents, as well as teachers, extension officer, stenographers, and watchmen. According to Yaro (2002; 2009), farmers in this category normally cultivate crops such as rice and groundnuts in the rainy season and engage in tomatoes production during the dry-season. The "rich" are usually the first to cultivate their farms because they possess oxen and can afford tractor services and labor cost. Consequently, they are the first to harvest and take advantage of the favorable high prices in the market. The "better-off" are food-secure to a large extent and less vulnerable than the poor, but they are not able to meet all their needs. This group are able to feed their families, purchase inputs for their farmlands, cultivate at the appropriate time, harvest at the right time, and store their produce until prices appreciate. The "medium -poor" have few resources or endowments for participation in productive activities. For this category, Yaro (2002) contend that almost every investment decision is a gamble. The "ultra-poor" group is the poorest people in the community. The parcels of land owned by this group are usually inherited, and only the lucky ones have fertile lands. This group is composed of old couples who have lost their children to disease or migration, widows who are not supported by their extended families,

and young people who have taken to alcoholism and drug-addiction. The common asset for this group is poultry. It was observed that the "medium -poor" formed the majority of the population in the Gia-Kajelo community in the Kassena Nankana traditional area (Yaro, 2002).

Moyo (2016) differentiated family farms (socially and economically) according to the relative sizes and quality of their landholdings and levels of capitalization (e.g. mechanization) which influence the operational scale and labor intensity. The spectrum of family farms ranges from the "better-off" family farms (sometimes called market-oriented or capitalist family farms) that employ more hired labor than family labor, and sell larger quantities of produce to markets. These family farms often live well above the poverty line (FAO, 2014). According to Moyo (2016), at the bottom end are the "poor" family farms (or near landless, semi-proletariat) that largely sell labor to other farms and non-farm entities and hardly produce enough to meet family food requirements, let alone to sell. These family farms fall below the poverty line and are often labor constrained (France, Rajania, Goodman, Ram, Longhurst, Pelka, & Erskine, 2016), largely due to itinerancy of some family members and /or other social depravations (poor health, death, etc.). In between is the middle family farm (sometimes labeled the semi-subsistence family farm), which neither hires nor sells labor but produces most of its food requirements and sells some produce to meet a range of family needs.

2.2.2 Gender Roles in Farming Systems

There are differentiated roles in farming systems with men and women playing vital, but complementary roles. Traditional farm chores are often 'gendered'. For instance, land preparation is usually undertaken by men, planting is done by women and children with

men assisting; weeding, harvesting, transportation, and marketing are primarily done by women (Drafor, Kunze & Alhassan, 2005). Women account for about half of the agricultural labour force and produce around 70 per cent of Ghana's food crop (SEND Ghana, 2014), constitute 95 per cent of those involved in agro processing, and 85 per cent of those in food distribution (FAO, 2012; SEND Ghana, 2014). Due to the specific role of women farmers in food production, many of them are repository of knowledge on cultivation, processing, and preservation of nutritious and locally adapted crop varieties (SEND Ghana, 2014).

One of the most significant gender-based constraints that women farmers face is access to, ownership and control of agricultural land (FAO & ECOWAS, 2018). Women's restricted control over land reflects deep-rooted land tenure customary practices and laws (SEND Ghana, 2014). FAO & ECOWAS (2018) observed that women's land rights are directly linked to marriage, where married women are able to access land through their husbands, but in most cases such access is often only to marginal lands. Patriarchal society gives absolute priority to men and to some extent limits women's human rights (Sultana, 2010). According to Sultana (2010), patriarchy is a system whereby women are kept subordinate in a number of ways including discrimination against girls in educational opportunities, burden of household work on women and young girls, and male control over women's bodies and sexuality (p. 8).

However, evidence from ethnographic data has shown that women's roles and strategies in carrying out agricultural activities have been changing as a result of agricultural transformation and the different "tunes" being played by multiple actors (Drafor et al., 2005; Nchanji, 2017). Nchanji (2017) argues that the introduction of gender sensitive

agricultural policy has changed ownership and access mechanisms to land for women in irrigation sites in Tamale in the Northern Region of Ghana, and the change has not only reshaped the way agriculture is practices, but has also changed household dynamics and gender relations.

In the past, traditional knowledge played a key role in the process of adapting farming systems and cropping patterns to the natural environment and conditions of each location. The next section therefore focuses attention on the concept of traditional knowledge systems and the role they play in crop production.

2.2.3 Traditional Knowledge Systems

Generally, knowledge is considered as an important strategic resource and regarded as the major driving force of innovation and development (World Bank, 1999). Some authors use alternative terminologies to classify knowledge systems in similar lines as: 'western' or 'indigenous', 'formal' or 'informal', 'insider' or 'outsider'. Irrespective of the different ways of knowing, various groups of people in different parts of the world perceive and relate with the environment in their own peculiar ways. Their divergent perceptions, interactions and knowledge are largely influenced by their different worldviews (Maweu, 2011).

Traditional knowledge is anchored in a specific worldview just as other systems of knowledge. The holders of this knowledge system embrace indigenous worldview which tends to be holistic. This worldview is based on the understanding that the living world is made up of three worlds: the human world, the natural world and the spiritual world (Haverkort et al., 2012). In reality, these worlds are interrelated and emphasize the

symbolic nature of the relationship between human and the natural world. Traditional knowledge interweaves empirical, spiritual, social, and other components. By isolating elements from such worldview, one runs the risk of misrepresenting both the element and the whole (Haverkort et al., 2012). On the basis of these perceptions, people organize themselves and determine their interactions with nature as well as their religious activities.

The literature on traditional knowledge does not provide a single definition of the concept. Some authors use alternative terminologies depending on their disciplinary orientation. Consequently, the terms 'local knowledge', 'indigenous knowledge', 'traditional knowledge', and 'traditional ecological knowledge' are often used interchangeably. In some jurisdictions, Indigenous knowledge is widely used to emphasize attachment to a place and establishes a link with indigenous people (Dei, 1993). However, for some this connection narrows the term's application and excludes certain people who are not officially recognized as indigenes but nonetheless possess sophisticated sets of knowledge about the natural environment. The processes in local knowledge production involve the interaction between local communities and external agents who have their own practices and discourses (Pottier, 2003). Thus, "localization" of knowledge allows adapting external knowledge to local situations through mediation and negotiations within certain cultural parameters. For the purpose of this study, the term traditional knowledge is adopted to suggest that it is the body of knowledge that is adapted through mediation of established cultural parameters. Traditional knowledge often refers to the body of knowledge, innovations and practices of local communities, developed from experience gained over the centuries and adapted to the local culture and environment and transmitted orally from generation to generation (Menzies, 2006). This definition highlights special features of

traditional knowledge which distinguishes it broadly from other knowledge systems. It is *local* and rooted in a particular community within a broader cultural tradition; it is predominantly *tacit* or *embedded in practices and experiences*; it is *transmitted orally*; *experiential* rather than theoretical; *learned through repetition*; and constantly *changing* through mediation and *adaptation* within some cultural parameters.

Traditional knowledge is indeed dynamic and changes through creativity and innovativeness as well as through contact with other local and international knowledge systems. Traditional knowledge is embedded in community practices, institutions, relationships, and community rituals (Harverkort et al., 2012). It is not just about immediate technical solutions to everyday problems, but it also contains non-technical insights, ideas, and wisdom. Indeed, traditional knowledge is local knowledge that is unique to a given culture or society that people hold and apply to their daily sustenance (Senanayake, 2006). It forms the basis for local decision-making in agriculture and husbandry; health care and coping with disease and injury; food preparation, conservation and distribution; natural resources management; interpretation of meteorological and climate phenomena; hunting, fishing and gathering, among others (Harverkort et al., 2012). This study is particularly interested in traditional knowledge related to agricultural production and non-technical insights. As a result, traditional agricultural knowledge is used to refer to the body of knowledge which is native to farmers. By using the term 'traditional' agricultural knowledge, the study emphasizes historical and intergenerational continuity in farming practices.

2.2.4 Traditional Knowledge and Rural Development

Traditional knowledge is considered an important strategic resource for rural development (World Bank, 1998). The World Bank (1999) argues that traditional knowledge is an integral part of the development process of local communities and a key element of the 'social capital' of the poor – their main asset – to invest in the struggle for survival, to produce food, to produce shelter or to achieve control of their own lives. According to the 1998/99 World Development Report, knowledge, not capital, is the key to sustainable social and economic development (World Bank, 1999). Building on local knowledge, the basic component of any country's knowledge system, is the critical first step to mobilize such capital.

In the 50s and 60s, theorists of development saw traditional knowledge as ineffective, inferior and an obstacle to development. As Escobar (1995) puts it, development has relied exclusively on one knowledge system, namely, the western science whose dominance has dictated the marginalization and disqualification of non-western knowledge systems. However, traditional knowledge as a field of research and practice has moved from the periphery of development debates to a rather more central position as a development intervention of promise (Briggs, 2013). This optimism was heightened by the shift from the preoccupation with the western technically oriented solutions of the past decades that failed to transform the lives of the majority of the peasant and smallholder farmers in the global south, especially those in Sub-Saharan Africa.

A better understanding of the local conditions, including traditional knowledge systems and practices could help better integrate global technologies to solve the problems facing

local communities in the developing countries. The World Bank (1999) asserts that by investigating what the local communities know and having a good understanding of the local conditions, will provide a productive context for activities designed to assist poor rural communities. The Bank further argues that adapting international practices to the local setting can help improve the impact and sustainability of development assistance World Bank (1999). To ignore local people's knowledge is almost to ensure failure in development (Brokensha, Warren & Werner, 1980). It is in this light that Chambers (2014) points to the need for integrating the knowledge of local people with new development approaches to ensure local ownership and sustainability of development assistance.

Traditional knowledge plays an important role in sustainable use and management of agricultural and natural resources and has gained credence as a key weapon in the fight against climate change and food insecurity (Briggs, Sharp, Yaboub, Hamed, & Roe, 2007). Traditional farmers have found ways of improving soil structure, water-holding capacity and nutrient and water availability without the use of artificial inputs (Harverkort et al., 2012). The major strength of traditional farming systems lies in the functional integration of different resources and farming techniques.

As with other forms of knowledge systems, it is important to recognize that not all traditional knowledge and practices are beneficial to sustainable development of local communities and may not provide appropriate solutions for a given problem (Sillitoe, 2004). Traditional knowledge has its limitations and weaknesses (World Bank, 2005). Many of the taboos, rules, and prohibitions seem no longer to be serving any useful purpose. Besides, it is observed that some local practices and technologies are time demanding and cannot be replicated on large scale.

2.2.5 Traditional Knowledge and Scalability

One of the broad themes in indigenous knowledge debates which has evolved over the last few years is that indigenous knowledge is invariably local and geographically specific and tends to be deeply embedded within the society in which it has been developed and therefore cannot be easily extracted from its local context (Briggs et al., 2007; Sollitoe & Marzano, 2009). Briggs contends that, "this is awkward for development practice as it makes broader application of indigenous knowledge difficult between different geographic, cultural and economic settings" (Briggs, 2005, p. 21).

Although there has been a trend to continue to build up repertoire of examples of good practices of traditional knowledge from different geographic, economic and cultural settings as much as possible which undoubtedly has made significant contributions to the depth of local knowledge understandings, there still remains a pervading sense of disappointment and frustration that traditional knowledge in development initiatives has not succeeded in making a leap from a set of conceptual and empirical proposition to a position where it is deployed in development interventions as a matter of course (Briggs, 2013). Briggs opines that, without being able to do that, traditional knowledge may well remain at the periphery of development practice and continue to disappoint (Briggs, 2013).

For many development practitioners, traditional knowledge is heterogeneous and complicated and inconveniencing for development (Sillitoe & Marzano, 2009) and its use requires long-term engagement with communities in the development process from inception through to implementation. Indeed, this cuts little ice with development practitioners who seek effective and quick-win solutions for development interventions.

The development industry is driven by short-term, measurable outcomes to demonstrate effectiveness and value for money. Some scholars have argued that the application of traditional knowledge from one context to another carries serious risks of failure and that there is little merit in trying to develop indigenous knowledge as a generic planning tool (Briggs, 2005). This view is in line with Eyzaguirre's (2001) assertion that a global recognition of indigenous knowledge as a planning tool may be at a price.

However, such views miss the point, in that, a culturally embedded traditional knowledge provides possibilities for new ways of thinking and new ways of making development interventions relevant for rural communities. Sollitoe (2004) contends that indigenous knowledge could provide locally-driven insights to enrich and broaden current scientific understanding of scientific technologies. As mentioned earlier, traditional knowledge is not just about immediate technical solutions to everyday problems, but it also contains non-technical insights, ideas, and wisdom. There exist other school of thought who see traditional knowledge not as a planning tool, but rather more as a perspective of development, as a way of knowing (Ferguson, Huysman & Soekijad, 2010). According to Briggs (2013), this line of reasoning shifts the focus of indigenous knowledge from a focus on content to a focus on practice or process. Therefore, drawing on inspiration from Berkes' (2009a) assertion that traditional knowledge should focus less on its continuing interest on content and rather focus on process, Briggs (2013) opines that the focus should now become indigenous ways of knowing, with focus on the epistemology of indigenous knowledge systems.

According to the World Bank (1998), exchange of indigenous knowledge is a process that typically begins with recognition and identification of knowledge as expressed in a

technology or a problem solving strategy. The Bank contends that lessons from earlier transfers of modern technologies indicate that the cultural, political, and economic environment and the level of technical competence of the recipients are critical for sustainable adoption and adaption of foreign technologies (World Bank, 1998). As a result, careful selection of cooperating partners and potential beneficiaries in a participatory process is a prerequisite for a successful transfer. Therefore, Berkes (2009b) argues for the establishment of co-management comprising a partnership of equals between local communities and development experts. Consequently, re-ordering of power relations becomes central to the debate and the challenge becomes one of convincing experts to think in new ways, and in so doing, to concede some, or perhaps even a large element, of their power (Mackinnon, 2006).

2.2.6 Knowledge Integration and Localization of Knowledge

A major theme in traditional knowledge research agenda over the last decade has been the ways in which traditional knowledge might be usefully and purposefully integrated with western science to contribute to successful development interventions. The challenge of integrating the two knowledge systems remains a concern for many (see Mercer, Kelman, Taranis, & Suchet-Pearson, 2010). Even the word 'integration' remains problematic, invoking past power imbalances and assimilation of traditional knowledge by western science such that the distinct identities of traditional knowledge are no longer recognizable. According to Wikipedia, knowledge integration is a process of synthesizing multiple knowledge models (or representations) into a common model and the process of incorporating new information into a body of existing knowledge (en.wikipedia.org/wiki/knowledge_integration).

Some scholars have resisted 'knowledge integration' on the grounds that the conceptual models and ontologies of traditional knowledge and western science are sufficiently distinct to make these knowledge systems incommensurable (Cruikshank, 2005) and that some forms of integration can have unintended and undesired consequences (Fox, Suryanta, Hershock, & Pramono, 2006). Nevertheless, interest in integrating the two knowledge systems is steadily growing along several lines of argument. One is that this form of knowledge is essential for maintaining global cultural diversity (Maffi & Woodley, 2010). A second argument makes the point that knowledge integration often fills gaps that either alone cannot (Johannes, 1998). A third argument is that recognition of traditional knowledge has importance beyond scientific or broader societal merit: it is tantamount to social justice, sovereignty autonomy of traditional peoples (Agrawal, 1995; Aikenhead & Ogawa, 2007).

Knowledge integration remains a challenge undoubtedly due to the tension posed by the binary divide between traditional and western scientific knowledge (Maweu, 2011). For a long time now, traditional knowledge has been understood as being in binary opposition to western scientific knowledge (Agrawal, 1995). For some scholars, there are fundamental differences between traditional knowledge and western scientific knowledge. They contend that traditional knowledge is transmitted through oral tradition, whereas western scientific knowledge employs written word. Besides, traditional knowledge is holistic, whereas western scientific knowledge is reductionist – deliberately breaks down data into smaller elements to understand the whole complex phenomenon (Johnson, 1992). Traditional knowledge is often perceived as "primitive, unscientific and lacking in

objectivity and credibility", whereas western scientific knowledge is seen as "contemporary, objective and universally true hence more credible" (Maweu, 2011).

Agrawal (1995) summarized the major themes that presumably separate traditional knowledge from western knowledge under three chief dimensions: 1) substantive grounds – there are differences in subject matter and characteristics of indigenous and western knowledge; 2) methodological and epistemological grounds – the two forms of knowledge employ different methods to investigate reality, and possess different worldviews; 3) contextual grounds – traditional and western scientific knowledge differ because traditional knowledge is more deeply rooted in its context. Agrawal (2002) further argues that the two knowledge systems though premised on different worldviews, are not fundamentally different but both result from the rational process of creating order from disorder as a survival mechanism. Besides, both have inherent similarities that can be harnessed to assess and understand the environment from a broad perspective. Therefore, attempts to draw a clear line between western knowledge and traditional knowledge on the basis of method, epistemology, context or content are untenable (Agrawal, 2002). Consequently, Agrawal (2002) contended that the two knowledge systems should not be viewed as mutually exclusive, but rather as complementary by focusing on points of agreement rather than disagreement.

In order to engage traditional agricultural knowledge productively in development practice, there is a need to move beyond the dichotomy of traditional versus western and work towards building bridges across the two divide (Agrawal, 2002). This is in line with the call on western science to view itself as complementary to traditional knowledge and not a replacement (Bohensky & Maru, 2011). However, it is unclear how to effectively and

purposefully integrate the two knowledge systems to improve household food security. Fortunately, there have been some attempts in certain jurisdictions to integrate the two forms of knowledge systems to adapt to land degradation and reduce vulnerability to environmental hazards.

Reed, Dougill and Taylor (2007) examined how local and scientific knowledge can be combined to identify rangeland management strategies to reduce or adapt to land degradation in three degradation 'hotspots' in communal rangelands of Kalahari in Botswana. To achieve this, they developed and applied a four-stage social learning approach based on stakeholder participation. First, current practice and possible management options were identified from the literature (the western knowledge input). Second, a series of semi-structured interviews with rangeland users were conducted to identify local knowledge and adaptation strategies employed to address land degradation in the Kalahari (the indigenous knowledge input). Third, focus group discussions with stakeholders on the various scientific and indigenous options were held at the various communities. Finally, the outputs from these focus group discussions were used to produce assessment guides to provide locally relevant management options. Reed et al. (2007) concluded that, this combination of knowledge and the involvement of local stakeholders produced more relevant results than either knowledge system could have done separately.

Like Reed et al. (2007), Mercer et al. (2010) developed a framework to demonstrate how relevant traditional knowledge and western knowledge may be integrated to reduce vulnerability to environmental hazards in Papua New Guinuea. The framework involved a partnership between the community, the researcher and associated stakeholders (e.g. government agency and NGOs). They also suggested a four-step approach along the lines

of (a) community engagement – to determine how the community judges their levels of vulnerability to environmental hazards; (b) identification of vulnerability factors – to identify extrinsic and intrinsic components impacting vulnerability in the community. The intrinsic impacts identified are then prioritized to be addressed by the community; (c) identification of indigenous and scientific strategies – this involves identifying both indigenous knowledge and scientific strategies used both in the past and present to cope with the intrinsic factors affecting vulnerability. The merits of each strategy is assessed based on a criteria to determine its future viability; and (d) the development of an integrated strategy – it involves an analysis of the data in step (b) and (c) in order to negotiate and develop an integrated strategy to reduce vulnerability to environmental hazards in the community (Mercer et al., 2010).

Raymond, Fazey, Reed, Stringer, Robinson, and Evely (2010) compared three environmental management projects that aimed to integrate knowledge from different sources in the United Kingdom, Solomon Islands, and Australia. The comparative results indicated that integrating different types of knowledge is inherently complex. They argued that there is no single optimum approach for integrating local and scientific knowledge and therefore encouraged a shift in science from the development of knowledge integrated products to the development of problem-focused, knowledge integration processes. According to the study, these processes need to be systematic, reflexive and cyclic so that multiple views and multiple methods are considered in relation to the problem to be addressed (Raymond et al., 2010).

The significance of these knowledge integration frameworks to this study is the use of participatory approaches that draw on local and outside capacities and knowledge to

develop strategies that work best for local communities. However, the frameworks raise concerns regarding how members of a given community will engage in view of the perceived power play between community members and development experts who actively promote western agricultural technologies. With regards to such engagements, Haverkort et al. (2012) remind us of the importance of 'learning with', rather than 'learning from', and should be undertaken in an active spirit of mutual engagement. Mercer et al. (2010) assert that an integrated strategy within a community can only occur through dialogue based on mutual respect and communication between associated stakeholders and the community.

2.2.7 Diffusion of Innovation

The process and models of adoption have been studied by different scholars with the most popular and widely used being that of Everett Rogers, titled *diffusion of innovations* (Sherry & Gibson, 2002). Rogers (2003) defines diffusion as "the process by which an innovation is communicated through certain channels over time among the members of a social system (p.5). This also involves individual valuation of the undetermined benefits of the innovation relative to the costs (Hall & Howard, 2008). As expressed in the definition, innovation, communication channels, time, and social system are the four key components of the diffusion of innovation. Some authors restrict the term "diffusion" to the spontaneous, unplanned spread of new ideas, and use the concept of "dissemination" for diffusion that is directed and managed (Rogers, 1983). However, Rogers (2003) used these concepts interchangeably.

According to Rogers, "an innovation is an idea, practice or project that is perceived as new by an individual or other unit of adoption" (Rogers, 2003, p.12). In the literature,

"innovation" and "technology" are sometimes used interchangeably. For Rogers, "a technology is a design for instrumental action that reduces the uncertainty in the cause-effect relationships involved in achieving a desired outcome" (p.13). It is composed of two parts: hardware and software. While hardware is "the tool that embodies the technology in the form of a material or physical object," software is "the information base for the tool" (Rogers, 2003, p. 259).

Upon introduction of a new technology, it can either be adopted if found to be beneficial and profitable relative to existing alternatives or rejected if found unprofitable (Dinar & Yaron, 1992). Therefore, the need for an understanding of the adoption decision process and the factors that could affect adoption of new technology is critical. Rogers (2003) describes the innovation-decision process as "an information-seeking and information-processing activity, where an individual is motivated to reduce uncertainty about the advantages and disadvantages of an innovation" (p.172). Sahin (2006) asserts that technological innovation creates uncertainty in the minds of potential adopters and often perceived to be an obstacle to the adoption of innovation.

For Rogers (2003), the innovation-decision process involves five steps including: knowledge, persuasion, decision, implementation, and confirmation. According to Rogers, these stages typically follow each other in a time-ordered manner (Rogers, 2003). For Ugochukwu and Phillips (2018), the adoption process starts with getting information (awareness) about the new technology, followed by a careful review of the perceived attributes of the technology and the potential benefits and costs of acquiring the technology. After examining the characteristics and weighing the benefits, costs, and trade-offs associated with the new technology, the decision to either adopt or reject the technology is

then made (Ugochukwu & Phillips, 2018). Ugochukwu and Phillips (2018) assert that, an important consideration in technology adoption which previous studies have not explored in modeling adoption decision process is the issue of transaction costs. They argue that, the potential adopter continuously seeks more information about the technology and therefore incurs transaction costs (Ugochukwu & Phillips, 2018).

Several studies in the literature have examined adoption of agricultural technologies and found common factors that influence adoption (Bandiera & Rasul, 2006; Abera, 2008; Uaiene, 2011; Akudugu, Guo & Dadzie, 2012; Diiro, 2013; Mwangi & Kanuki, 2015). Zavale, Mayaba and Christy (2005) used a probit model to show that level of education, access to credit, extension, household size, and off-farm employment influence farmer adoption of improved maize seed. According to Diiro (2013), off-farm income is expected to provide farmers with liquid capital for purchasing productivity enhancing inputs such as improved seeds and fertilizers. Akudugu et al. (2012) observed that maximum level of education within the farm household was found to have a positive relationship with the probability of adoption. Uaiena (2011) looked at the factors influencing agricultural technology adoption by rural households in Mozambique. The results showed that rural farmers who have access to credit and extension advisory services, attended higher level of education, and are members of association have a higher probability of adopting new agricultural technologies.

Learning through networks has been identified as a factor that influence technology adoption. For example, Bandiera and Rasul (2006) examined the role of social networks and how the adoption choices of network members influence a farmer's adoption decision in Northern Mozambique. They found that farmers who discuss and/or learn about new

technologies with their social network have a greater tendency to adopt. Abera (2008) used xtprobit and random effect models to examine the influence of farmer learning and intensity of adopting improved wheat technologies in northern and western Shewa zones of Ethiopia. The study underscored the importance of learning and experience as key drivers of continued technology adoption.

Many studies have reported a positive relation between farm size and adoption of agricultural technology (Gabre-Madhin & Haggblade, 2001; Mignouna et al., 2011; Mwangi & Kakuiku, 2015). Akudugu et al. (2012) found that farm size and the expected benefits from adoption of technology are significant economic factors that influence the decision of farm households in the Bawku West District of the Upper East Region of Ghana. According to Mwangi and Kakuiku (2015), farmers with large farm size are more likely to adopt a new technology as they can afford to devote part of their land to try new technology unlike those with less farm size. Besides, a technology such as a tractor requires economies of size to ensure profitability (Mwangi & Kakuiku, 2015). On the other hand, Yaron, Dinar and Voet (1992) found negative relationship between technology adoption and farm size.

2.2.8 Household Food Security

The history of food security since the 1974 World Food Conference witnessed several definitions and overlapping paradigm shifts. These shifts drifted from the global to the national and to the household and subsequently to individual food security. Besides, the concept also witnessed a shift from a food first perspective to a livelihood perspective and from objective indicators to subjective indicators (Maxwell, 2001).

During the early 1970s, food security was mostly concerned with availability of food at the national and global levels. This was the period when most countries in Asia and Africa were faced with severe food crises mainly due to drought. Consequently, early definitions of food security focused on the ability of a region or nation to assure an adequate food supply for its population (Mckeown, 2006). One of these definitions was provided by the United Nations (UN) in 1974 as: "availability at all times of adequate world food suppliers of basic food stuff to sustain a steady expansion of food consumption and to offset fluctuations in production prices". The indicators developed were on the basis of a food supply deficit model and the crisis was measured at the national level. In the mid-1970s, there were increased aid flows and increased investments in agriculture and rural development. Cereal production increased considerably while prices on the market dropped sharply. However, despite this favorable condition, incidences of hunger and under-nutrition remained high. From the analysis, it was learned that the principal problem of food insecurity was not a lack of food supply, but rather a chronic lack of access to enough food at the level of vulnerable groups due to a lack of purchasing power or what Sen (1981) cached as a lack of entitlement to food. These lessons led to the shift in focus from adequate supply of food to inadequate access to food and the focus shifted to the questions of access to food at household and individual levels.

The food first approach regarded food as a primary need basic to all human's needs. It assumed that the coping strategies of people were designed to maximize immediate consumption. Over time, the assumptions underlying the food first approach were questioned because it was noticed that people may choose to go hungry just to preserve assets for future livelihoods. De Waal (1990) observed that people were quite prepared to

put up with considerable degree of hunger in order to preserve seed for planting or avoid having to sell an animal. The finding showed that poor people had other objective other than immediate consumption. These thoughts led to a shift from food first to a wider sustainable livelihood approach. This new insight was supported by Omosa (2006) who reported that food security comprised more than availability, access and stability of food supplies. Omosa asserts that the search for adequate food at rural household level is a function of how individuals concerned conceptualized and actualized their livelihoods.

The many definitions and conceptual models all agree that the key defining characteristic of household food security is 'secure access at all times to sufficient food'. However, the most influential definition that has become widely accepted is the outcome of the World Food Summit held in 1996 which defined food security as a situation in which all people at all times have physical and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life (FAO, 1996).

The FAO (1996) definition of food security establishes the key pillars of food security; it deals with the availability of sufficient quantity and quality of food physically present in an area through own production, markets, food provided as food aid or gifts. Although food may be available some households may not have access due to lack of purchasing power; the definition also addresses distribution in that sufficient food for a nutritious diet can be accessed by all either through a combination of own production, stocks, purchase, barter, gifts, borrowing or food aid; it also covers consumption in the sense that the energy and nutrients food needs of the individual are met in order to be active and live a healthy life. Furthermore, the definition addresses the reliability of access to food in a sustainable manner and not be at risk of becoming food insecure as a consequence of shocks or cyclical

events such as seasonal food shortages. The concept of stability may also refer to both availability and access to food security. This current study focused on two components: availability and access.

Basically, there are two forms of food insecurity, namely chronic and transitory. Chronic food insecurity implies a persistent inability on the part of the household to access adequate food. This type of food insecurity affects households that persistently lack the ability to either produce their own food or purchase food. Transitory food insecurity on the other hand, is a temporary decline in a household's access to enough food as a result of shocks due to economic as well as natural disasters. According to Omosa (2006), the categorization of food secure and insecure is only a temporal snapshot because the reality is that, it is highly dynamic and fluid to the extent that people's definition of food security encompasses having the hope that assistance will be forthcoming. Food security is about having hope. Households with dependable social networks such as able relatives feel less food insecure in the face of a shortfall than those with no one in sight to assist. In that regard, food security goes beyond physical stocks or ability to purchase. It encompasses having sufficient reasons to be hopeful and hence dependable social networks (Omosa, 2006).

Osoma (2006) suggests that, at one level, command over adequate food varies with household size, the age distribution of the household head, land size, quantity of food harvested and, how food supplies are managed. Her work revealed that at the household level, food security is perceived as ability to manage one's harvest well to the extent that those who "feed from the market" are assumed to have failed in their search for adequate

food. She further contends that at the rural household level, it is not culturally acceptable to plan to "feed from the market".

The State of Food Insecurity report reveals that after a prolonged decline from 24.2 percent in 1990-92 to 9.6 percent in 2014-16 (FAO, 2015), world hunger appears to be on the rise again: 815 million people were undernourished in 2016, up from 777 in 2015 (United Nations, 2018). In 2017, 157 million children under five years suffered from stunting (low height for their age), 51 million suffered from wasting (low weight for height), and 38 million were overweight (Ibid). Conflict, drought and disasters linked to climate change are among the key factors causing this reversal in progress (Ibid). The Sub-Saharan Africa (SSA) region is still challenged with rapid population growth which affects the ability of the countries to assure stable supply of, and access to food. The challenge is aggravated by the inability of the agri-food system to provide for the changing food and nutrition requirements of the evolving population, poverty in rural areas and the impacts of globalization on Africa agriculture, such as climate change and globalization of markets (FAO, 2015).

In Ghana, food insecurity continues to persist. According to the WFP (2009), about 1.2 million people, representing five percent of the population of Ghana, are food insecure and 2 million people are vulnerable to food insecurity in an event of any natural or man-made shock. Poverty has been identified as one of the causes of food insecurity. The WFP (2009) finds that about 46 percent of farming households are identified as the most affected among all economic sectors. Similarly, climate change is jeopardizing agricultural production, deepening the woes of food insecure households.

In northern Ghana (i.e. Northern, Upper East and Upper West regions), the incidence of poverty, malnutrition and stunting among children under five years of age is high (METSS-Ghana, 2012). The WFP (2012) observes that more than 680,000 were considered either severely or moderately food insecure of which 140,000 were classified as severely food insecure where the Upper East region has the highest proportion of households who are either severely or moderately food insecure. In terms of regional distribution, the Upper East region has the worse food insecurity status (28%) followed by Upper West region (16%) and then Northern region (10%). Nkegbe et al. (2017) observed that food insecurity still persists in the Savanna Accelerated Development Authority (SADA) region at levels unacceptable in modern society and that the Upper East Region is the worst affected of food insecurity because it experiences the longest food shortage period (p. 9). In the UER, poor households do not only have limited means of purchasing food but have smaller harvests and greater vulnerability to shocks due to reduced coping capacity (WFP, 2012). Publication by the Ghana Statistical Service indicates that more than four in every ten persons are poor in the Upper East Region (UER) and seven out of every ten in the Upper West Region (Ghana Statistical Service, 2013). The country still faces lots of nutritional deficiencies. Available statistics by the Ghana Health Service (GHS) indicate that 12,000 children in Ghana die every year of underweight related ailments due to malnutrition (GHS, 2012). The proportion of underweight children ranges from seven percent in the Greater Accra region to 27 percent in the UER.

Studies to examine the food security situation of farmer households in the three most deprived and poverty-stricken regions in northern Ghana have concluded that, although farmers in these regions cultivate purposely for household consumption and sell the

surplus, food was not available throughout the year in farmer households (Quaye, 2008; Alhassan, 2015). These studies observed that households usually employ a wide range of coping strategies to be able to survive when there was not enough food. Among these are collection of wild foods, sales of livestock[1], migration, market purchase, and support from relatives or friends. Others include reduction in the number of meals served each day, reduction in the portion/size of meals and consumption of less preferred foods.

Analysis of food insecurity situation in Chiana community of the Upper East Region revealed that, the period between September (harvest season) and April (onset of the next season) is the period where households depend on their 'own produced' grains for consumption (Yaro, 2004). According to Yaro (2004), availability of food stocks over this period (September to April) vary according to crop type. Furthermore, he observed that May to August is often the period when most households have exhausted their 'own produced' food stocks and then resort to buying grains from the market to support household consumption. Yaro (2004) described June to July as the most critical food insecure period. In a related study to examine months of inadequate food provisioning in northern Ghana, Quaye (2008) observed that farmer households experienced a significant degree of food insecurity period spanning between three and seven months. The Upper East Region was the worst affected as it experienced the longest food shortage period of six months. According to the Comprehensive Food Security and Vulnerability Analysis report of the WFP (2012), three out of the five food insecure districts are found in the UER.

[1] Livestock plays a crucial role in bridging the hunger gap. It reduces the risks associated with crop production and represents liquid assets that can be realized at any time. Usually, income from crop production is often invested in livestock keeping which serves as safety nets during shocks.

According to the Food and Agriculture Development Policy (FASDEP II), the higher rates of food insecurity across the north of Ghana are largely the result of limited household resources available to purchase food, combined with limited agricultural output and the seasonality of food availability (MoFA, 2007). Poor agricultural performance has been noted as a major cause of food insecurity in northern Ghana following the high dependence on agriculture both for income and for substance (WFP, 2012; Alhassan, 2015). Another view contends that food might be available in the market but that people lack the means of acquiring it because of ineffective demand (Sen, 1981; Omosa, 2006). A third view contends that politics and associated power distributions within societies cause famine or food insecurity (De Waal, 1990). Theories of food security can be categorized into food availability decline, entitlement failure, and livelihood failure. It is not the intention of this study to reinvent the wheel as detail overview of these theories and critique of the theories and approaches to food insecurity has been discussed extensively by Yaro (2004).

2.2.9 Household Food Insecurity in Northern Ghana

In many rural communities in Africa, agricultural production is largely underpinned by two critical drivers: low soil fertility and coping with risk and uncertainty (Yaro, 2004; Derbile, 2010; WFP, 2012; Ndamani & Watanabe, 2016). In this section, attention is drawn to two significant features of the natural environment which are reflected in tropical farming systems which underpin food insecurity situation in the Savanna ecological region. These features are: climatic influences and soil conditions.

Climatic influence and food insecurity

The production potential of tropical farming is widely acknowledged. However, most of the tropics experience a seasonal pattern of rainfall, with distinct periods of high and low levels of precipitation. This means that soil moisture levels at certain periods are not sufficient to sustain plant growth. There is considerable degree of uncertainty with respect to the level of rain that will fall in any one season, with both drought and flood as serious possibilities (Kasei et al., 2010). In many tropical areas, the dry season is the time of fairly high winds which not only reduce the opportunity for plant growth, but also bring threads of wind-induced erosion (Kombiok et al., 2012). Climate exerts its influence on farming not only through the control that it imposes on the timing and value of plant growth, but also through its effect on livestock production (Yaro, 2004).

Account of most farmers in northern Ghana reveals unfavorable intra-annual distribution which often leads to dry spells and drought in some months and high rainfall intensities in order months during the rainy season (Derbile, 2010). Besides, farmers have also observed shortening duration of rainfall. These farmer perceptions of rainfall variability have been corroborated by several studies (Yaro, 2004; Derbile, 2010; Logah et al., 2013). In a study to examine long-term conitegration and causality between rainfall and yields of selected staple crops in some districts in northern Ghana, Amikuzuno and Donkoh (2012) found evidence of how total rainfall influenced crop yields of those selected crops. Other studies however, maintain that the distribution of rainfall rather than the total amount of precipitation affects food production most (Yaro, 2004; Mkonda, 2014). Mkonda (2014) argues that heavy rainfall with few wet spells in the growing season might not necessary have any impact on crop production because it occurs with fewer wet spells while crop

production is favored by numerous and fairly distributed wet spells. Thus, fair distribution of wet spells is very important as it ensures the sustainability of wet on the ground.

Enhancing household food security

In farming, the objective of every household is to produce most of the basic food needs and other natural-product needs of the family. It is therefore essential for the household to be able to maintain a minimum amount of food of different kinds throughout the year. In meeting this objective, farmers over the years have developed and adapted time tested strategies to attain household food security. Some of these strategies include; multiple farm holdings – which offer farmers the opportunity to spread their risk and ensure a constant supply of produce (Derbile, 2010); diversification of production – which enables farmers to grow a range of crops; phased planting – this helps farmers to deal with uncertainty by staggering planting over a period and also able to manage the demand for labour over several months (Briggs & Moyo, 2012); cultivation of climate smart varieties such as drought tolerant varieties, adoption of early maturing varieties and mixed cropping strategies (Yaro, 2010).

Generally, smallholder farmers cultivate multiple farms under mixed cropping and stagger planting regimes in a holistic effort to adapt crop production to rainfall variability. They adapt measures within their context to deal with risk associated with food crop production. According to Briggs and Moyo (2012), risk aversion is clearly a key element of crop farming among rural households and the opportunity to stagger planting through the rainy season ensures more secured outcomes in terms of household food security. The drive for household food security is reinforced by the wide range of crops chosen for cultivation.

The range of food crops often include grains, vegetables and fruits which provide a relatively balanced household diet in terms of nutrition and also spread risk. From the perspective of smallholder farmers, food security is only achieved by growing a range of crops (Briggs & Moyo, 2012) and decisions on planting dates and cropping pattern are based on local predictions of the weather condition.

One important step in reducing the impact of rainfall variability on crop production is the development of an early warning system for the prediction or forecast of the event (NDPC, 2014). Most rural communities apply traditional knowledge in early warning systems that calculate risks or detect extreme weather events, drought or floods. In some societies in Africa, people rely on those with specialized powers to read natural signs and predict events and subsequently warn the community (Millar, 2014). Others also rely on indigenous indicators such as trees, insects, plants, animals, etc. in predicting climate parameters (Merlin & Narasimhan, 2009). According to Yaro (2009), the limitations of peasant technology in countering the effects of weather vagaries constitute a great source of vulnerability to their livelihoods. In northern Ghana, it appears conscious efforts have not been made to identify and document effective traditional warning systems which may help rural communities in their daily and seasonal farming activities.

Soil condition and household food insecurity

Tropical soils vary enormously in type and suitability for farming. Some are derived from materials that are the products of fairly recent geological events, being volcanic or sedimentary in origin, whilst others are derived from very old igneous material (EPA, 2002). Poor soil structure of most tropical soil is a prominent feature that detracts their fertility (Yaro, 2004). As a result of this feature, they may not be resilient under intensive

cultivation which consequently increases the high risk of water and wind erosion (Kombiok et al., 2012). A widespread feature is the extent to which the pattern of precipitation in sudden heavy rainstorms has led to extensive leaching so most of the soluble plant nutrients have been carried away (Derbile, 2010).

Initially, nutrients removed through continue cropping was replaced by practicing shifting cultivation or land rotation. However, with the increase in population, pressure is brought to bear on land use thereby making the practice unsustainable. According to Kombiok et al. (2012), the situation renders the soil bare exposing it to both wind and water erosion in the dry and rainy season respectfully thereby depleting the micro-nutrients such as Nitrogen, Phosphorus and Potassium (NPK) and organic matter from the soil. Others argue that low soil fertility can result from low inherent soil fertility. Derbile (2010) argues that although soil fertility may be inherent in the soils of the Upper East Region, soil fertility has declined considerably overtime due to human activities such as intensive cultivation, bush fires, over grazing, tree felling, charcoal burning, and soil erosion. Farmers who work under such circumstances are often faced with the dilemma of soil fertility challenges. In every situation, the dominant importance of this critical driver is highlighted, together with a consideration of the ways in which technological and institutional changes can be made so as to overcome this major challenge.

Soil fertility maintenance strategies

Over the years, smallholder farmers have developed a range of local soil fertility maintenance strategies based on continually evolving local knowledge and understandings, with many farmers taking the view that traditional methods of soil fertility maintenance are

more cost effective and significantly soil-friendly than applying chemical fertilizers (Briggs & Moyo, 2012). Manure remains the most known and widely used soil fertility amendment in northern Ghana (Quansah, Safo, Ampontuah, & Amankwah, 2000). Derbile (2010) observed that majority (97%) of farmers in the Atankwidi basin apply some form of local organic manure in food crop production as a means to improving soil fertility. Many studies have confirmed the positive effects of manure on crop yields and soil fertility maintenance (Place, Christopher, Barret, Ade, Josua, & Bernad, 2003; Kombiok et al., 2012). Derbile (2010) observed two traditional forms of manure: *NandenePu'usego* is mainly produced from the decomposition of cow dung and plant residue which is usually located within the homestead. The second is *TampugerePu'usego* produced through the decomposition of a wide range of organic materials from a refuse dump. As a result of changing circumstances, other forms of manure such as *Tanuku* and *Na'ambea* forms of manure have evolved (Derbile, 2010).

In practice, manure is usually transported to the fields and placed in heaps. It is then broadcast on the surface of crop fields just prior to ploughing. Under this circumstance, nitrogen losses might occur through volatilization or displaced into deeper soil strata through leaching after the first heavy rains when plant growth is insufficient to absorb the mineralized N (Brouwer & Powell, 1995; 1997). Consequently, farmers in Burkina Faso often dig holes on farmlands to deposit manure there and sow during the rainy season. This traditional method is often called *Zai* (Critchley, 1991). Zai is the name in the local Moore language and it describes wide and deep planting holes. *Zai* are usually 20 – 40 cm in diameter, 10 – 20 cm deep, and spaced 90 cm apart. It is reported that this *Zai* technique can lead to yield increases of about 500% if well executed (World Bank, 2005). Although

manure shows great promise in boosting crop yields, factors such as: large quantities are required to make a significant contribution to crop yields, its bulkiness, make transportation difficult, it is labour intensive, and its competitive utilization constrains many smallholder farmers from applying manure to improve crop production.

Inorganic fertilizer has been a major agro-chemical input introduced into the local farming systems (Houssou et al., 2016). It use is widespread and adoption rate is increasing among farmers because the fertility of most lands under cultivation has declined. As soil fertility declines, chemical fertilizer is often used to maintain or increase crop yields. However, it is also noted that farmers use less than the recommended rate of chemical fertilizer for many reasons, including financial constraints, inadequate knowledge of the nutrient status of their soils, and the availability of fallow lands (Kombiok et al., 2012). With regards to cropping patterns, farmers are practicing multiple cropping systems, benefiting from the nitrogen fixed in the soil by the legume crops. Hence farmers are able to apply less or no chemical fertilizers to reduce their production cost (Abebe & Deressa, 2017).

2.3 Agricultural Development Policies and Pragrammes in Ghana

Over the years, successive governments have provided Medium-Term National Development Policy Frameworks to guide the preparation and implementation of sector and District Development Plans in Ghana, aimed at reducing poverty and improving the social wellbeing of the people. This section reviews such national policy framework and programmes within the context of technologies and innovations being promoted in agricultural development in Ghana.

Ghana Poverty Reduction Strategy (GPRS)

The Ghana Poverty Reduction Strategy (GPRS I) was a comprehensive policy document prepared as a pre-condition for Ghana to benefit from a significant measure of debt relief under the Highly Indebted Poor country Initiative (HIPC). It was primarily aimed at positioning the country in an improved macroeconomic environment to address critical issues of poverty. A general assessment of the overall policy environment following the implementation of GPRS I revealed significant stabilized macroeconomic environment with potentials for attaining higher rates of growth (GoG, 2003). It is against this background that GPRS II was adopted and implemented from 2006 – 2009 with a shift in focus and context to accelerate growth of the economy towards sustained poverty reduction and the attainment of middle income status.

Ghana Shared Growth and Development Agenda (GSGDA)

Consistent with its commitment to own the development process and provide a successor to GPRS II, the Ghana Shared Growth and Development Agenda (GSGDA) 2010 – 2013, was initiated to achieve and sustain macroeconomic stability while placing the economy on a path of shared growth and poverty reduction. The GSGDA provided the strategic direction to lay the foundation for the structural transformation of the economy within the framework of Vision 2020, through industrialization based on modernized agriculture and sustainable exploitation of Ghana's natural resources (NDPC, 2010). The GSGDA acknowledged that Ghana's agriculture is dominated by subsistence smallholders with weak linkages to industry and the services sector and further recognized their peculiar challenge of low productivity, low income and un-competitiveness in production,

processing and distribution. Consequently, the focus of agricultural policy over the medium-term was to accelerate and modernize agriculture and ensure its linkage with industry through application of science, technology and innovation. Modernized agriculture sector was expected to underpin the transformation of the economy through job creation, food security, and supply of raw materials for value addition and rural development as well as poverty reduction (NDPC, 2010). Some broad objectives to be achieved under the medium-term development strategy included; improved agricultural productivity; increased agricultural competiveness; Promote selected crop development for food security; and improved institutional coordination for agricultural development.

Although the GSGDA acknowledged that Ghana's agriculture is dominated by subsistence smallholder farmers, it failed to recognize that smallholder farmers are a heterogeneous group of farmers largely driven by traditional knowledge systems which define their decision-making in agriculture and natural resource management.

Food and Agricultural Sector Development Policy (FASDEP)

The first Food and Agricultural Sector Development Policy (FASDEP I) was formulated in 2002 as a holistic policy, building on the key elements of the Accelerated Agricultural Growth and Development Strategy (AAGDS) with focus on strengthening the private sector as the engine of growth. FASDEP I was the principal policy document for the Ministry of Food and Agriculture (MoFA) which sets out governments' intentions for the development of the agricultural sector in Ghana. The policy document was meant to provide a framework for modernizing the agricultural sector and making it a catalyst for rural transformation in line with the goal set for the sector in the GPRS I. After nearly four

years of its implementation it became necessary to revise it to respond to changing needs of the sector. A Poverty and Social Impact analysis of FASDEP I concluded that the policy would not be able to achieve the desired impact on poverty for a number of reasons including the following: *" the expectation of modernizing poor smallholder agriculture was unachievable because of improper targeting of the poor within an environment where the drivers of modernization, access to credit and technology, and markets are very limited; problem analysis was weak and did not sufficiently reflect client perspectives on their needs and priorities"* (MoFA, 2007, p. 1).

Consequently, it became necessary to revise FASDEP I to reflect lessons learned and to respond to the changing needs of the sectors. FASDEP II emphasized sustainable utilization of all resources and commercialization of activities in the sector with market-driven growth in mind. The policy document states that: *"the national vision for the food and agricultural sector is a modernized agriculture culminating in a structurally transformed economy and evident in food security, employment opportunities and reduced poverty" (MoFA, 2007, p. 20).*

This vision for the food and agriculture sector was linked to the national vision in the GPRS II, the Comprehensive Africa Development Programme (CAADP) of the New Partnership for Africa's Development (NEPAD). Based on the role of agriculture in the national development framework, the objectives for the food and agriculture sector policy were specified as: *"Food security and emergency preparedness; improved growth in incomes; increased competitiveness and enhanced integration into domestic and international markets; sustainable management of land and environment; Science and Technology Applied in food and agricultural development; and improved Institutional Coordination"*

Unlike FASDEP I, FASDEP II acknowledged that smallholder farmers are a heterogeneous category and constitute the most vulnerable to food insecurity and therefore will be targeted with intervention to reduce their vulnerability and help them improve productivity. Subsequently, in pursuit of a modernized agriculture in FASDEP II, the policy strategy focused on the development of at most five stable crops (i.e. maize, rice, yam, cassava, and cowpea) and MoFA support for food security at the districts was expected to focus on at most two of the crops above selected based on comparative advantage, importance of the crops to the people in the district and availability of markets (MoFA, 2007). In effect, the strategies for food security and emergency preparedness were to target the poor to enhance their capacity to cope with production and food insecurity risk. Besides, the policy prioritized research on the basis of commodities targeted in the FASDEP II document.

Despite its acknowledgement of differentiated smallholders, it is clear that FASDEP II continued the path of its predecessor of not addressing the felt needs of the different categories of smallholder farmers who largely cultivate a range of food crops to achieve household food security (MoFA, 2007). It further implies that smallholder farmers engaged in food crops not targeted by the policy are not expected to benefit from MoFA extension support at the district level to improve production. Besides, the top-down transfer of technology and training approach through extension officers do not follow the demand-driven research approach stipulated in the policy document (Dzanku & Aidam, 2013). Consequently, traditional food crops such as Neeri, Bambara beans, millet among others have not received research attention as compared to maize and rice largely due to public funding challenges. These traditional crops have not been prioritized in current agriculture sector police (Dzanku & Aidam, 2013). Furthermore, the focus on science and technology

without any reference to traditional knowledge systems in agricultural innovation and development suggests that it has been relegated although it is a dominant knowledge system among smallholders. Indeed, the modernization approach does not provide scope for participatory engagement with smallholder farmers to address their priorities and aspirations. Darko and Atozone (2013) argue that the productivity of smallholder subsistence farmers will not be directly targeted by many of the modernization strategies outlined in FASDEP II.

Medium-Term Agriculture Sector Investment Plan (METASIP)

The Medium-Term Agriculture Sector Investment Plan (2009 -2015) is a sector wide investment plan for the implementation of the broad strategies specified in FASDEP II. The METASIP policy document which was developed based on FASDEP II objectives acknowledged that Ghana's agriculture is dominated by small scale producers who are characterized by low crop productivity resulting in generally low yields. The policy attributes the non-attainment of achievable yields to low fertility of the soils. However, the policy does not recognize the significant role of traditional farmer knowledge in soil fertility management among smallholder farmers. Similarly, METASIP acknowledges the fact that inadequate agricultural financing and difficulties in accessing agricultural credit have significantly contributed to low agricultural production and productivity (MoFA, 2015). That notwithstanding, the policy does not recognize alternative sources of local credit mobilization mechanisms such as Village Savings and Loan Associations (VSLA) in rural areas. Indeed, VSLA has been identified by development practitioners as a powerful tool for promoting access to credit in rural areas.

Furthermore, the METASIP (2014-2017) was developed with strong emphasis on the Accelerated Agriculture Modernization and Sustainable Natural Resource Management which is envisaged will transform the agricultural sector to increase productivity and output, create jobs, increase incomes, and ensure food security over the medium term (MoFA, 2015). METASIP did not discuss the role of traditional knowledge systems in innovation and agricultural development but rather placed emphasis on science and technology. The emphasis on science and technology is underscored by the vision of the National Development Planning Commission (NDPC), which is to achieve "a modern economy based on the development of Science and Technology" (MESTI, 2017). The principal thrust of the National Science, Technology and Innovation policy (2017-2020) is to ensure that science and technology drive all sectors of the economy. In order to achieve these objectives, sectorial policies, programmes and strategies would have to be implemented on the basis of the STI Policy. However, weak institutional coordination has been identified as an important hindrance to effective and efficient delivery of agricultural policies, programmes and projects (Dzanku & Aidam, 2013).

Social science and culture seems to be neglected in the national science, technology and innovation policy and does not recognize the development of locally initiated technologies (Darko & Afozone, 2013). Furthermore, it does appear that there is no attempt to support the search, acquisition, development and application, and utilization of traditional farmer innovations in the STI Policy document. Nonetheless, the need to promote the development and creation of innovation and utilizing indigenous knowledge and technology is necessary for sustainable development in line with SDG goal 2 – which seeks to end hunger, achieve food security and improved nutrition, and promote sustainable agriculture. In countries

such as Nigeria, Kenya and Ethiopia, the National Science, Technology and Innovation (STI) policy documents recognize the significant role of indigenous resources, traditional knowledge and technology which are well articulated under their strategic policy strategies as part of their national innovation systems to facilitate technological development, transfer and diffusion for the accomplishment of national strategic development goals.

Agricultural Development Prorammes

The Ministry of Food and Agriculture (MoFA) in line with its mandate to accelerate the modernization of agriculture and to increase the productivity of the Ghanaian farmer, has initiated a number of programmes to achieve this mandate (Dzanku & Aidam, 2013). For the purpose of this study, I will provide a brief review of two of such initiatives to illustrate how smallholder farmers and their farming knowledge are excluded from government efforts to transform agriculture in general.

Government re-introduced the National Fertilizer Subsidy Programme in 2008 to increase agricultural productivity to ensure food security and improve standard of living. The program aimed at increasing the national average of fertilizer use among farmers, which is one of the lowest in the world, to increase crop yields and production, raise profitability of crop production, and private sector development in the fertilizer market. The programme subsidized all-size crop for farmers that can afford the subsidy price, covering approximately 50 percent of the fertilizer prices, and distributed in the form of fertilizer-specific and region-specific vouchers. Some studies have suggested that the fertilizer subsidy programmes appear to be ineffective in spite of the huge investments, as evidence shows that not much has been achieved by way of improvement in the rate of application as well as growth in outputs (Fearon, Adraki & Boateng, 2015). One major concern about

fertilizer subsidies is how much of the subsidized amount really gets to the intended target as against how much ends in wrong pockets. Though targeting poor and smallholder farmers is the key in the program implementation guidelines of fertilizer subsidy program, the Ghana Strategy Support Program's (GSSP's) recent works of fertilizer subsidy targeting in Ghana show that there are considerable challenges in the existing methods of targeting (GSSP, 2017). It is observed that large-scale and wealthier farmers are the main beneficiaries of subsidized fertilizer even though the stated goal is to target smallholder farmers with fertilizer subsidies (GSSP, 2017). Furthermore, the focus of the programme affirms the assertion that the national agricultural policies have relegated traditional farming practices such as compost/animal manure to the background in favor of western scientific agricultural practices.

Agricultural Mechanization Service Centers (AMSEC)

In 2007, the government of Ghana launched the Agricultural Mechanization Service Centers (AMSEC) programme. The programme was a credit facility to assist the private sector to purchase agricultural machinery and set up commercially viable AMSECs in strategic locations (Diao, Cossar, Houssou, & Kolavalli, 2014). The facility was government's response to deal with low level of agricultural mechanization in the country to enable farmer have widespread access to mechanization service at affordable price to improve agricultural production (MoFA, 2007). It was observed that many of the AMSECs were unable to follow the repayment schedules and therefore defaulted on repayment leaving the government responsible for the repayment of the concessional loans. According to Diao et al. (2014), the AMSEC model promoted by the government seems not to be viable and that continuous implementation of such model will not only increase the

financial burden to the government, but also encourage rent-seeking behavior and diminish the role of the private sector in developing mechanization supply chain. Besides, providing heavy subsidy on large and more costly tractors does not seem to be the most appropriate solution to a country dominated by smallholder farmers. Smallholder farming systems, particularly, in northern Ghana find the use of bullock plowing on compound farms more suitable than tractor. Besides, many smallholder farmers are financially constrained to use tractor services. Following from the literature review, the next section discusses the theoretical framework to guide analysis of the study.

2.4 Theoretical Framework

The theoretical framework that guided this study combined two theories: evolutionary process of farming systems developed by Boserup (2014) and diffusion of innovation by Rogers (1983). Boserup (2014) is credited as being the first scholar to theorize an evolutionary process of farming systems that directly responded to the more pessimistic viewpoint of the Malthusian hypothesis, which posited the decline of per capita agricultural production as population grows. Boserup argues that farming systems follow an evolutionary intensification process that drives the adoption of various inputs/technologies. According to Boserup, each of these stages entails different cultivation techniques and the model implies a progression from less to more intensive cultivation. The main argument focuses on how population pressure stimulates technological innovation and intensification due to reduced fallow and access to virgin lands (Boserup, 2014). Boserup (2014) asserts that the kind of agricultural tool or technology needed at any given context depends upon the system of land use and that there is a close association between the system of fallow and the farming practice or technology being used.

A number of case studies to test Boserup's theory in the African context have emerged. A review by Wiggin (1995) revealed earlier cases in support of Boserup's theory. Codjoe and Billsborow (2011) found evidence supporting Boserup's intensification argument for farming systems in the Guinne Savanna and Transition Zones. Headey, Dereje and Taffesse (2014) found strong evidence favoring Boserup's theory for explaining intensification at the village level in Ethiopia. However, few studies have suggested possibilities of a differential pattern of agricultural intensification in Africa. Amanor and Pabi (2007) argued that change is not the product of simple evolutionary sequences of responses to population pressures or adoption of modern technologies but rather arises out of a complex set of factors which are increasingly commoditized and commercialized.

Nin-Pratt and McBride (2014) suggested that agricultural intensification in Ghana has not been driven by population density but rather by the adoption of both labor-saving (mechanization) and land-saving (improved seed and chemicals) technologies. The pattern of intensification observed appears to be a strategy to cope with high labour costs and reduced production opportunities in agriculture. Therefore, they contend that to assume that Africa is on the surge of another Asian-style Green Revolution will be misleading and could result in a frustrated attempt to attain sustainable agricultural growth because they found no correlation between population density and input intensity in Ghana. More recently, Houssou et al. (2016) observed a gradual move towards intensification in Ghana through increasing use of labor-saving technologies rather than land-saving technologies. The findings further provide evidence of dynamism occurring in African farming systems and opine that farmers' response to both endogenous and exogenous factors has led to the emergence of a farming system that has both elements of intensification and extensification

(Houssou et al., 2016). This system which involves new cropping systems, combinations of technologies and specialization of crops as well as expansion of farm size (p. 27).

The farming system theory provided useful insights and framework that guided the discussions and analysis of how smallholder farmers describe their farming systems and the association between the systems of land use and their choice of farming practices and technologies. Furthermore, the theory provided insights into the criteria used to select study communities in terms of communities that have reached their land frontiers and those that still have lands available for farm expansion. This criteria allowed the study to examine whether reduced fallow or access to virgin farmlands stimulates adoption of agricultural technology as stipulated by Boserup's model. Similarly, the theory provided understanding into the process of agricultural intensification which guided the study to examine the pattern and drivers of agricultural technology adoption among smallholder farmers in the area.

That notwithstanding, farming systems theory was limited in providing understanding of the factors that influence or hinder smallholders' decision to adopt agricultural technologies and practices. Hence, the need to draw in diffusion and innovation theory to provide insights and understanding of the rationale underpinning smallholder farmers' decisions of their choice of farming systems. Furthermore, the diffusion and innovation theory provided a framework to examine the process of developing knowledge integration model that facilitates smooth innovation diffusion for sustainable smallholder farming systems.

A review of the literature on innovation and diffusion reveals several distinct schools of thought. The 'school' which has been most influential and influenced development projects is led by Everett Rogers. Rogers defines diffusion as "the process in which an innovation is communicated thorough certain channels over time among the members of a social system" (Rogers, 1983). This school views innovation and diffusion as distinct processes, takes the need for the innovation as given, treats technology as a free-standing object independent and devoid of cultural meaning, and views problems of diffusion as one of communication and persuasion. The unsuitability of the innovation itself or difficulties arising from the material condition of the potential adopter and the ability of the agent promoting the innovation to persuade potential adopters are not emphasized.

In contrast to the Rogers school, Agarwal and others have argued that innovation and diffusion are not separate processes. Rather, innovation is essentially the first step in the diffusion process and potential adopters' decision concerning adoption is based on rationality rather than persuasion (Agarwal, 1983). In this school, innovations are ideas or technologies which are continually adapted as they are adopted, and represent sequential socio-cultural change (p. 369). This school places primary emphasis on the process by which the innovation itself is generated and developed and, on the need to ensure suitability and appropriateness to the user's needs and requirements to bring about ready acceptance and successful diffusion of the innovation.

Economists have focused on the economic factors 'inducing' innovation, and have taken a market rather than personal perspectives. According to Hayami and Ruttan (1970, 1985), the direction of technical change in agriculture is induced by differences in relative resource endowments and factor prices.

A more recent strand of literature has sought to classify the factors that influence the adoption of modern agricultural production technologies into economic factors, social factors and institutional factors (Akudugu et al., 2012; Mwangi & Kakuiku, 2015). The economic factors include; farm size, cost of technology, expected benefits from adoption of the technology, and off-farm activities (Diiro, 2013; Lavison, 2013). The social factors include; age, level of education, gender and household size (Akudugu et al., 2012; Lavison, 2013; Nazziwa-Nviiri, Van Campenhout, & Amwonya, 2017). Institutional factors include: access to information, extension services and social network (Akudugu et al., 2012; Mwangi & Kakuiku, 2015). Other studies have focused on market participation and household wealth as important factors influencing agricultural technology adoption behavior among smallholder farmers in developing countries (Jack, 2011; Nazziwa-Nviiri et al., 2017; Baiyegunhi & Hassan, 2018).

Generally, combining both theories was useful and relevant to investigate how social differentiations of smallholder farmers are harnessing the synergies and complementarities between traditional and western agricultural knowledge systems to improve household food security in the study area. The next section sheds light on the concepts underpinning the study.

2.5 Conceptual Framework of Knowledge Integration

Following from the review of relevant literature, I present a conceptual framework to guide the analysis of the study. This conceptual framework is used to examine how socially differentiated smallholder farmers are harnessing the synergies and complementarities between traditional and western agricultural knowledge systems for improved household

food security in the Kassena Nankana traditional area. In order to clarify how this framework guided the study, I describe the main components and show how they interrelate to produce household food security outcomes. The main components are farming systems, traditional knowledge systems, western scientific knowledge systems, knowledge integration, and household food security (see Figure 2.1).

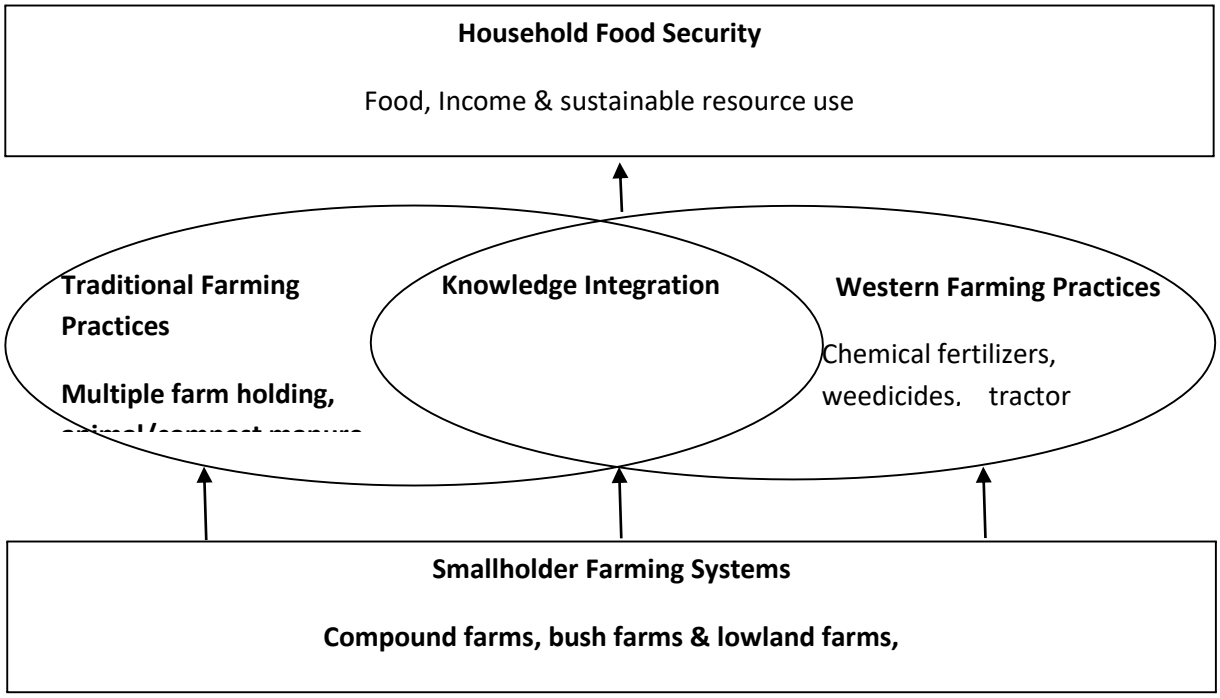

Figure 2. 1: Conceptual framework: Farming systems, knowledge integration and household food security

Source: Author's own construct (2018)

Farming systems constitute the starting point in this conceptual framework. Three types of cultivation systems are of interest in this study. These include: compound farms, bush farms and lowland farms (Derbile, 2010; Briggs & Moyo, 2012). Within these cultivation systems are two types of cropping systems: multiple cropping and mono cropping (Wood, 2013). Given that farming systems evolve (Headey, Dereje, & Taffesse, 2014), this study

is interested in the associations between the cultivation systems and farming practices and technologies being used by smallholder farmers in the study area. The types of farming practices and/or technologies a farmer will adopt may be drawn from traditional agricultural knowledge systems, western agricultural knowledge systems or both.

Traditional agricultural knowledge is adopted to refer to the body of knowledge which is native to farmers. In this regard, the emphasis is on traditional agricultural practices related to crop production. In light of this, the key variables investigated include the use of animal manure, compost and cropping systems to address soil fertility constraints, measures of land preparation, cultivation of a wide range of crops, and phasing planting to deal with risk and uncertainties (Briggs & Moyo, 2012). Above all, the wisdom and perceptions underpinning their choice of different blend of farming practices is of interest to the study.

Apart from traditional agricultural knowledge system, a farmer may adopt western agricultural knowledge system. This system connotes the concepts, ideas, values, practices and technologies which are imparted in the minds of farmers by extension officers, both public and private, who are trained in western (modern) scientific agriculture. In pursuit of increased production and productivity to improve household food security and serve markets with surplus, agricultural activities are usually mechanized and production practices employed often include mono-cropping, application of inorganic fertilizers, use of agro-chemicals, use of improved crop varieties such as hybrids and certified seeds, and irrigation.

Given that the two bodies of knowledge systems in their different ways are quite limited in their abilities to address emerging issues around sustainable agricultural development, it is

envisaged that purposeful integration of the two knowledge systems will improve household food security outcomes in the Kassena Nankana traditional area. Knowledge integration is used in this study to refer to blending of proportions of relevant traditional and western farming practices and technologies to increase crop production. This study is interested in how social differentiations of smallholder farmers are harnessing the complementarities between traditional and western agricultural knowledge systems to improve household food security and the rationale for their decisions. High or low degree of knowledge integration will be used to measure the extent of integration of the two knowledge systems. "High degree" refers to a larger proportion of western agricultural practice being adopted relative to traditional agricultural practice, whereas "low degree" refers to a smaller proportion of western agricultural practices being adopted relative to traditional agricultural practice. The adoption of farming practices and technologies is largely influenced by economic factors, social factors and institutional factors (Akudugu et al., 2012; Mwangi & Kakuiku, 2015).

Household food security outcomes are considerably influenced by the kind of food security strategies pursued by households (Alhassan, 2015). In this study, household food security is conceptualized as a household's ability to command adequate amount of staple grains all year round through own production or combination of existing sources. To this end, the MAHFP is used to measure household food security access and availability. The key indicators to measure include household food provisioning, consumer behavior in respect of coping strategies such as sale of livestock for income to purchase food from the market, and sustainable farming practices to ensure secured household food provision. It is acknowledged that food security strategies pursued by households differ among social

differentiations of smallholder farmers in dealing with the key drivers (i.e. poor soil fertility and rainfall variability) of household food security. It is instructive to note that the logical relationships among the key concepts/variables are framed within a broader environment – physical, social, economic, and policy framework.

2.6 Conclusion

The chapter explored and situated the study in related literature and established the theoretical and conceptual framework to guide the study. The literature reviewed is significant to the study as it exposed the study to diverse theories and conceptual issues around smallholder farming systems, knowledge integration and household food security and provided insights into the development of appropriate and sound methodology for the study. The next chapter presents the research methodology for the study.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Introduction

Research methodology is the general research strategy that outlines the way in which a research project is to be undertaken and, among other things, identifies the methods to be used in it (Igwenagu, 2016). It offers theoretical underpinning for understanding which method, set of methods or best practices which can be applied in research and helps to inculcate the ability to evaluate and use research results with reasonable confidence and in decision making. This chapter discusses the research design and the methods of data collection and analysis within the context of the study location. To do this, I structure the discussions into two sections. In the first section, I provide a description of the study area. In section two, I discuss the research design underpinning the study and justify why this is appropriate for the study and then proceed to outline the data collection methods and analysis.

3.2 The Study Area

This study was conducted in the Kassena Nankana East Municipal and Kassena Nankana West District of the Upper East Region (UER) of Ghana (see Figure 3.1). The UER is located in northern Ghana and is the second smallest of the 10 administrative regions of the country, occupying a total land surface of 8,842 square kilometers or 2.7 percent of the total land of Ghana. It is located in the north-eastern corner of Ghana, bordered by Burkina Faso to the north and Togo to the east. The UER is divided into 15 districts made up of two municipal and 13 ordinary districts. The UER is noted to have the largest proportion of food insecure households in northern Ghana and has the largest proportion of smallholder

farmers. Indeed, the four out of the six districts with the highest proportion of food insecure households are found in the Upper East Region (WFP, 2012). The study area covered two out of the four districts with the highest proportion of food insecure households in the UER (p.20). These two districts are the Kassena Nankana Municipal and Kassena Nankana West. These two districts are coterminous with each other. Hence, for the purpose of this study, Kassena Nankana Traditional Area (KNTA) is used to refer to the two districts.

The main languages spoken in the KNTA are *Kasem* and *Nankani*, with *Builí* being spoken by most of the minority tribe. Linguistically, the *Kasem* speaking people are Grusi and *Nankani* are Nankansi (Derbile, 2010). Despite the linguistic distinction, the population is, in many respects, a homogeneous group with a common culture. The Kassena Nankana East Municipality lies approximately between latitude 11˚ 10˙ North and longitude 10˚ 1˙ West and has Navrongo as its political and administrative capital. According to the 2010 Population and Housing Census, the Municipality has a population of 109,944 representing 10.5 percent of the region's total population. Males constitute 48.8 percent and females represent 51.2 percent. About 72.7 percent of the population lives in rural areas. The average household size in the Municipality is 5.4 persons per household and majority (i.e. 82.7%) of the household depend on agriculture for their livelihood of which about 96.1 percent are involved in crop farming and poultry production (GSS, 2014a).

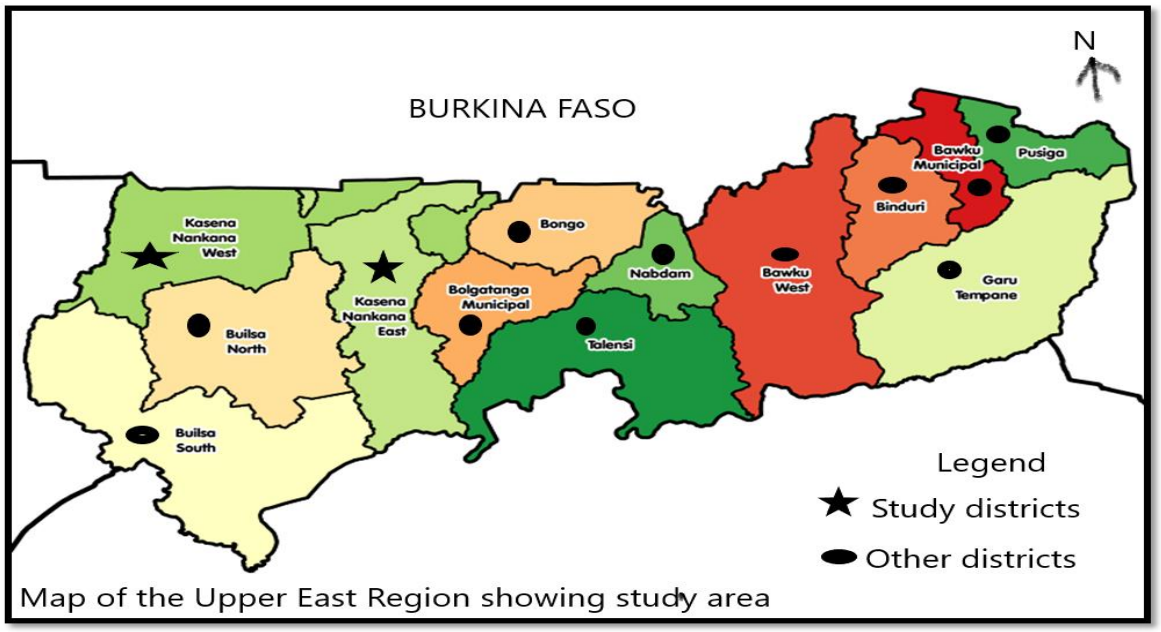

Figure 3. 1: Map of the Upper East Region showing study location

Source: Adapted from Wikipedia

The Kassena Nankana West District is located approximately between latitude 10.97˚ North and longitude 01.10˚ West with a total land area of approximately 1,004sq.km and has Paga as its political and administration capital. According to the 2010 Population and Housing Census, the population of the Kassena Nankana West District is 70.667. Males constitute 50.8 percent and females represent 49.2 percent. About 79 percent of the population is rural and as high as 90.7 percent of households are engaged in agriculture with majority of households (98.2%) involved in crop farming and poultry (chicken) production (GSS,2014b).

The Kassena Nankana Traditional Area lies within the Guinea Savannah woodlands, covered mainly by Sahel and Sudan-Savannah types of vegetation comprising the Savannah grassland with short tress. Common trees found are Dawadawa, Baobab, sheanut and mango. The Guinea Savannah covers almost the northern two-thirds of the country and

is the largest ecological zone in Ghana. The natural vegetation has undergone considerable changes as a result of human activities (EPA, 2002; Yaro, 2004). This has given rise to gradual onslaught of desertification in most part of northern Ghana, especially the UER (Derbile, 2010). The natural vegetation (tree fauna) has been severely depleted. Analysis of the rates of land cover changes over the period have shaped the current state of desertification to the extent that northern Savanna (Guinea and Sudan) are regarded as the most vulnerable to soil erosion (EPA, 2002). Desertification and land degradation remain a development problem affecting northern Ghana most especially.

The Kassena Nankana Traditional Area falls within the interior continental climate zone of the country characterized by the dry and wet seasons and largely influenced by two air masses – the North-East Trade winds and South-West (Tropical Maritime). The harmattan air mass (North-East Trade Winds) is usually dry and dusty as it originates from the Sahara Desert. During such periods, rainfall is virtually absent due to relative humidity. The influence of these air masses has given rise to a single major agricultural production season in northern Ghana. Rain fed agriculture is impacted by climate change and variability which has adverse implications for household food security. The total rainfall averages 950 mm per annum. Rainfall variability is a reality in the KNTA and northern Ghana at large. It manifests in both 'inter-annual' and 'intra-annual' variability (Derbile, 2010). This makes rainfall unreliable and exposes farmers to multiple stresses and risks that create difficulties in crop production,

There are basically two main soil types found in the traditional area: Savannah Ochrosol and the ground water laterite. The Savannah Ochrosol soil type are porous, well drained, loamy and mildly acidic and interspersed with parches of black or dark-grey clayey soils

suitable for the cultivation of cereals and legumes while the ground water laterites makes cultivation difficult. The soils are old and have leached over a long period of time. As a result, their organic matter content is generally low, suggesting low inherent soil fertility. These soils are most deficient in nitrogen and phosphorous because of the very low organic matter content. It is argued that low organic matter content makes soils non-responsive to chemical fertilizers (Abebe & Deressa, 2017). Furthermore, the loss of soil organic matter also represents physical soil degradation (EPA, 2002).

I will now tend attention to the research approach for the study.

3.3 Research Approach

Research approaches are plans and procedures of enquiry that span the steps from broad assumptions to detailed methods of data collection, analysis, and interpretation (Creswell, 2017). There are broadly three major approaches being used today in the social and human sciences. They include: qualitative, quantitative and mixed methods approaches. Each approach has its own history, purpose, considerations, philosophical assumptions, procedures, strengths, challenges, and variants. According to Creswell (2017), the choice of approach must best fit the problem and the research questions in the study. Given that this study seeks to investigate how differentiated smallholder farmers are harnessing the synergies and complementarities between traditional and western scientific agricultural knowledge systems to improve household food security outcomes in the KNTA, this study utilized mixed methods approach. Research approach is considered mixed if it employs qualitative and quantitative approaches at any stage of the research process, including sampling strategies, data collection approaches, data analysis methods, or conclusions (Creswell & Clark, 2011).

The underlying idea of mixed methods approach is to combine different strengths and non-overlapping weaknesses of quantitative methods with qualitative methods. Its usefulness is in the fact that the advantages of the methods are maximized and the disadvantages are minimized (Yin, 2014). Every method has its own weaknesses but by combining methods one can compensate by offsetting with the strengths of another method. Morse (2009) asserts that mixed methods research provides a more balanced perspective than a purely quantitative or purely qualitative study. Mixed methods also help to corroborate findings and minimize alternative explanations (Johnson, Onwuegbuzie & Turner, 2007). Furthermore, it helps to report more accurately and provides comprehensive perspectives, breadth and depth to enrich understanding of the phenomenon under study and also maximizes the empirical power and effectiveness (Yin, 2014). O'Cathain, Murphy and Nicholl (2007) observed that researchers employ mixed methods largely because it is comprehensive, increase validity and give voice to marginalized groups.

Greene, Caracelli and Graham (1989) identified five basic reasons for mixing qualitative and quantitative methods within a study. These reasons include: 1) triangulation – which seeks convergence and corroboration, 2) complementarity seeks elaboration, illustrations, and clarifications of results, 3) development seeks to use the result from one method to help develop or inform the other method, 4) initiation seeks the discovery of paradox and contradictions, and 5) explanation seeks to extend the breath and range of inquiry by using different methods.

Some researchers have distinguished among three sub-types of mixed methods research. These are: qualitative dominant, pure mixed and quantitative dominant (Johnson et al., 2007). This study adopted the qualitative dominant approach. According to De Lisle

(2011), 'qualitatively driven' approach to mixing methods offers enormous potential for generating new ways of understanding the complexities and contexts of social experience and enhances our capacities for social explanation and generalization.

Research Design

Research designs are types of inquiry within qualitative, quantitative, and mixed methods approaches that provide specific direction for procedures in a research design (Creswell, 2017). Creswell and Clark (2011) proposed four main mixed method design types**:** Convergent Parallel Design – this design occurs when the researcher collects and analyzes both quantitative and qualitative data during the same phase of the research process and then merges the two sets of results into an overall interpretation. This design is used when the researcher wants to triangulate the methods by directly comparing and contrasting quantitative statistical results with qualitative findings for corroboration and validation purposes; Embedded Design – It is a mixed method approach where the researcher combines the collection and analysis of both qualitative and quantitative data within a traditional qualitative research design or quantitative research design. According to Greene (2007), researchers use this design when they need to include qualitative data to answer a secondary research question within the predominantly quantitative study; Explanatory Sequential Design – is a mixed method design in which the researcher begins by conducting a quantitative phase and follows up on specific result with qualitative phase. The second qualitative phase of the study is designed so that it follows from the results of the quantitative phase to explain the initial results in more depth. This design is well suited when the researcher needs qualitative data to explain quantitative significant or non-significant results, and; Exploratory Sequential Design – the primary purpose is to

generalize qualitative findings based on a few individuals from the first phase to a larger sample gathered during the second phase. The exploratory sequential design (also referred to as exploratory design) occurs in two interactive phases. It begins with and prioritizes the collection and analysis of qualitative data in the first phase and then building from the exploratory results, the researcher conducts a second quantitative phase to test or generalize the initial findings. The researcher then interprets how the quantitative results build on the initial qualitative results. Because this design begins qualitatively, it is best suited for exploring variables that are unknown (Creswell & Clark, 2011).

For the purpose of this study, the exploratory sequential mixed method design was adapted to adequately answer the research questions. Given that the research problem is qualitatively oriented and some of the important variables regarding knowledge integration are unknown, the exploratory design was deemed suitable and appropriate to collect and analyze qualitative data to gain multiple perspectives and deeper understanding of the research variables at the initial stage of the study which then feed into the quantitative strand of the study.

The first phase of qualitative data collection commenced with the support of field officers to arrange focus group meetings with farmers at the community level to clarify and confirm some of the variables in the literature and further explored other variables. Key variables explored during focus group discussions include: types of farmlands and their associated farming practices, perceptions and challenges with the use of both traditional and western farming practices, the rationale underpinning the blend of farming practices, social differentiations among smallholder farmers and the criteria for classification, household food security situation of differentiated smallholder farmers, and coping strategies of the

differentiated smallholder farmers. Data from this phase was largely used to answer research questions one and two: in respect of showing how social differentiations among smallholder farmers define their choice of farming systems and the rational for blending traditional and western agricultural knowledge systems. Subsequently, the output from the first phase was used to design questionnaires for a survey in the second phase.

The second phase was largely a survey based on the variables identified from the first phase and also from the literature. The survey took the form of pre-coded structured questionnaires administered to sampled households at the community level. The questionnaire was structured to cover: personal and household information, features of farming systems, knowledge integration, and household food security situations. This phase helped to identify types and size of farmlands owned by smallholders and the farming practices of the different categories of smallholder farmers to achieve adequate household food security. Furthermore, this phase helped to establish how social differentiation of smallholder farmers are harnessing the synergies and complementarities of the two forms of farming practices and further highlighted the key drivers and challenges of knowledge integration to improve crop production in the study area. Also, it helped to establish the link between differentiated smallholders, the blend of farming practices and household food security outcomes. Broadly, this phase helped to address research questions two and four: in terms of how differentiated smallholder farmers integrate traditional and western farming practices and technologies and how it affects their household food security situation. Furthermore, this phase provided data to describe the socio-demographics of the study participants. The output from this phase informed subsequent in-depth interviews for deeper insights and understanding beyond the figures and frequencies.

The third phase was mainly qualitative and employed tools such as in-depth interviews to collect data from key informants based on their rich knowledge and experience to provide deeper insights and understanding of the different blend of farming practices and technologies, driving factors, challenges associated with knowledge integration, and appropriate mechanisms to support the integration process. This phase was particularly useful in providing insights to respond to research questions three, four and five: in terms of the key drivers and challenges of knowledge integration in crop production, why some smallholder farmers blend farming practices and technologies and experience household food shortages while others do not, and how traditional and western agricultural knowledge systems can be purposely integrated to facilitate smooth innovation diffusion among smallholder farmers. This phase also offered me the opportunity to interact with technically relevant resource persons to explore practical strategies and approaches for integrating traditional and western farming practices to ensure smooth innovation diffusion among smallholder farmers and the institutional framework to support effective integration. Indeed this phase provided depth and roundedness of understanding of the variables to ensure that the relevant contexts are brought into focus so that situated knowledge can be produced (Mason, 2006).

3.4 Sources of Data

A hallmark of mixed methods research is the use of multiple data sources, a strategy which also embraces data credibility (Patton, 1990; Yin, 2003). This ensures that the issues under investigation are not explored through one lens but rather a variety of lenses which allow for multiple facets of the phenomenon to be revealed and understood. Data sources may include but not limited to: documentation, archival records, physical artifacts, interviews,

participant observation, and direct observations (Yin, 2003). Yin (2014) advises that data from these multiple sources should converge in the analysis process rather than handled individually.

Consequently, this study made use of data from secondary as well as primary sources. Secondary data were obtained from published journals, books, articles, documentary evidence, and project reports. The study explored literature on farming systems in Sub-Saharan Africa, traditional and western scientific knowledge systems, knowledge integration, and food security in Sub-Saharan Africa. The secondary data provided me with diverse theoretical concepts and frameworks to enrich the research endeavor. Furthermore, the issues and variables from the literature were later compared and contrasted with the empirical findings of the study. Primary data were sourced from smallholder farmers, agricultural extension agents and some experts in food security in northern Ghana using methods such as interviews, household surveys, and focus group discussions. Results from these methods helped to triangulate the data for validation to overcome the inherent weakness in each technique when used separately.

3.5 The Study Population

Research population is usually the total number of potential subjects for any research endeavor. Ofori and Dampson (2011) describe research population as the universe of units from which the sample is to be selected. In this study, the target population comprised smallholder farmers in the KNTA cultivating less than 2ha, Agricultural Extension Agents (i.e. MoFA and NGO), and individuals deemed to be knowledgeable in food security issues in northern Ghana. From this population, a sample was drawn to participate in the study.

3.6 Sampling Procedure

Sampling and selection are principles and procedures used to identify, choose and gain access to relevant data sources from which you generate data using your chosen methods (Mason, 2006). In a research study of this nature, a sample is needed to give the researcher access to data that will allow him/her to develop an empirically and theoretically grounded argument about the subject under investigation. Usually, the objectives of the study and the characteristics of the population determine which and how many people to select. Karma (1999) shares the view that it must be at the discretion of the researcher.

Essentially, there are two main types of sampling methods: probability and non-probability sampling (Osuala, 2005; Kwabia, 2006). Probability sampling is where each and every unit within the population is given an equal chance of being selected. On the other hand, non-probability sampling is where respondents are selected based on their relevant rich knowledge and experience on the subject under investigation. For this study, a multi-stage sampling technique was employed in selecting participants to avert the weakness inherent in one stage sampling (Etikan & Bala, 2017).

The first stage involved purposively selecting the study communities using a criteria developed based on Extension officers' knowledge and experience of the KNTA. The criteria include: (i) a community that has reached its land frontier (that is, unable to expand farmlands any further within its own community boundary but may have access to land in neighboring communities); and (ii) a community that still has some virgin lands available for expansion or at minimum, sufficient fallow lands. This criterion is underscored by Boserup's (2014) assertion that reduced fallow and access to virgin lands trigger intensification process and stimulate technology adoption. Consequently, this study sought

to find out whether reduced fallow or access to virgin lands correlates with the blend of farming practices of smallholder farmers. Eventually, eight communities were selected (i.e. 4 in KNW and 4 in KNM) for the study.

The second stage involved the use of purposive sampling techniques to select participants for focus group discussions. According to Krueger and Casey (2014), a typical focus group session consists of a small number of participants who are deemed knowledgeable about the topics under investigation. Consequently, with assistance of extension officers, eight focus groups were constituted (i.e. one per community) at the community level and their membership were purposively selected from Farmer Associations particularly targeting male and female heads of household who have lived in the community for more than ten years. This was to ensure that participants have adequate traditional farming knowledge and experience and appreciate the worldviews of the rural community. Detail composition of the membership per community is as follows: *Punyoro* (6 females and 8 males), *Vunania* (8 females and 6 males), *Saboro* (8 females and 4 males), *Mirigu* (4 females and 9 males), *Kajolo* (3 females and 10 males), *Gingabnia* (2 females and 7 males), *Bonia* (3 females and 4 males), and *Doba Gayingo* (4 females and 10 males). A total of 93 participants (37 females and 56 males) were involved in the eight focus group discussions.

The third stage involved the use of simple random sampling technique to select respondents for the household survey. According to Salant and Dillman (1994), a prerequisite to sample selection is to define the target population as narrowly as possible and the people selected to participate in the sample must be selected at random – all must have an equal chance of being selected. For this study therefore, the target population was clearly defined as smallholder farmers with landholding size less than 2.0ha (Chamberlin, 2008) which was

confirmed through the focus group discussions. Having selected the study communities, I proceeded to divide each community into four strata (i.e. north, south, east, and west) and numbered accordingly to develop a list of household per stratum. From the list of households, I randomly selected four households from each stratum using simple random sampling technique. To ensure that, at least, two female head of households are selected from each stratum, the study purposely selected female headed households in the event that the sampling technique did not capture such female headed households. This was relevant because gender plays a major role in the process of knowledge differentiation and women's indigenous knowledge can differ from that of men (Voeks, 2007). The total sample size per community summed up to sixteen households per community and sixty four households per district. The grand total of the sample size for the survey was 128 heads of households. However, 122 respondents were successfully surveyed during the period.

Subsequently, purposive sampling technique was used to select participants for indepth interviews for deeper understanding of the issues beyond the figures. A total of seventeen key informants were selected. They include six smallholder farmers, two from each of the three cohorts of smallholder differentiations and eleven key informants comprised of experts in food security, agricultural extension, project managers, researchers who are deemed knowledgeable on the subject matter of the study.

3.7 Methods of Data Collection

The study adopted a three-phased mixed method design to collect data and utilized mainly focus group discussions, household surveys, in-depth interviews, and observations. The first phase of data collection commenced in January, 2018 with initial field engagement with extension officers (i.e. DoA and NGOs) operating in the Kassena Nankana Traditional

Area to facilitate community entry processes and engagement with opinion leaders in the communities. These introductory meetings at the community level helped to build rapport with community people. This was essential to overcome the effects of mistrust and build trust necessary to uncover local constructions to understand the contexts and its culture. Gleane and Pashkin (1992) maintain that in qualitative research, "a good rapport is a distance-reducing, anxiety-quieting, trust building mechanism that primarily serves the interest of the researcher" (p. 94).

3.7.1 Focus Group Discussions with Smallholder Farmers

Focus group discussions were used at this initial phase of the data collection process to elicit information from smallholder farmers to clarify and confirm variables in the literature as well as explore new variables. Krueger and Casey (2014, p. 6) define focus group discussion as "a carefully planned discussion designed to obtain perceptions on a defined area of interest in a permissive, non-threatening environment". I chose this research instrument because it is a good way of bringing together people from similar background or experience to discuss issues of interest. It was useful in providing insights into different opinions among the different discussants and enabled me to gain in-depth understanding of the variables under investigation. The strength of focus group discussion relies on allowing the discussants to agree or disagree with each other so that it provides an insight into how the group thinks about the issues under discussion.

Eight focus group discussions were conducted with smallholder farmers at the community level. Detail composition of the membership per community is as follows: *Punyoro* (6 females and 8 males), *Vunania* (8 females and 6 males), *Saboro* (8 females and 4 males), *Mirigu* (4 females and 9 males), Kajolo (3 females and 10 males), *Gingabnia* (2 females

and 7 males), *Bonia* (3 females and 4 males), and *Doba Gayingo* (4 females and 10 males). According to Krueger and Casey (2014), a typical focus group session consists of a small number of participants who are deemed knowledgeable about the topics under investigation and the discussions are facilitated by the researcher in a non-directive and unbiased framework with guiding questions to generate data necessary and adequate enough to answer the key research questions.

In all the focus group discussions, the purpose of the study was discussed with participants and they consented to freely participate in the study. Similarly, participants were informed that the data provided will be treated as confidential and no statement will ever be identified with their personality. Consequently, permission was granted for the researcher to use tape-recorder and also take notes at the side. I facilitated the discussions in a non-directive and unbiased manner using a thematic focus group guide (Krueger & Casey, 2014). The guide was structured in thematic areas to explore issues related to: farming systems in the study area showing how social differentiations among smallholder farmers define their farming systems: how differentiated smallholder farmers integrate traditional and western agricultural knowledge systems and how they rationalize their decisions: driving factors and challenges associated with knowledge integration: how knowledge integration affects household food security situation of differentiated smallholder farmers: and their recommendations for effective blending of the two knowledge systems for sustainable smallholder farming systems. Details of this instrument is attached as appendix II. The discussions were conducted in such a way that discussants could here each other's responses and contributions and they could confirm or differ with each other's contributions. The focus group discussions lasted approximately 1 hour 45 minutes in

duration per group and were audio-recorded. Using the tape recorder enabled the researcher to completely focus on the guide and provided a full account of the discussions but created a burden afterwards as extensive time was required for transcription.

These focus group discussions enabled me to collect large amount of data in a relatively short period of time. It also provided insight into the ways in which people collectively made sense of the phenomenon under discussion given that the discussions stimulated 'synergistic group effects' where group members reacted to comments made by other members (Creswell, 2016). This tool allowed me to access the substantive content of verbally expressed views, opinions, experiences and attitudes. It also allowed discussants ample opportunity to express diverse opinions, explain and share experiences. It was found to be a useful method to employ prior to designing survey questionnaires. Indeed, the output from the focus group discussions was used to design the survey instrument.

3.7.2 The Household Survey

Surveys are popular methods of collecting primary data. They are processes of collecting information from a selected group of people using standardized questionnaires (Statistics Canada, 2010). Glasow (2005) asserts that surveys are useful in describing the characteristics of a large population and make collection of large data faster and cheaper because of their reliance on representative samples. Bell (2014) also reported that surveys are inclusive in the types and number of variables that can be studied, require minimal investment to develop and administer, and are relatively easy for making generalization. On the basis of these advantages and attributes stated above, this study used survey method to collect data from 122 household heads.

Consequently, questionnaire with closed-ended questions was developed to collect quantitative data from sampled participants. The questionnaire was structured into five sections. Section A was designed to capture personal information of participants related to age, sex, marital status, and level of education. Section B covers household information related to number of household members, age cohort and household asset base. Section C captures data on farm size, types of farmlands, types of crops being cultivated on the different types of farmlands and cropping system, farming practices and technologies in use. Section D elicits information on blending traditional and western farming practices, types of farmlands on which blending occurs, and ranking of difficulties associated with applying traditional or western farming practices. Section E looks at sources of food for households, hunger periods, reasons for food shortage, and coping strategies.

Subsequently, six field assistants were recruited and trained to administer the questionnaires. Their recruitment was based on familiarity with the local languages in the study area, academic qualification (minimum of first degree), and experience in data collection. The training was organized from 16th – 17th March, 2018 at the ACDEP conference room in Bolgatanga to enable the field assistants familiarize themselves with the content of the questionnaires and how to administer. The training approach was participatory involving discussions and role plays to provide understanding and how to pose such questions.

3.7.3 Pretesting the Questionnaire

Following the training, a pre-test was conducted to ascertain any need for questionnaire revision. The purpose of the pre-test was to assess the suitability of the questions, bring

field assistants to a common understanding of the intent and purpose of the questions, and be conversant with the instrument. The pre-test gave insights into the flow of the questions and the average time it will take to administer each questionnaire. This helped to finalize the questionnaires for use.

According to Salant and Dillman (1994), face-to-face interviews are useful where the participants are unable or unlikely to respond to written survey. As a result, the questionnaires were administered face-to-face to enable respondents who are largely non-literate to respond to the questionnaires. For non-literates, the field assistants translated the questions into the local language (i.e. Gruni or Kasem) to enable respondents to appropriately respond.

Given that survey as a research method is limited in providing opportunity to engage in any meaningful dialogue with figures for better understanding of the context of the phenomenon under study and unable to capture respondents' feelings and opinions beyond the figures, the study employed in-depth interviews to complement the strength of surveys. Having established how the household survey was deployed in this study, the next discussion focuses on how in-depth interviews were conducted.

3.8.3 In-depth Interview

Interview is probably the most commonly used method in qualitative research. It is often referred to as a conversation with a purpose. However, they differ from everyday conversation because they are conducted in most rigorous way in order to ensure reliability and validity (Patton, 1990). In-depth interviews are optimal for collecting data on individual's perspectives and experiences on a subject matter. They are mostly long-

duration, face-to-face, and conducted to achieve desired goals. Indeed, in-depth interview is a method of extracting more detailed information or deep understanding of a subject or concept. The primary advantage of in-depth interviews is that they provide much more detailed information than what is available through other data collection methods, such as survey. They provide more relaxed atmosphere in which to collect data by creating enabling environment for the researcher to 'probe' respondent's responses and engage with them according to their individual personalities and styles and use probes to encourage them to elaborate on their answers. In the light of this, in-depth interviews were used to collect data from selected smallholders and senior agricultural production officers to appropriately respond to the research questions.

In-depth interviews with smallholder farmers

Six in-depth interviews were conducted separately with six individual smallholders, two from each of the three categories of smallholder farmers (i.e. 2 high resource-endowed, 2 low resource-endowed & 2 medium resource-endowed). These informants were purposively selected to understand the factors that influence their choice of farmlands, blend of farming practices and technologies and their household food security situation upon blending the two forms of farming practices. The selection was based on survey information suggesting that they combined both forms of agricultural knowledge systems but experienced different household food security situations. To gain gender perspective of the issues under investigation, I selected a male and female from each farmer category.

In-depth interview guide was developed and used to collect data (see appendix IV for details). Information from key informants helped to answer research question one which

looks at how smallholder farmers describe their farming systems, the factors influencing their blend of farming practices, and how they are rationalizing their decisions. It also provided useful data to respond to research question three which focuses on key drivers and challenges of knowledge integration. Furthermore, it provided useful information to account for why some smallholder farmers combined farming practices and technologies and yet experienced different household food security situations.

In-depth interviews with key informants

A total of eleven key informants were also engaged in the in-depth interviews. They are, three senior agricultural production officers in ACDEP, three senior officers of the Ministry of Food and Agriculture (MoFA), two food security experts, and three senior officers managing food security projects in the UER with operational activities in the study area. These key informants were purposively selected based on their expertise and experience in extension services, promotion of local innovations in agricultural production and food security initiatives in northern Ghana. The food security experts were identified through snowball technique. I initially contacted a senior staff at ACDEP who I understand has extensive working experience in food security programmes in northern Ghana with special focus on promoting local innovations among smallholder farmers. My interaction with him was rich and insightful as it provided me with a deeper understanding of smallholder farming systems, the kinds of local innovations being promoted and the likely reasons why most food security initiatives do not continue beyond the project lifespan. Given the objectives of this study, he recommended that I contact a senior MoFA staff in Bolgatanga based on his rich knowledge and experience on the subject matter under investigation. Following from our discussion, he referred me to a research fellow at CSIR/SARI in

Tamale and a former Coordinator of RELC in the Northern Region for a long period of time. This process continued until no new information was discovered. According to Mason (2006), purposive sample sizes are often determined on the basis of theoretical saturation – a point in data collection when new data no longer bring additional insights to the research question. In the light of this, I did not continue to identify more respondents when it was observed at a point that subsequent in-depth interviews did not bring any additional insight to the study. This approach was useful because it enabled me to identify technically relevant key informants who could not be selected through other sampling strategies.

Generally, there are three identifiable styles of interviews: structured, semi-structured and unstructured. This study employed semi-structured style of interviews. This type of interview allows a certain degree of flexibility for the researcher to respond to the answers of the interviewee and therefore develop the themes and issues as they arise. It is one of the most important forms of data collection methods because it is a form of 'guided conversation rather than structured queries' (Yin, 2009, p. 89) and exchange of views.

Consequently, semi-structured interview guide was used to elicit information from participants. The question guide was developed (see appendix I) and included sufficient number of open-ended questions to allow participants to present their own experiences, feeling and opinions (Merriam, 2009). The question guide explored: farmer categories, perceptions of farming practices, innovations and extension delivery systems; challenges in promoting farming practices; blending of farming practices and technologies and their associated challenges; ways to purposely blend farming practices and mechanisms to

support effective integration. The guide also explored suitable criteria for community selection based on their knowledge of the study districts.

3.8. Observation

Creswell (2014) asserts that observational data is useful to overcome discrepancies between what people say and what they actually do. It is also useful to uncover behaviors of which the participants themselves may not be aware of. In order to understand these complexities, field observation was used to collect on-the-spot information related to social norms, values, and beliefs around traditional and western farming practices and technologies used to improve food crop production and productivity. This technique increased the reliability and validity of the data collected by tracking consistency through the focus group discussions, survey and interviews. Observation also provided deeper understanding of meanings and contexts of behaviors. After establishing the methods of data collection, the next section outlines how the data was analyzed.

3.9 Data Analysis

A number of techniques were used to analyze the data from the various sources. Detail description of how both quantitative and qualitative data were analyzed is as below.

3.9.1 Quantitative Data Analysis

Following the survey data collection, the pre-coded questionnaires were cleaned to ensure quality of the data for entry. Data collected were then coded, categorized and processed using Statistical Product and Service Solutions (SPSS) Windows, version 20.0 to provide frequency tables and percentages. This was useful in describing socio-demographics characteristics of respondents and was valuable for the purposes of describing the general

sample and drawing correlations and relationships between variables in the questionnaires. This also provided a better visualization of the phenomenon under study through descriptive and inferential statistics such as pie charts, frequency and percentages (Owusu Ackah & Gruijters, 2012). Analysis of the quantitative data allowed the researcher to interpret the data, make inferences, deductions and meanings toward addressing the research questions and objectives which culminated into the final research report.

3.9.2 Qualitative Data Analysis

There are a number of ways to analyze qualitative data. A researcher may use a thematic, descriptive approach or more in-depth methods (Patton, 1990). The qualitative data from the focus groups and interviews were transcribed, coded and analyzed using Clarke and Braun's (2013) five phase framework for qualitative thematic data analysis:

Phase one: Familiarization with the data

This phase involves the researcher immersing himself in the data by reading and re-reading textual data (i.e. transcripts of the interviews) multiple times and listening to audio-recordings to be familiar with the data. Upon reading the transcripts multiple times and listen to the audio-recordings, I made notes of the data at the sides and highlighted items of potential interest to the study. This phase was useful to the extent that I became intimately familiar with the dataset's content and begun to notice things relevant to the research questions.

Phase two: Generating initial codes

This phase began with systematic analysis of the data through coding. In this study, the transcripts were segmented into broad topics to facilitate the coding process. Indeed, codes

are the building blocks of analysis. They identify and provide a label for a feature of the data that is potentially relevant to the research questions. I coded on the hard-copy data through the use of a numbering system which highlighted portions of the text relevant to a specific research question.

Phase three: Searching for themes

In this phase, the analysis started to take shape as I shifted from codes to themes. A theme "captures something important about the data in relation to the research question and represents some level of patterned response or meaning within the dataset" (Clarke & Braun, 2013, p. 82). At this stage, I reviewed the coded data to identify similar phrases, relationships, patterns, and overlaps between codes. Similar themes were extracted from their original contexts and put together in cluster so that they reflect and describe a coherent and meaningful pattern in the data. Besides, relationships between themes were also considered as useful to respond to the research questions.

Phase four: Review of potential themes

This phase involves the process whereby the themes identified are reviewed in relation to the coded data and the entire dataset. This process is basically to ensure quality. Consequently, I ensured that the themes capture the entire dataset by re-reading all the transcripts over again. This allowed me to ensure that the most important and relevant

elements of the qualitative data are captured to sufficiently respond to the research questions.

Phase five: Defining and naming themes

Clarke and Braun (2013) assert that a good thematic analysis will have themes that are focused and related but do not overlap and should directly address the study research questions. According to them, each theme should build on and develops from previous themes and should together provide a coherent overall story about the data. This phase was particularly helpful to select extracts to analyze and set out the story of each them. Each extract provided a vivid, compelling example that clearly illustrated the analytical points being made. Largely, the extracts selected to quote and analyze provided the structure for analysis. More importantly, analysis of the themes with associated patterns and relationships were examined in the light of literature to inform the study report.

3.10 Ethical Considerations

Ethics are the moral principles that govern a person's behavior. Research ethics may be referred to as doing what is morally and legally right in research (Parveen & Showkat, 2017). According to Parveen and Showkat (2017), researchers have to take the sole responsibility for their own research. Consequently, the researcher ensured that the research process was conducted in a manner that met ethical standards and requirements of the University for Development Studies which included consent procedures covering confidentiality, privacy, risks, honesty, and benefits.

The research goal, objectives and nature were clearly explained to the participants and were assured that the research was purely for academic purposes and as such their participation

would enhance the success of the study. The privacy, anonymity and confidentiality of the participants were given due consideration by ensuring that the identity of participants was concealed and no statement made by any participants was identified with their personality. Besides, participants were given the option to reject the data gathering device such as the tape recorder and the information provided was treated as confidential.

Furthermore, the researcher respected the rights, values, cultural, religious, spiritual and other issues of the participants and upheld the principles of integrity (conducted the study with sincerity and strived for consistency of thought and action), honesty (data manipulation was avoided and the results were based on the views of participants) and objectivity (the researcher remained neutral).

CHAPTER FOUR

4.0 SMALLHOLDER DIFFERENTIATIONS AND CHOICE OF FARMING SYSTEMS

4.1 Introduction

Strategies for transforming agriculture in northern Ghana often fail to differentiate between the different cohorts of smallholder farmers or investigate how social differentiations of smallholder farmers shape their choice of farming systems (Chamberlin, 2008). This chapter examines farming systems and the factors influencing social differentiations of smallholder farmers in their choice of farming systems. The discussion is in four sections. In the first section, I present an overview of the socio-economic characteristics of the participants of the study and then proceed to give account of how smallholder farmers describe farming systems in the study area. In the second section, I then discuss farming system constraints and show how they affect different smallholder farmers. The third section examines how social differentiation among smallholder farmers influences their choices of farming systems. In the final section, I discuss the key findings.

4.1.1 Socio-economic Characteristics of Respondents

The age, sex composition and educational levels of respondents are important characteristics in the study analysis to show how these variables shape the behaviors and understandings of different smallholders in their quest to improve household food security (Nazziwa-Nviiri et al., 2017). This study engaged a total of 122 respondents (69 males and 53 females) from eight (8) communities in the Kassena Nankana Traditional Area. Detail description of the socio-economic characteristics of the survey respondents are presented below.

The age of the respondents is important because it provides a sense of how the different age cohorts of smallholder farmers are utilizing traditional, western agricultural knowledge systems or integrating both knowledge systems to improve crop production and perhaps also allow me to see whether age has any role to play in blending farming practices following claims that younger people compared to older ones are more likely to adopt western farming practices relative to traditional practices (Nazziwa-Nviiri et al., 2017). Figure 4.1 presents a picture of the age distribution of the participants. The survey result shows that 25 percent household heads are within the age bracket of 51 -60 years and only two respondents fall within the age bracket of 81 – 90. Furthermore, 26 percent of respondents fell within the economically active bracket (31-40). Given that a good proportion of the respondents are within the economically active bracket, it does suggest that more smallholder farmers in the are more likely to adopt western farming practices relative to traditional farming practices to achieve household food security.

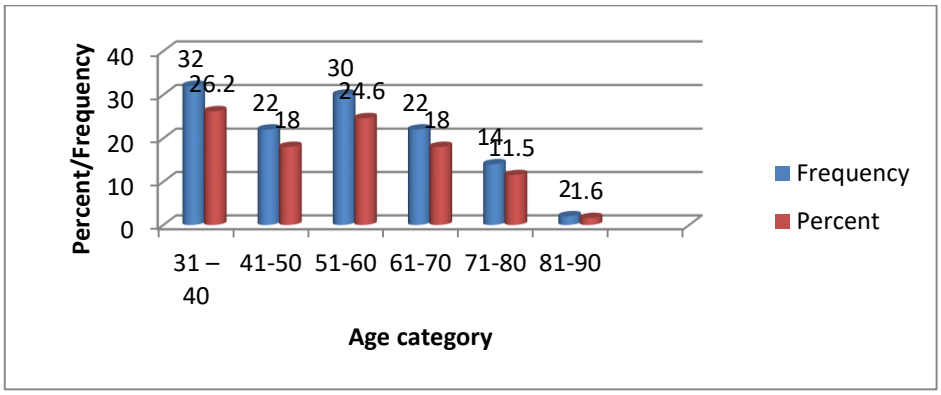

Figure 4. 1: Age distribution of household heads

Source: Survey Data, 2018

Educational attainment is critical for access and utilization of extension information to improve farming practices (Akudugu et al., 2012). Level of education has positive influence on access to new technology, rates of adoption and diffusion of innovation as

well as achieving more effective management of farm enterprise (Lavison, 2013). More importantly, households headed by persons with higher levels of education are less vulnerable to food insecurity (WFP, 2012). Figure 4.2 illustrates the educational levels of respondents. It shows that of the total sample size of 122 respondents, more than half (53 %) have no formal education and there was no significant variation between males and females. The survey recorded 34.4 percent of respondents who have attained basic level education not exceeding Primary/Junior Secondary School level (JSS). The results suggest that, household heads with minimal or no formal education may not be inclined to innovate by integrating good aspects of western and traditional farming practices to improve crop production (Lavison, 2013). Further analysis of the survey shows that the educational level of males is higher than their female counterparts at all levels. This is often attributed to the discrimination against girls in educational opportunities, burden of household work on women and young girls and male control over women's bodies and sexuality (Sultana, 2010). The low level of formal education among respondents has implication on the mode of communication in delivering agricultural extension services to smallholder farmers in the area.

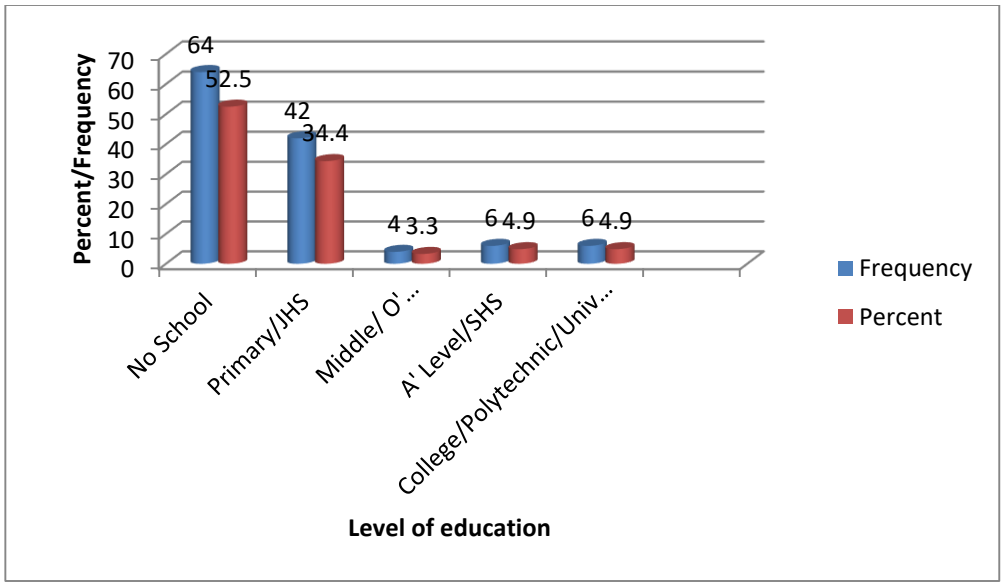

Figure 4. 2: Educational levels of household heads

Source: Survey Data, 2018

Marriage is one of the institutions in Ghana. It is often argued that women's land rights are directly linked to marriage (FAO & ECOWAS, 2018). As a result, married women in northern Ghana are able to access land through their husbands. Figure 4.3 depicts the marital status of the respondents. Out of the sample size of 122 respondents, the results show that 65 percent are married and three percent are not married. This implies that, majority of the respondents are more likely to have access to land as suggested by FAO and ECOWAS (2018). Also, they are more likely to have male partners to support their farming activities. The same logic may apply for 26 percent of the respondents who are widowed. Out of the 32 participants who are widowed, 94 percent (30 out of 32) are females as compared to six percent being males.

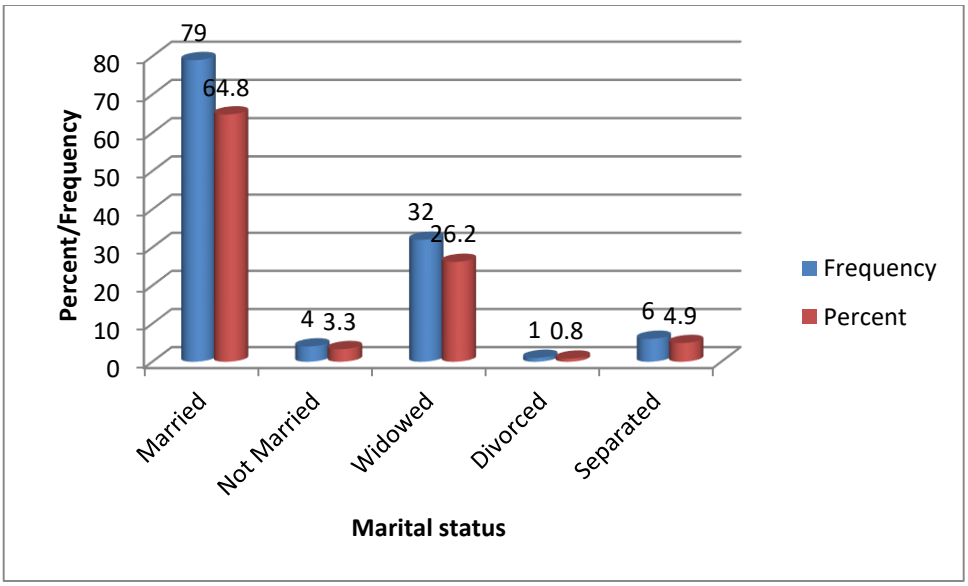

Figure 4. 3: Marital status of respondents

Source: Field Data, 2018

Household size is commonly taken as a proxy for family labour available (Kuivanen et al., 2016) and an important variable to examine food security situations of households (Al-Hassan, 2015). Household members often comprise a husband, wife, children, and other relatives including parent in-laws, grand children or house helps living with them. The survey shows that 54 percent of the respondents have more than seven household members while seven percent have household with less than three members. This suggests that, more than half of the respondents have high household members to cater for. This obviously has implications for adequate household food provisioning over a certain period (Alhassan, 2015).

Ownership of assets is critical for increasing agricultural productivity and is often closely linked with economic growth, poverty reduction and reduced vulnerability (Yaro, 2009). Livestock rearing is a major economic activity that has always been of great value to the people of northern Ghana (Alhassan, 2015). The main livestock in the area include cattle,

goats, sheep, pigs, donkeys, and poultry (i.e. chicken, ducks and guinea fowl). The study shows that women owned fewer livestock and poultry compared to men. For example, men owned 20 percent more cattle than women and 10 percent more in small ruminants and poultry (Figure 4.4). The pattern of livestock ownership between men and women is largely attributable to cultural underpinnings which have circumscribed animal rearing substantially a male livelihood activity (SEND Ghana, 2018). That notwithstanding, women play key roles in supporting their husbands to raise livestock, some of the roles include feeding, watering, tethering, plastering animal pens, cleaning the kraals, transporting and applying manure on farm lands (FAO & ECOWAS, 2018). However, in spite of the significant role they play, there is an assertion that women rarely own and control vital household assets such as cattle and small ruminants to support their livelihoods (SEND Ghana, 2018). However, the trend is changing as more women are beginning to demonstrate ownership and control over their livestock. Interaction with women during focus group discussions revealed that women in the study area are beginning to exercise full control and decision-making over their livestock, particularly small ruminants. In response to a question whether women have control over their livestock, discussants had this to say:

> Previously, the best we could do was to provide water and feed the livestock (goat and sheep), but now we take all decisions as to when to sell the goat or sheep and what to use the money for. Just last market day, I asked my son to carry one of my goats to the market, so I can support him to dowry his wife [Kayoro, discussants, Jan, 2018].

This remark portrays how some women in the area take decisions regarding their livestock. The phenomenon of women exercising control over their livestock in recent time may be as a result of the various forms of gender sensitization programmes by NGOs and other

development partners in the study area. The response by discussants corroborates Nchanji's (2017) assertion that introduction of gender sensitive agricultural programmes has changed ownership and access to land for women in the Northern Region of Ghana.

The study also shows low ownership of cattle and preponderance of poultry and small ruminants. As a social insurance mechanism, small ruminants and poultry are more likely to be sold out in the market to meet pressing household needs. Yaro (2009) reports that livestock is always the first to get to the market when crisis strikes and under such circumstances, poultry and goats are initial market candidates followed by sheep and subsequently cattle, showing a progressive sale of more valuable livestock in dealing with crisis situations.

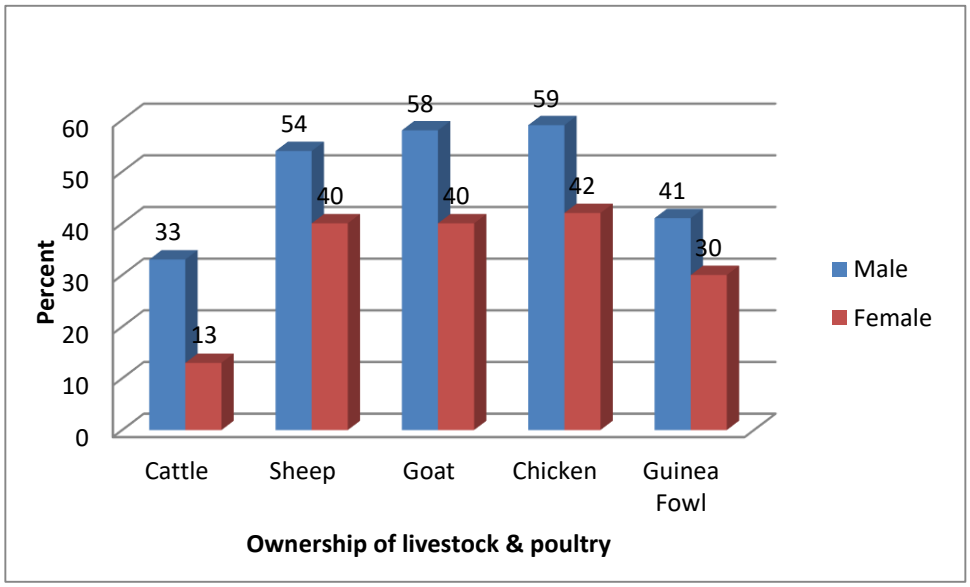

Figure 4. 4: Resource portfolio of respondents

Source: Survey Data, 2018

Other assets owned by participants include animal drawn cart, bicycle, motorcycle, TV set, and mobile phone. The survey reveals that 82 percent (100 out of 122) of respondents own mobile phones as compared to 18 percent who do not own phones. Mobile phone is an innovative and effective ICT tool for networking and sharing market information including price, advisory service, extension service and linkages with relevant actors in the agricultural sector (Barnett & Srivastava, 2017).

With this general characteristics of the participants as background information, I will now proceed to answer research question one in respect of how smallholder farmers describe farming systems in the study area and the factors influencing social differentiations of smallholder farmers in their choice of farming systems.

4.2 Smallholder Farming Systems in the Study Area

In this section, I present smallholder farmers' description of their farming systems by drawing on data from focus group discussions and survey using Clarke and Braun's (2013) framework for thematic data analysis and SPSS to analyze the qualitative and quantitative data respectively. Consequently, the study identified three types of agricultural land use systems in the Kassena Nankana Traditional Area. These are Compound farms, Lowland/Valley farms and Bush farms locally referred to as *kaduga*, *bwolo* and *kara* respectfully among Kasem - speaking communities and *sammani, borim and vatiim* among Nankani - speaking communities[2]. These land use systems are similar to those noted by Briggs and Moyo (2012) in farming communities in northern Malawi and corroborate the

[2] In this study, only the Kasem equivalent of the local names would be used.

multiple farmland account of the Atankwidi Basin by Derbile (2010). Each of these multiple farmlands are described in detail below.

4.2.1 Compound Farms *(Kaduga)*

The Compound farms (*kaduga)* was a recurring theme during focus group discussions in the area. Discussants referred to them as the type of agricultural farmlands located within close vicinity of the homestead with farm sizes varying from 0.4ha to 1.2ha and are mainly fragmented. According to discussants, fragmentation of the *kaduga* is largely as a result of increased household membership who may require a portion of the family land in the *kaduga* farmland for cultivation to feed their immediate household while staying in the community. However, smaller households with large *kaduga* farmlands often have the luxury to fragment their farm plots based on soil characteristics relative to the soil structure or water requirements of the crops under cultivation. Sometimes, the household head may also choose to allocate a portion of the *kaduga* to a daughter for farming activities if she commits to staying in the community. Discussants reported that more than ten food crops are typically grown in *kaduga.* They shared this remark:

> All the food crops needed for our survival are grown on our *kaduga* farm. So on this farm you will find that we have sowed *naara* (early millet), *zea* (late millet), sorghum, maize, groundnuts, Bambara beans, cowpea, and the women will use the edges and parts of the farm to plant vegetables like roselle, kenaf, okra, Naari, and pepper [Bonia, discussants, January, 2018].

Usually, women plant leafy vegetables such as okra, pepper, roselle, and kenaf in *Kaduga* farmlands because of proximity to provide for household consumption needs. Figure 4.5 below confirms the statement above. It does appear that growing a wide range of food crops is a local strategy to spread risk and provide varied balanced diet for the households (Briggs & Moyo, 2012). Discussants affirmed

through focus group discussion that *kaduga* is the main farmland for smallholder farmers and maintained that it is on this farmland that the bulk of household food production is undertaken.

Figure 4.5 presents the food crops mostly grown on compound farms. The results show that early millet, late millet, vegetables, and maize are dominant food crops grown on compound farms under mixed cropping system. Mixed cropping pattern in *Kaduga* farmland is largely to reduce risk, crop losses from pest and diseases. It makes efficient use of scarce labour, increase crop cover, and improves household food security (Wood, 2013). The cultivation of sorghum, maize, early millet, and late millet is important for the provision of carbohydrate to the local diets and straw for fuel and foliage to feed animals (Equavoeh, 2007). The other food crops such as cowpea, Bambara beans and groundnuts contribute to fulfilling the protein needs of the local population (Marfo, 1992).

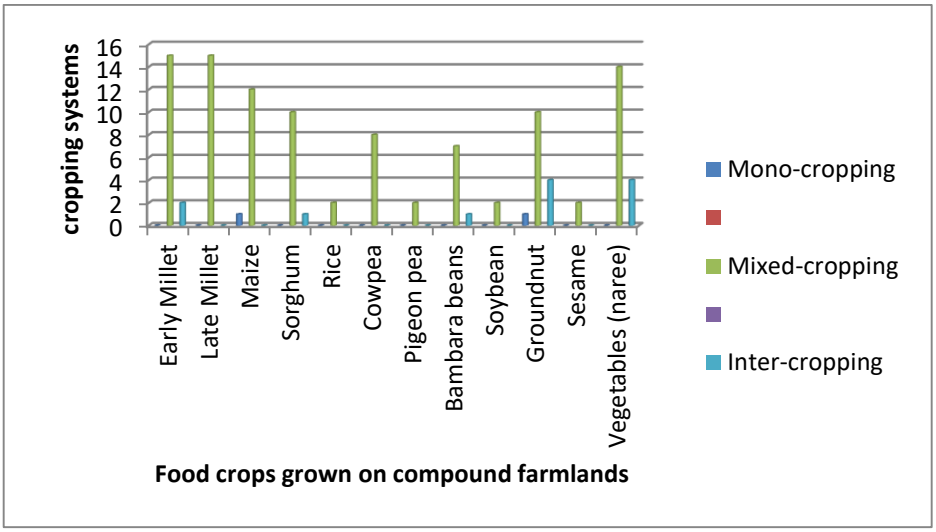

Figure 4. 5: Compound farms (kaduga) and cropping systems

Source: Survey Data, 2018

Discussants during focus group discussion reported that, before the onset of the rainy season, poultry and animal manure from droppings of livestock from the kraal are collected and spread on *Kaduga* before plowing, using tractor, animal (bullock) traction or by hand weeding with hoe depending on the resource endowment of the smallholder and size of farm.

The survey results presented in Figure 4.6 show that the use of hoe, animal traction, recycling of own seeds, stick dibbler/hoe in planting, animal/compost manure, and mixed cropping system are predominant farming practices and technologies on compound farms. Furthermore, the results show that zero tillage and slash and burn are rarely employed as measures to deal with soil fertility and weeds control respectively. The results further show that all the smallholder farmers are using hand weeding with hoe and 87.6 percent use animal (bullock) traction for land preparation in *kaduga*. Relatively large numbers of smallholders are using these methods for land preparation because they neither own adult male cattle to plough their farms nor have other resources that will enable them to pay for animal traction service.

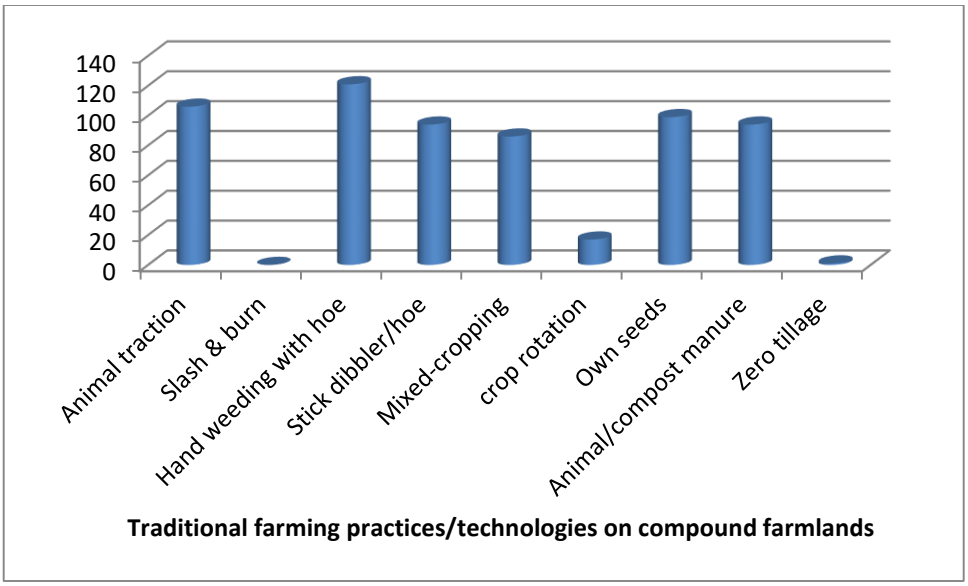

Figure 4. 6: Traditional farming practices and technologies in Compound farms

Source: Survey Data, 2018

According to participants in focus groups, stick dibblers are often used to punch holes to facilitate sowing which is mostly done by men. Figure 4.6 shows that majority (77.7%) of the study participants used stick dibbler to punch holes to facilitate sowing. Women on the other hand, use hoe in one hand to punch holes and simultaneously drop the seed from a calabash in the other hand using their fingers. Even though animal manure remains the most known and widely used soil fertility enhancement technology in *kaduga*, it has become a scarce commodity in recent time as livestock numbers continue to dwindle in most households. Discussants during focus group discussion asserted that *kaduga* farmlands do not require recommended rates of chemical fertilizer to meet acceptable soil fertility level to produce expected crop yields given the traditional farming practices they employ. Furthermore, it was reported that some traditional food crops (e.g. *chaara*) do not respond to chemical fertilizer application, hence its minimal use. This claim corroborates Callo-Concha et al. (2012) report that local varieties are poorly responsive to fertilizer.

The results have shown that compound farms are the main farmlands where the bulk of household food crops are cultivated and the cropping systems, systems of land preparation, and systems of soil fertility maintenance are predominantly traditional. This suggests that smallholder farmers predominantly in compound farms rely heavily on traditional farming practices and technologies. However, over reliance on traditional farming practices and technologies has been noted to have adverse implications of household food security (Alhassan, 2015).

4.2.2 Lowland Farm *(Bwolo)*

According to discussants in focus group discussion, lowland or valley farmlands *(bwolo*) are located along streams, riverbanks, lowlands, or valleys and are a few kilometers outside the community. The discussants explained that it is called *bwolo* because it is a waterlog area used for both main season farming activities (i.e. April to September) and dry-season garden (DSG) activities after harvesting the main crop (i.e. from October to April). This is how they described it:

> The reason we called it *bwolo* is because, that area of land is waterlog and supports some types of food crops. If you decide to cultivate other crops there, they won't do well. The soils there are clay loamy, fertile and retain water most of the time to support plant growth. The moisture there is different from other farmlands and therefore provides cold condition for the plants [Punyoro, discussants, January, 2018].

This remark explains why lowlands are called *bwolo* in the kasem language. Largely, the characteristics of the soil underscore smallholder description of the agricultural land use systems in the area. The discussants reported that *bwolo* farm sizes are much larger than *kaduga* farmlands during the main farming season and that rice is the major food crop being cultivated. They indicated that soils in *bwolo* are loamy and better at moisture retention

which is suitable for rice production largely under mono-cropping system during the main farming season. Other crops like maize, late millet or sorghum are cultivated under mono-cropping with the understanding that moisture retention in the soil will support plant growth during spells. During the dry season, vegetables are mostly grown in the gardens dominated by women smallholders. Some of the vegetables include: roselle, kenaf, okra, pepper, tomatoes, onions, etc. mainly produced for the market and household consumption.

The discussants reported that *bwolo* farmlands are often prepared using tractor, bullock (animal traction) or weedicides/herbicides depending on the smallholder's resource endowment and farmland size. Figure 4.7 presents results of western farming technologies often used on *bwolo* farmlands. It show that chemical fertilizer, weedicides/herbicides and tractor ploughing are widely used on *bwolo* farmlands. The use of tractors in *bwolo* is often common among resource endowed smallholders who are cultivating relatively large farm sizes hence see the need to use tractors as the most efficient way to plough their farms to take advantage of early rains to maximize production. Discussants reported that tractor plow is more suitable for rice cultivation compared to other forms of land preparation. They further indicated that early planting at *bwolo* is most appropriate because early rains are often not consistent and are characterized by intermittent spells.

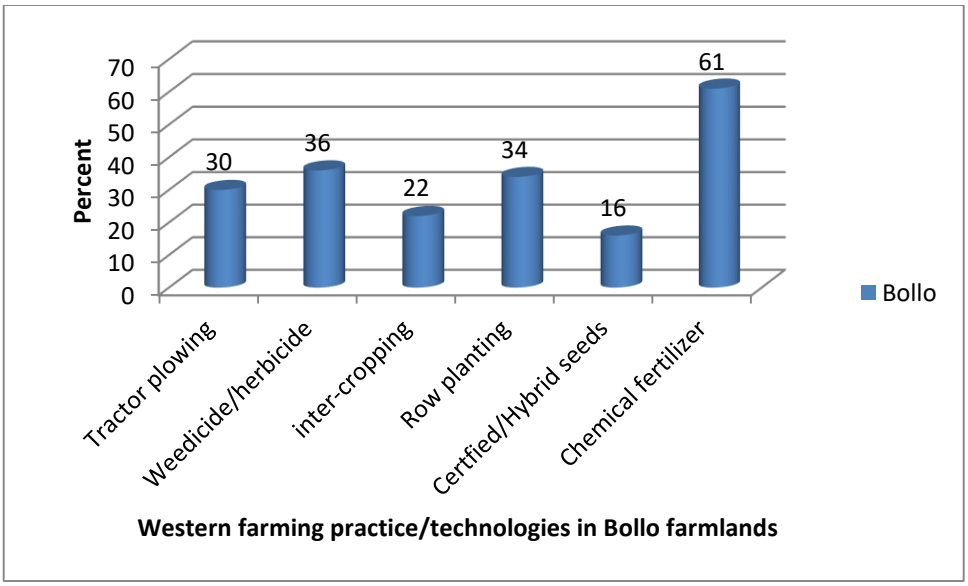

Figure 4. 7: Western farming practices/technologies in Lowland farms

Source: Survey Data, 2018

Furthermore, the results (Figure 4.7) show that chemical fertilizer use is the main strategy for soil fertility enhancement in *bwolo* farmlands. Its application in *bwolo* farmlands is fairly high as compared to *Kaduga* because crops cultivated in *bwolo* are largely cash crops as a result resourceful smallholder farmers often invest in chemical fertilizers for better yields. According to participants, manure application in *bwolo* is rare because it is easily washed away when it rains. Focus group discussants remarked:

> Cow dung on *bwolo* farms easily washes away when it rains because of the nature of the land. So if you struggle to carry these *vala-benu* (livestock dropping) to the *bwolo* farms and there is a heavy rain, you are likely to lose everything. It is usually farmers in the gardens who are able to use them because of the mad fens. Besides, some of the rice fields are very large so we cannot get large quantities of the dung to cover the whole field [Punyoro, discussants, January, 2018].

The statement above highlights three key issues regarding the use of animal manure in *bwolo* farmlands. First, some discussants claim that animal manure is easily washed away by rain. However, others were ambivalent and draw attention to the

fact that the nutrients in the manure will be absorbed before it is washed away. The second point draws attention to the fact that dry season garden farmers often use animal manure to enhance soil fertility to grow vegetables. The third point highlights scarcity of animal manure making it difficult for it to be applied on large farm sizes. This suggests that although farmers acknowledge that animal manure shows great promise, the large quantities required to make significant contribution to crop yields constrain smallholder farmers from using animal manure to improve crop production.

The findings suggest that lowland (*bwolo*) farmlands are relatively large and are use to cultivate mainly cash crops. These farmlands are the most intensive land use system in the study area and farming practices and technologies are more oriented toward western farming practices and technologies stimulated by market incentives (Kuivanen et al., 2016).

4.2.3 Bush Farms (*Kara*)

Bush farms are located outside the community, sometimes at distances more than 3 km. In some cases, communities that have reached their land frontiers may have their *Kara* in neighboring communities. The *kara* farmlands comprise large farm sizes varying from one to 20 hectares in the study area. However, survey shows that smallholder farmers usually own farm sizes varying from one to 1.21 ha. Smallholder farmers described *kara* as farmlands whose soils are sandy and do not retain much water. Here is what discussants in focus group discussion had to say about *kara* farmlands:

> We refer to those farms (i.e. Bush farms) as *kara* because they are sandy, retains less water and are on hilly grounds and very suitable for groundnut farming. But, if you are able to fertilize the soils well, you can also farm

maize or millet there and you will get good harvest [Vunania, discussants, January, 2018].

The remark depicts how smallholder farmers in the study area describe bush farmlands showing features of the soil and the types of crops it support. Figure 4.8 shows the food crops commonly cultivated in *kara* farmlands. They include: legumes (groundnuts, bambara beans, and soybean), rice, late millet, maize and sesame. The survey (Figure 4.8) shows that groundnut is the most cultivated food crop cultivated in *kara* farmlands followed by maize. The dominance of groundnuts in *kara* farmlands is because of the suitability of the soils and the fact that it is also a commercial crop well sold in the market. This consistent with report by Williams (2002) that groundnut is a preferred legume because it is sold in the market. Besides, it is a key ingredient in most household meals which contributes significantly to the protein dietary needs of households in the study area (Callo-Concha et al., 2012).

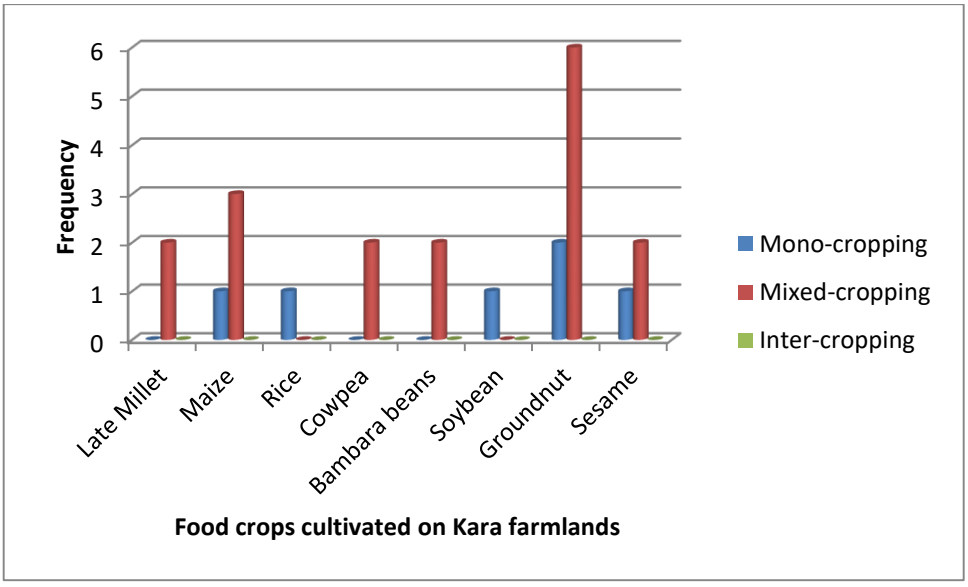

Figure 4. 8: Bush farmland and cropping systems

Source: Survey Data, 2018

Land preparation in *kara* farmland is largely through tractor plough, animal (bullock) traction, hand weeding with hoe, and the use of weedicide/herbicide before manual sowing with stick dibbler/hoe. Discussants in focus group discussion indicated that hand weeding with hoe is the main method of weed control and that twice weeding is required when maize or millet is planted and only one weeding is required when legumes such as groundnuts, Bambara beans or cowpea are cultivated. Discussants reported that cow dung is often stockpiled on *kara* farmlands during off-season in preparation towards the main farming season and get mixed with the soil during ploughing by tractor or bullock to improve soil fertility. They revealed that in most cases, the farmlands in *kara* are cleared, manure applied, and then ploughed using tractor or bullock before planting. Furthermore, they reported that *kara* farmlands are usually the last to be planted relative to other farmlands. They explained:

> *Kara* farms are last to cultivate because the focus is usually to cultivate early millet and other crops in *kaduga* when the rains set in to ensure that there is food available for the family to deal with hunger as most of us would have run short of food by that time of the year". [Saboro, discussants, January. 2018]

This statement affirms the assertion that *kara* farmlands are usually the last to cultivate. It also shows that cropping system is often staggered by first planting early on compound farms during the onset of early rains to ensure that households are able to harvest early millet to mitigate the onslaught of hunger. This stems from the fact that most households begin to run out of food stock at the beginning of the farming season and therefore cultivate early millet to enable them meet their food needs during that period.

The findings show that *kara* farmlands are relatively large and mainly used to cultivate food crops such as legumes, maize and late millet under mixed or mono-cropping patterns.

The farming practices and technologies are either solely traditional or mixed with western farming practices depending on the smallholder farmer's resource endowment.

4.2.4 Ownership of Multiple Farmlands

The study shows that multiple farms constitute a major feature of the farming system in the study area because majority of smallholder farmers find it useful to have multiple farms to cultivate variety of food crops to meet their consumption needs. The findings from both survey and focus groups show that smallholder households cultivate multiple farms located at different places within and outside their community. The survey results presented in Figure 4.9 below show that 34 percent (41 out of 122) of respondents cultivate in only *kaduga* farmlands while the remaining 66 percent (81 out of 122) cultivate multiple farms at different permutations. For instance, 30 percent (37 out of 122) of respondents cultivate in *kaduga* and *bwolo*, whereas 21 percent (26 out of 122) of respondents cultivate farms in *kaduga* and *Kara* compared to 14 percent (17 out of 122) cultivating in all the three kinds of farms (i.e. *kaduga*, *bwolo* and *kara*).

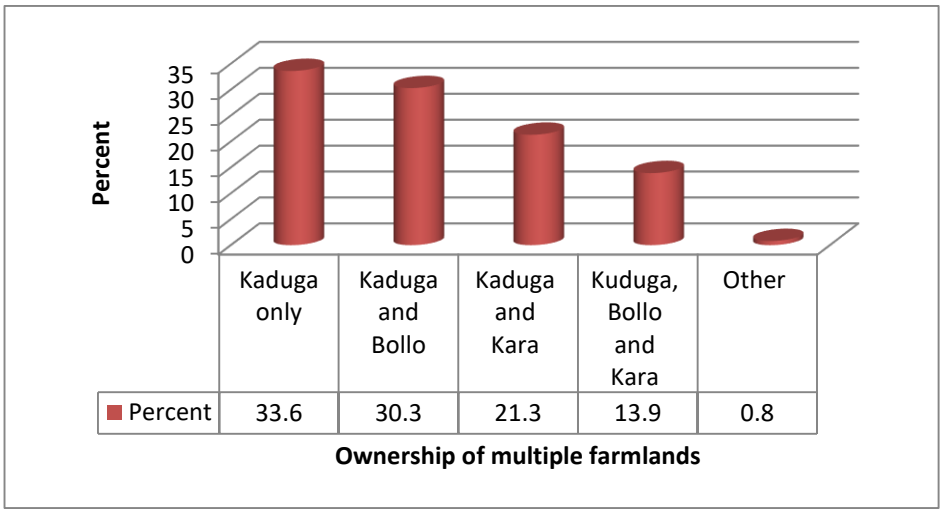

Figure 4. 9: Ownership of multiple farms

Source: Survey Data, 2018

Smallholder farmers assert that multiple farms allow them to cultivate variety of food crops to meet household consumption needs since different farmlands determine the type of food crop(s) to cultivate. In attempt to explain the need for multiple farms for majority of households, discussants tried to illustrate how moisture requirements of crops and suitability of specific soils influence the cultivation of certain crops. they had this to say:

> The reason why we have multiple farms is that there are different types of soils deemed suitable for certain crops. Every soil has the kind of food crop it can support for growth. For instance, the *bwolo* is suitable for rice production and *kaduga* for millet and maize while Kara is suitable for groundnut. You cannot decide to plant rice in *kaduga* and expect it to do well because that land [*kaduga*] does not retain enough water to support rice production. So that explains why we have different farms such that depending on the type of food crops you want to cultivate, you choose the most suitable soils to support it. There is no farmer in this community who will contemplate planting rice in *kara* knowing that it won't perform because it is not a waterlog farm [Punyoro, discussants, January, 2018].

The statement suggests that smallholder farmers have knowledge and understanding of the different crops and their varying requirements for water and micro-soil nutrients and the characteristics of the soil structure suitable for specific types of crops. This finding supports Derbile' (2010) assertion that compound farms are usually fragmented based on farmers' knowledge and understanding of soil characteristics. Clearly, smallholder farmers' knowledge of soil characteristics determines the type of crop to cultivate. Having multiple farms is indeed a way to spread the risk of crop failure. Risk aversion is clearly a key element of crop farming in the study area. This explains the rationale behind the cultivation of a wide range of food crops by smallholders in the study area.

The findings so far have shown that smallholder farmers describe their farming systems in terms of a mixture of farming activities and practices they undertake to achieve desired levels of crop production to meet household consumption needs. Key features used to

describe their farming systems include: types of farmlands (i.e. Compound, Lowland *and Bush farms*), cropping systems, systems of land preparation, systems of soil fertility maintenance, cultivation of a range of food crops based on their knowledge of the crops and soil characteristics, fragmentation of *kaduga* farmlands, staggering of planting regimes, zero tillage, and use of stick dibbler. The farming practices and technologies used on the different land systems suggest a pattern where household food sustenance and opportunities associated with market oriented production play a role in the choice of farming systems.

Generally, the study has shown that smallholder farmers continue to use traditional hand weeding with hoe and animal traction for land preparation and apply animal and/or compost manure to improve soil fertility. The use of traditional seeds and recycling of seeds are common practices among smallholder farmers. However, some smallholder farmers use tractors to plough farmlands in *bwolo* and *kara* and apply chemical fertilizer often below recommended rates and the use of certified or hybrid seeds are limited. It is clear that smallholder farmers employ different farming practices and technologies to achieve desired levels of crop production. Several factors may account for their choice of farming systems. The next section examines how social differentiations of smallholder farmers influence their choice of farming systems.

4.3 Social Differentiation of Smallholder Farmers in the Study Area

Smallholders are a diverse range of relatively small-size socio-economic farmers that use limited landholdings to pursue diverse agricultural activities for both self-consumption and sale (Yaro, 2002). They are differentiated socially and economically according to the

relative size and quality of their farmlands and levels of capitalization which influences the operational scale, labour intensity and level of input use (Moyo, 2016).

In the light of clues about the nature and characteristics of smallholder agriculture in Ghana, I categorized smallholder farmers in the study area into three social groupings using landholding size as the key indicator of who is a smallholder farmer (Chamberlin, 2008). Thus, I classified smallholder farmers into: high resource-endowed farmers (*vale-didera*), medium resource-endowed farmers *(achea*) and low resource-endowed farmers (*vale-nabona*), using farmer perceptions based on wealth characteristics of small-farm households such as: farmland size and fertility, access to household labour, access to mechanization, livestock holdings, having enough food, housing, ability to address household crisis situation, and household resource endowment. Below are detailed characteristics of the different smallholder farmers in the study area.

4.3.1 High Resource-endowed Farmers - *Vale-didera*

The *vale-didera* have farmlands less than 1.2ha in *kaduga* cultivating traditional food crops such as early millet (naara), late millet (nea), groundnuts, and sorghum under mixed cropping pattern. A good number of farmers in this category also cultivate Maize in *kaduga* under mono-cropping pattern. Others own farmlands up to 2ha in *bwolo* cultivating mainly rice during the main farming season. Smallholder farmers in this category also own farmlands less than 2ha in *Kara* and cultivate largely maize and groundnuts under mono-cropping pattern. The average farm holding size of smallholders in this category is about 2ha. Most of them inherited large parcels of land and livestock from their parents and grandparents (Yaro, 2009). Their farmlands are located at different places within and outside the community, but their preference is in *kara* and *bwolo* farmlands because such

farmlands offer them the opportunity to cultivate relatively large farms. Most farmers in this category are able to afford the costs of plowing (animal traction or tractor service) and labour and own livestock (i.e. cattle, donkey, pigs) and large numbers (5 and above) of small ruminants (i.e. goats and sheep) and poultry (i.e. chicken, guinea fowls, and ducks). Other assets owned by this category include: animal drawn cart, bicycle, motorcycle, and motor-king.

The *vale-didera* also comprises farmers who are engaged in income generation activities such as basket weaving, *pito* brewing, and petty trading. Others are in formal employment like watchmen and teaching. As a result of their involvement in non-farm activities or formal employment, they have the resources required to invest in recommended agricultural inputs such as chemical fertilizers, hybrid and certified seeds, weedicides, pesticides, and tractor service. In that regard, they are able to take advantage of early rains to plow their fields early and apply substantial amount of inputs, particularly on their maize and rice farms to improve production. Besides, they are able to engage hired labour to optimize crop production and participate actively in markets. Out of the total number of respondents (122), the results presented in Figure 4.10 classify 21percent (26 respondents) as *vale-didera* comprising of 16 males and 10 females. Further analysis of the survey data shows that there are fewer *vale-didera* (26) as compared to *vale-nabona* (54) and the *achea* (42).

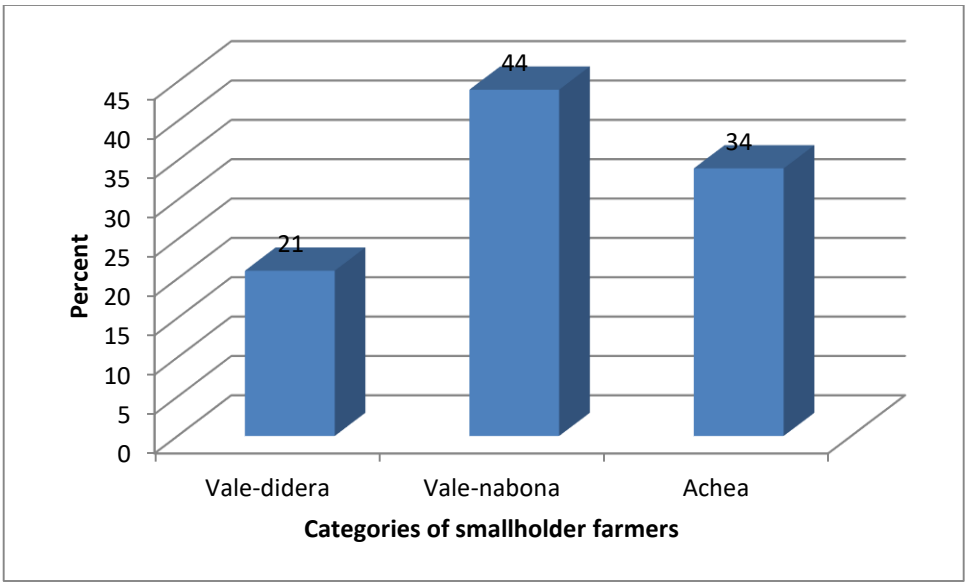

Figure 4. 10: Social differentiations of smallholder farmers

Source: Survey Data, 2018

4.3.2 Low Resource-endowed Farmers - *Vale-nabona*

The low resource-endowed farmers have farmland size less than 0.4 ha mainly in *kaduga* and cultivate traditional crops such as early millet, late millet, groundnuts, cowpea, and leafy vegetables such as okra, pepper, roselle, and kenaf under mixed cropping pattern. Few of them own farmlands in *bwolo* with farm sizes less than 0.4 ha and cultivate rice and sorghum under mixed cropping. The mean farm holding size of this category is about 0.8ha. They are largely farmers who own three or less numbers of small ruminants and poultry and less household assets portfolio including bicycle and mobile phone. They are largely males and females who are widows, divorced or separated from their partners. Yaro (2002) describes this group as composed of old couples who have lost their children to death, migration and reckless life style such as alcoholism within the community. Consequently, they are not adequately supported by the extended families. The results presented in Figure 4.10 show that 44 percent (54 out of 122) of respondents are categorized as *vale-nabona*

(poor farmer group) comprising of 28 males and 26 females. Most households in this category are unable to afford plowing and labour cost and have limited access to household labour. Hand weeding with hoe is the primary land preparation method among this category and they mostly recycle their own seeds and rarely purchase chemical fertilizers or certified seeds. Their primary focus is to produce to meet household subsistence hence their choice of food crops such as early millet, late millet, groundnuts, bambara beans and leafy vegetables under mixed-cropping pattern.

Farmers in this category are unable to take advantage of early rains during the farming season to guarantee optimal yields of cultivated crops. Besides, continuous cropping on the same piece of land without adequate conservation measures further depletes the soils of nutrients. Consequently, they are unable to maximize production to have enough food to meet household consumption needs beyond few months after harvest. Therefore, this category of households often experience food shortages and therefore resort to coping mechanisms such as offering labour to the *vale-didera* to earn income.

4.3.3 Medium Resource-endowed Farmers - *Achea*

In between the high resource-endowed farmers and the low resource-endowed farmers is the *"achea"* mostly labeled semi-subsistence smallholder farmer. Discussants in focus group discussion described the a*chea* as persons neither rich nor poor but who can provide for their household from own production up to a point and complement their household food needs from other food sources to successfully end the year. This category of smallholder farmers cultivate less than 0.8 ha, 1.21 ha and 1.21 ha in *kaduga*, *bwolo* and *kara* farmlands respectively with mean farm holding size of about 1.3ha. They also have farms at different places with farm sizes slightly more or even the same as the poor but

their farms are predominantly in *kaduga* (compound farm) or/and *bwolo* (Lowland or valley farms). The survey results presented in Figure 4.10 show that 34 percent (42 out of 122) of participants are categorized as *achea* comprising 25 males and 17 females. A major characteristic of this category is that they have few resources or endowments to participate in productive activities (Yaro, 2002). As a result, they are able to feed their households up to some extent but have to purchase food from the market mainly through the sales of livestock or adopt other household coping mechanisms to cope with sustenance when their household does not have enough food to feed. According to Yaro (2002), seasonal migration is common and seen as a way of reducing pressure on their inadequate landholdings and averting risk of falling into the poor category.

4.4 Smallholder Farmers and Choice of Farming Systems

Following from the discussion above on the nature and characteristics of smallholder farmers in the study area, I now proceed to present major themes that underscore smallholder farmers' choice of farming systems in the area based on Clarke and Braun's (2013) framework of thematic analysis of data from the focus group discussions. Detail discussion of these themes is presented below.

4.4.1 The Desire to Attain Household Food Security

A common feature in the farming system of the study area is cultivation of a wide range of food crops in *kaduga* farmland. The survey shows that all three categories of smallholder farmers own farmlands in *kaduga farmland* cultivating almost similar food crops such as: early millet, late millet, sorghum, groundnuts, Bambara beans, cowpea, maize, and vegetables such as kenaf, roselle, okra, and pepper under mixed cropping pattern. Discussants during focus group discussion reported that *kaduga farmland* is the main

farmland and is largely use to cultivate traditional food crops required to meet household food consumption needs. Discussants shared their views as follows:

> Farming is our major source of food for the family, and the family requires different types of food to provide strength and energy to live. Therefore, we cultivate all the types of food crops and leafy vegetables to help maintain good health and growth for our children [Kolgo, discussants, February, 2018].

Discussants further explained that:

> A household must just have some variety of food because you can't feed on one type of food all the days. As for us we cultivate a number of food crops also to ensure that a failure in one crop does not affect the family food needs as other food crops may not be affected [Kolgo, discussants, February, 2018].

Both remarks highlight the need to cultivate a range of food crops not only to meet household consumption needs but also as a strategy to avert total crop failure (Briggs & Moyo, 2012). The study made a number of observations from the list of food crops grown and the comments expressed. First, the wide range of food crops including grains and vegetables provide relatively balanced household diet in terms of nutrient (Eguavoen, 2007). This was highlighted in the remarks above with regards to the family's desire to provide 'energy, maintain good health and growth'- key elements of food security. Second, the second comment makes allusion to the fact that cultivating a wide range of crops does not only provide variety of food to meet the household food requirements but also spread the risk of crop failure (Briggs & Moyo, 2012). As indicated earlier, risk aversion is a key feature of farming systems in the study area (Briggs, 2010). This knowledge and understanding underscore the wide range of crops cultivated under mixed cropping pattern.

However, the importance of attaining household food security is not only reflected in the wide range of crops being cultivated in the study area, but also in the recognition that in

recent times the traditional crops alone are not adequate to meet household food needs, therefore there is increasing interest among smallholder farmers to cultivate maize in *kaduga* to complement other food crops. According to discussants, maize is not one of the traditional crops inherited from their fathers and grandfathers but has become necessary in most households to augment the declining yield potentials of traditional crops which are no longer adequate in dealing with household food security. Maize is usually cultivated in combination with sorghum and millet in *kara* farmlands. As a result of it being demanding with respect of nitrogen, phosphorus and soil organic matter, it is cultivated mostly on virgin lands (Callo-Concha et al., 2012).

4.4.2 Knowledge of Crops and Soil Characteristics

Smallholder farmers' knowledge of crops and soil characteristics play a key role in influencing the choice of farming systems in the study area. They have a good understanding of the different types of crops and their varying requirements for water, sunlight, fertilizer, among others and the soil characteristics that support their growth. For instance, smallholders indicated that they usually cultivate rice in lowlands or valley areas because the soils there are clayed loamy and retain water to support rice production. Besides, *kara* is specifically noted for groundnut production because the soils are sandy and suitable for groundnuts production. Similarly, they pointed out that *kaduga* is noted for millet production because of the nature of the soils there. Discussants noted:

> We have different types of farms and they determine the types of crops based on their soils. So the soil on the land will tell you what type of crop to farm. Their food crops are different. If you go and plant household food in the *bwolo* farm it will not do well because it is a clayed loamy soil and doesn't support all kinds of crop. The moisture level there is always high and good for rice. The *kara* farms for instance are sandy that is why we

> often plant groundnuts but if you are able to apply enough manure then you can plant millet or maize [Kajolo, discussants, February, 2018].

The above statement highlights the role of soil characteristics in determining the type of crop to cultivate. In this statement, the participants indicated that sandy and clayed loamy soils are suitable for groundnuts and rice production respectively. Consequently, smallholder farmers cultivate multiple farms based on their knowledge of the nature and characteristics of the soils that better support the growth of the selected crop. Furthermore, mixed cropping system is a common farming practice identified among smallholder farmers in the study area because they believe that mixed cropping system has the potential to utilize the soils more efficiently and gain more from a given unit of land. Their approach to soil fertility maintenance is also influenced by their perceptions of the soils. For many low resource-endowed farmers, soil fertility maintenance does not require expensive chemical fertilizers to meet acceptable levels of fertility given the cropping strategies they employ with its emphasis on cultivating to meet household consumption. The findings suggest that smallholder farmers' knowledge of soil characteristics and fertility play significant role in their choice of cropping and soil fertility maintenance systems to adopt.

4.4.3 Smallholder Endowment and Adoption of Farming Practice and Technologies

The study observed that resource endowment of smallholder farmers plays a critical role in their choice of farming systems. Both focus group discussions and survey results show that whereas high resource-endowed farmers usually use bullock or tractor to prepare their farmlands in *kaduga*, *bwolo* or *kara*, low resource-endowed farmers on the other hand often resort to hand weeding with hoe. Ability to afford was mentioned as a major consideration for the choice of land preparation methods to adopt. Similar reasons were given for the methods or strategies for soil fertility maintenance. Discussants reported that high

resource-endowed farmers are able to afford to use chemical fertilizers particularly for maize and rice production under mono-cropping. Labour constraints coupled with the time needed to weed relatively large acreages, make it more efficient for high resource-endowed farmers to opt for the use of weedicide/herbicide. The use of weedicides has come to replace the slash and burn method of land preparation (Kansanga et al., 2019). Usually, the cultivation of maize and rice are not only meant for household consumption but also for the market. As a result, farmers in this category often make modest investments in complementary inputs for the cultivation of crops with market value to increase production and maximize profit (Houssou et al., 2016).

The prevalence of low resource-endowed farmers in *kaduga* farmland has been attributed to their limited resource endowment. During focus group discussion, discussants intimated that the low resource-endowed farmers have no option than to cultivate in compound farms because they have no money to hire labour to undertake faming activities beyond compound farmlands. Discussants had this to share:

> The *val-nabona* (low resource-endowed farmer) knows that he/she does not have what it takes to farm in all three types of farms and therefore stays within the *kaduga*. Even though they stay within the *kaduga*, they are unable to maximize the farm potential there because of inadequate funds to purchase the needed inputs. Indeed, some own farmlands in *kara* but have willingly given them out to other farmers because they don't have the strength [the means] to farm on them. Their inability to cultivate beyond one farm explains their inability to produce enough food to feed on beyond Christmas [Mirigu: discussants, January, 2018].

This statement shows that low resource-endowed smallholder farmers are constrained by limited funds to adopt the necessary farming practices and technologies on their multiple farmlands to meet household food needs (Houssou et al., 2016). Furthermore, the statement suggests that their inability to cultivate more than one farmland is the reason for their

inability to feed beyond three month of harvest. This suggests that smallholder farmers cultivating on small farmlands in *kaduga* are not likely to obtain enough food crops to sustain their households throughout the year (Al-Hassan, 2015).

4.4.4. Risk and Uncertainty Avoidance

Risk is an important factor that influences smallholder farmers in their choice of farming systems (Briggs, 2010). Analysis of focus group discussions show that rainfall variability is the most important factor in the seasonal variability of food availability and access. The two main disturbing features of rainfall variability that affect food crop production have been identified as inter-annual and intra-annual rainfall variability (Derbile, 2010). A remark to buttress this point was captured as follows:

> Unlike you people who have secured salaries at the end of every month, whether it rains or not, we rely on the mercies of the rains and therefore if we miss out due to irregular rainfall, our suffering begins and continues up to the next season to have another chance [Punyoro, discussants, January, 2018].

The study observed that the cultivation of a wide range of food crops under mixed cropping pattern predominates in the study area. Food crops such as early millet, sorghum, late millet are sown in association with groundnuts which are planted a few weeks later. Mixed cropping is used as a strategy to minimize risk of complete loss as different crops/varieties have different water requirements and phonological timing in the event of adverse rainfall patterns. This strategy plays a dual role of diversification and adaptation to minimize risk of complete crop failure. Furthermore, smallholder farmers choose to cultivate early maturing varieties of food crops such as *chaara/naara* (early millet) in *kaduga* farmlands to shorten the duration of the hunger period from May to August and cultivate drought resistant crops such as cowpea, groundnuts and late millet in *kara* farmlands.

The findings show that major issues influencing smallholder farmers in their choice of farming systems in the study area include: the desire to attain household food security, smallholder farmers' knowledge of crops and soils, smallholder resource endowment, risk and uncertainty avoidance. In the next section, I examine how constraints associated with farming systems affect the different cohort of smallholder farmers.

4.5 Farming System Constraints in the Study Area

This section discusses constraints facing smallholder farming systems in the study area. Interaction with discussants during focus group discussion revealed that there are several constraints facing smallholder crop production in the study area. Some of the constraints mentioned include: market access, rainfall variability, poor access to animal traction, poor soil fertility, inadequate water supply for dry season gardening, diseases and pest infestations, high cost of chemical inputs, and scarcity of labour. In order of priority, respondents during survey were asked to rank these constraints in terms of how they affect their farming activities the most.

4.5.1 Production Constraints of Smallholder Farmers

In respect of production, the survey shows that rainfall variability is ranked highest; followed by poor soil fertility, late ploughing, unfavorable market and others including weeds control, disease and pest infestation, and scarcity of labour. Figure 4.11 gives a picture of how participants ranked the most pressing constraints affecting crop production in the study area.

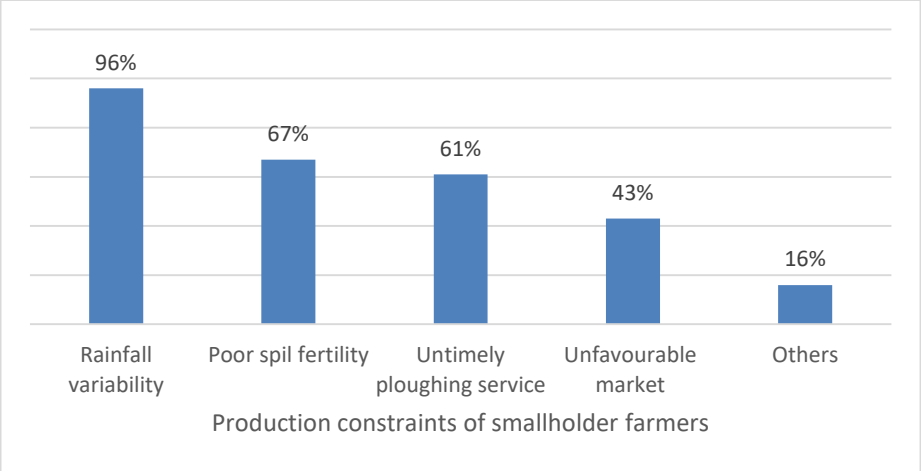

Figure 4. 11: Constraints facing crop production

Source: Field Data, 2018

With regards to rainfall variability, 96 percent (117 out of 122 respondents) ranked rainfall variability as the most important constraint affecting their farming activities in the area. This finding corroborates other research findings in the study area (Yaro, 2009; Derbile, 2010; WFP, 2012). Respondents' account reveals unfavorable intra-annual rainfall distribution as the major cause of rainfall variability in the area. This gives rise to occurrence of intermittent dry spells and drought in some months and high rainfall intensities in other months of the rainy season that are often not in harmony with plant water requirements (Derbile, 2010; Kasei et al., 2010). This constraint is heightened because rainfall is erratic and changes occur from year to year which makes predictability of rainfall with precision quite problematic. (Yaro, 2010). Consequently smallholder timing of sowing during the onset of the rainy season exposes crop production to risk of failure.

Conventionally, smallholders depended on indigenous weather forecasting parameters to predict rainfall patterns in planning farming activities. During focus group discussion,

participants indicated that this system of weather forecasting still persists among smallholders. Some of these indigenous weather forecasting parameters mentioned during the group discussion at Punyoro community include the fact that, when they observe extreme heat with dark red clouds gathering in the east, it is an indication of impending rainfall. In Mirigu community, it was said that when more than one toad start croaking in the morning in an unusual way, then it is a signal that rainfall is expected within a day or two. In Gingabnia community, it was recounted that when red berries (*sinsibi*) fruits are found ripening then it is an indication of the beginning of the rainy season.

Across the board, discussants assert that indigenous plants and animals that were used for predicting the weather are now getting extinct due to population growth and deforestation making weather prediction difficult these days. According to them, the accuracy of their predictions solely depends on God. In recent times, radio and other ICT tools such as Esoko, Ignatia and Voto mobile have attempted to provide weather information to assist farmers to plan their farming activities. However, the accuracy of weather information through these mediums is uncertain.

In terms of poor soil fertility, discussants identified it as the second most important constraint affecting crop production in the study area. The survey results presented in Figure 4.11 show that 67 percent of participants ranked poor soil fertility as second most important constraint. It is noted that low soil fertility results in low crop yields (WFP, 2012). Consequently, smallholders are unable to produce enough food to meet household consumption needs and virtually have no surplus to generate income (Alhassan, 2015).

Derbile (2010) argues that although soil fertility may be inherent in the soils of the Upper East Region, it has declined considerably overtime due to human activities such as intensive cultivation without adequate conservation measures, extensive bush fires, and soil erosion among others. According to Kombiok et al. (2012), bush fires render the soil bare exposing it to wind and water erosion in the dry and rainy season respectively thereby depleting the micro-nutrients such as Nitrogen, Phosphorus, and Potassium (NPK) and organic matter from the soil. Therefore, the use of chemical fertilizers has been recommended to enhance the fertility of the soil to support plant growth. However, broad application of chemical fertilizers due to lack of knowledge of the specific nutrient composition that is lacking in the soil is emerging as a concern for the need to conduct soil testing to establish the exact nutrient deficiency in the soil to inform the kind of chemical formulation required in fertilizer production.

Conventionally, animal manure, compost and different cropping strategies were the methods used in the past and even now to enhance the fertility of the soil for crop production. However, in recent times, the chief source of material - cow dung – has become relatively scarce because of dwindling numbers of livestock in most households in the study area.

Inadequate access to timely ploughing service was identified as the third most pressing constraint affecting crop production in the study area. Land preparation is important for successful crop production. It improves soil texture, opens up the soil, which in turn improves absorption and retention of rain water. Given that the raining season is usually short and unpredictable, ploughing and subsequently sowing must be accomplished quickly to ensure good crop yields (Kansanga et al., 2019). Any delay could lead to late sowing

which has greater risk of poor yields or total crop failure. This study has shown smallholder farmers depend almost exclusively on traditional hand-hoe technology for tilling their land but the use of bullock plough and tractor were mentioned during focus group discussion as mechanized technologies for tilling farmlands.

The survey results presented in Figure 4.11 show that 61 percent of participants ranked lack of timely ploughing service as the third most important constraint affecting farming activities. This constraint comes about as a result of limited availability of tractors and bullock plowing services in the area. The use of bullock plough and tractor significantly reduces per hectare labour requirement and shortens field work time of smallholder production (Kansanga et al., 2019). However, access to these critical services is largely underpinned by resource endowment of smallholder households and availability of tractors at the onset of the rains. Analysis of the survey reveals that, out of the 122 respondents, 23 percent of households own bullocks and none owns a tractor. The use of bullock traction among smallholders is more widespread than tractor plowing because bullock traction is relatively accessible and more cost effective (Diao et al., 2014). Usually, due to the fragmented nature and size of the *kaduga* farmlands, smallholder farmers prefer to engage the service of bullock traction. Discussants in focus group discussion reported that households with bullocks will usually attend to the needs of their household members before providing ploughing service to other households during the onset of the rains. As a result, there is often a rush for these services by smallholders who have cash to readily pay for the service but those who do not have would have to arrange for a special dispensation, that is, to pay in-kind after harvest. Consequently, smallholder farmers who fail to gain access to bullock traction due to lack of trust of repayment, would have no choice than to

resort to traditional hand–hoe technology to till their lands which is indeed time consuming and laborious, given the limited time available during the season.

In Ghana, as in most parts of West Africa, bullock traction technology for crop production has not received priority attention due to governments' obsession of modernizing the agricultural sector mainly through tractorization (Diao et al., 2014). From the early 2000s, governments in Ghana and several African countries started to re-emphasize the importance of mechanization and directly engaged in tractor imports (Diao, et al., 2014). In the study area, animal traction appears to be more suitable due to the nature and structure of the soils. Large proportions of the soils are old, fragile and shallow and have leached over a long period of time. As a result, their organic matter content is generally low. The top soils contain the nutrients usually on gently sloping surfaces which make them susceptible to erosion. Consequently, tractor plowing terribly disturbs the soil structure by going deep into the soil using the plowing disc to bring to the surface red soil with virtually no nutrients to rather bury the top soils. In the case of animal traction, the disc plow is shallow and appropriate for minimum tillage. As a result, the soils are virtually not disturbed and traction effectively blends the soil together with organic matter on the top soil to support plant growth.

Besides, it does appear that households in the study area have more access to animal traction than tractor. In virtually every community, there is animal traction service available as compared to tractors that are mostly found in the district capitals. Furthermore, animal traction appears more suitable for the fragmented nature of the *kaduga* farmlands and it is cost effective to hire animal traction service for smaller farms than tractor service.

In terms of market access as a constraint facing smallholder farming systems, participants ranked it as a major constraint affecting smallholder crop production in the study area. Markets are critical to the ability of peasants to satisfy their household food requirements (Yaro, 2009) but smallholder farmers should select the right market to meet their needs. To appreciate the market constraint as expressed by participants, I will attempt a brief contextual discussion here in terms of market types and their dynamics to provide understanding of the factors that affect smallholder market access and prospects to help them to decide which markets to target and the extension service approach required to meet the needs of different smallholder farmers. In broad terms, there are three basic types of markets: informal markets, formal markets and structured public markets. The structured public markets are organized by public sector buyers who offer standardized contractual buying arrangements with specific conditions. The formal markets operate using standard weights and measures and transactions are based on defined legal frameworks. Farmers must meet specific quality standards and apply best practices in production, handling of produce and regular volume requirements of the buyer. Informal markets on the other hand, have few regulations, no grades, no traceability and they rarely use standard weights and measures. Usually, food crops are sold informally through transactions at the roadside, community, districts, and regional markets. Prices are typically based on a combination of demand and supply, transaction cost and operations of trader cartels. These types of markets are often controlled by a cartel of traders who limit competition and virtually set market prices (Yaro, 2009). For majority of smallholder farmers, informal markets are the most accessible. The market constraint to smallholder farmers is the issue of ineffective functioning of the informal output markets (Poulton, Kydd & Dorword, 2006). The

effective functioning of this market is perceived in terms of the price being offered by buyers for agricultural products which determines the income the smallholders get from the sale of their food crops. Yaro (2009) has observed that exchange relations in the markets in Navrongo and Chiana have always been in favour of market women for most of the year.

Generally, farmers are price takers and therefore are unable to influence market prices to a large extent. They are expected to improve in productivity to gain higher yields per farm unit to maximize profit. However, smallholder farmers are constrained by poor soil fertility, high cost of inputs, and finance. As a result, they are unable to produce enough surpluses to sell to the markets. Individual smallholder farmers lack market power and therefore are unable to bargain much over prices as a result they accept the prices offered to them. Furthermore, there exist poor relationship between smallholder farmers and aggregators/buyers (Poulton et al., 2006).

4.5.3 Effects of Farming System Constraints on Different Smallholder Farmers

This section examines how farming system constraints affect the different cohorts of smallholder farmers in the study area. Focus group discussions revealed that rainfall and market affect all the three categories of smallholder farmers in the same manner. Discussants explained how these constraints affect smallholder farmers:

> As for rain it doesn't discriminate. Whether you are *vale-didera* or *vale-nabona*, the rainfall effect will be the same for both of you because the rain does not decide whose farm to rain. The same way, the market price of food crops is the same for all. We all sell to the same market. If a buyer comes to the community to buy produce, the price will be the same for all of us [Gingabnia, discussants, January, 2018].

The statement tells us that rainfall variability and market price for agricultural produce have similar effect on the different smallholder farmers. This confirms the assertion that

farmers are indeed price takers and therefore are unable to influence market prices to a large extent. It is also the case that lack of market information exacerbates their predicaments. In terms of rainfall variability, most smallholder farmers rarely use improved seeds that are draught tolerant or early maturing varieties as measures to deal with rainfall variability. Besides, lack of weather information makes them more vulnerable to rainfall variability.

In terms of access to timely plowing service and poor soil fertility, participants stated that they affect low resource-endowed and medium resource-endowed smallholder farmers more than the high resource endowed farmers. They explain that if a farmer has money, as in the case of the high resource-endowed farmer, he/she will not go through the trouble of accessing timely plowing service: tractor or bullock plowing. Besides, they intimated that a high resource-endowed farmer will be able to afford the cost of chemical fertilizers to improve the fertility of the soils. Response from discussants in focus group discussions on how production constraints affect different smallholders and gender is presented below.

> In my view, production constraint such as untimely plowing affects the *val-nabona* more than *vale-didera* because if both of them approach a bullock owner to request for plowing service and cash is demanded, the *vale-didera* would readily go into his room and come out with money to pay for the plowing service to commence on his farm. This means that he will be able to take advantage of the early rains to plant his crops. While the *vale-didera* is planting his crops on the farm, the *vale-nabona* is still searching for money that only God knows when he will find it and by the time he gets the money for the plowing, the farming season is far advanced. Obviously, by the end of the farming season the *vale-didera* is more likely to harvest more food crops than the *vale-nabona* who was affected by late plowing [Saboro, discussants, January, 2018].

The response shows that poor access to ploughing service affects low resource-endowed smallholder farmers more compared to high resource-endowed farmers. The statement

above indicates that high resource-endowed farmers are able to mobilize funds to pay for plowing service but takes longer period for the low resource-endowed smallholder farmer to be able to raise funds for plowing service. The implication is that low resource endowed smallholder farmers often plough late which sometimes lead to poor crop yields. This reiterates the point that delay in plowing leads to late sowing which ultimately has implications on crop yields and household food security.

With regards to gender, discussants assert that access to timely ploughing service affects women more, especially female widows. They assert that bullock owners are more inclined to provide plowing service on credit to males as compared to females because in the event of default, it is more expedient for the bullock owner to request the male to work 'by-day'[3] on his (i.e. bullock owner) farm to offset the debt but may not find it suitable to ask the female, especially a widow, because she may not be able to work adequately to offset the debt owned. Besides, pursuing a widow for repayment of outstanding debt is something that many bullock owners will like to avoid because of moral concerns in dealing with family relations and also the fact that reverence for the elderly is very strong. Usually, relations do not pay back loans arguing that whatever belongs to a family relation belongs to the family as a whole.

However, there was ambivalence on the viewpoint expressed above. Some discussants also argued that late plowing service affect both male and female farmers in the same manner. They explained that there are some widows who can afford the cost of bullock plough while

[3] A system whereby lobourers are paid according to the amount of work done based on a daily payment principle

other men are unable to afford. Therefore, the constraint is not about the sex of the person but rather the ability to pay for the service. The discussants noted:

> In our view, the bottom line is money not whether you are a woman or man. Why do I say this? If I am a widow and have the money to pay for ploughing cost, the bullock owner will receive it and then proceed to plough my farm. But the man who cannot afford will not be given any attention even though he is a man. The service provider is not interested in who is a woman or a man but interested in who can pay for the service. So for us, the problem is because we don't have money and not whether it is a woman, a widow, or a man. If you don't have the money readily available, they would plough for those who are handling cash first before attending to you and that will leave you behind [Vunania, discussants, January, 2018].

The argument above clearly attributes the challenge of inadequate access to timely plowing service to economic factors rather than gender considerations. This argument was supported by a number of discussants who pointed out that finance is indeed the major factor underscoring who is more likely to be affected by production constraints. Discussants buttressed this point with the narration below:

> The truth of the matter is that lack of money is the reason why some are affected by production constraints and others are not. I am a strong male farmer but there was a time I took a tractor to the farm to plow my field and the tractor operator asked me to clear the grass and storms before the tractor can plow. My neighbor at the farm also needed plowing service at the time and upon hearing this, she immediately went and hired the service of four young men to help her clear the field and got the tractor to plow her farm first while I struggled with my young son for two days to clear my farm. In this case, it is clear that the woman showed the power of money to access plowing service before me, even though I arranged for the tractor to the farm [Punyoro, discussants, January, 2018].

The statement shows that financial resource is critical to access timely plowing service. This enables smallholder farmers, irrespective of gender, to access timely ploughing service. This suggests that both economic constrains and gender considerations play critical role in access to timely ploughing service in the area.

4.6 Discussion of Key Findings

The study set out to examine how smallholder farmers describe their farming systems and the factors that influence different smallholder farmers in their choice of farming systems. The study has shown that smallholder farmers in the area describe their farming systems in terms of agricultural land use systems and the associated farming practices they undertake to achieve desired levels of crop production to meet household consumption needs. Key features in their description encapsulate the types of farmlands and their associated farming technologies and practices. The study classified the type of farmlands into: compound farmland, lowland farmland and bush farmland. This classification is consistent with Derbile's (2010) account of multiple farmlands in the Akankwidi basin in northeastern Ghana and Briggs and Moyo's (2012) report of farming communities in northern Malawi. The classification allows identification of farm type-specific opportunities and constraints for innovation targeting (Kuivane et al., 2016).

Smallholder farmers' description of their farming systems in the area revealed a differentiating characteristics of farming system heterogeneity which showed a pattern where the cultivation of traditional food crops such as early millet, late millet and Bambara beans as well as the use of traditional farming practices and cropping systems like mixed cropping are predominantly on compound farmlands whereas western farming technologies such as chemical fertilizers, tractor and weedicides are predominantly on lowland and bush farmlands driven largely by market incentives to cultivate market oriented crops such as maize, rice and groundnut. These differences influence the adaptive strategies of farmers in the face of declining soil fertility, climate change, land scarcity, as

well as their interest and capacity to take advantage of potential opportunities to adopt sustainable agricultural technologies and practices (Yaro, 2010; Kuivanen et al., 2016).

Given that livelihood strategies reflect the distinctive characteristics of farm households (Kuivanen et al., 2016), this study has shown that social differentiation of smallholder farmers has considerable influence in shaping their choice of farming systems. The findings show that low resource-endowed farmers are predominantly in compound farms mainly using traditional farming practices and cropping systems whereas high resource-endowed farmers predominantly in lowland and bush farmlands adopting western technologies on relatively large farm sizes. These findings corroborate conclusions by Baiyegunhi and Hassan (2018) that household wealth plays an important role in the adoption of improved agricultural technologies in developing countries. Subsequently, they argue that stratifying households into meaningful wealth groups is imperative for designing interventions aimed at helping farmers overcome challenges of technology adoption (Baiyegunhi & Hassan, 2018).

Furthermore, the study has shown that low resource-endowed farmers are predominantly in compound farmlands where traditional farming systems are developed around cultivation of a wide range of food crops under mixed cropping as a risk-copping mechanism. This corroborates Briggs and Moyo's (2012) assertion that risk aversion is a major feature in smallholder farming systems. However, ongoing transformation of smallholder farming in Ghana through the provision of subsidized fertilizers and ploughing services tend to indirectly condition the farming system for market oriented production (Kansanga et al., 2019). Consequently, cropping patterns are shifting away from traditional staple crops to market-oriented crops (Houssou et al., 2016). This transition has adverse

implications on the cultural dimension of food security (Kansanga et al., 2019). That notwithstanding, reliance on solely traditional farming practices does not appear to yield the desired results. Alhassan (2015) assert that over reliance on traditional farming practices leads to poor crop yields which poses a challenge to household food security. The challenge that remains is to promote appropriate and affordable farming technologies and practices for sustainable agricultural production.

In addition to household resource endowment and market incentives, farm size underscores the different smallholder farmers' choice of farming systems in the area. The findings show that smallholder farmers cultivating on relatively large farmlands in lowlands and bush farms often use tractors, weedicides and herbicides for land preparation compared to those on less farm sizes in compound farms who use animal traction or hand weeding with hoe. These findings are consistent with Mwang and Kakuiku's (2015) report that farmers with large farm size are more likely to adopt new technologies such as a tractor because it requires economies of size to ensure profitability. However, for some specific technologies, large farm size does not influence adoption. For instance, Baiyegunhi and Hassan (2018) reported that with the increase in farmers' total farm size, the use intensity of Integrated Striga Management (ISM) technology decreased by 1.8% and 1.4% for poorly-endowed and well-endowed respectively. This suggests that the effect of farm size on technology adoption may be negative, positive or neutral (Akudugu et al., 2012).

However, constraints facing crop production play a significant role in smallholder farmers' choice of the different farming systems. A number of constraints emerged from the study. They include, poor soil fertility, rainfall variability, inadequate plowing services, market constraints, and socio-cultural constraints. Several studies corroborate these findings

(Yaro, 2004; Derbile, 2010; Kombiok et al., 2012; Mkonda, 2014). However, the findings show that aside market constraints, all the constraints affect low resource-endowed farmers more than high resource-endowed farmers in the area. Yaro (2004) describes rainfall variability as the single most important vulnerability-imposing variable of the climate in the area creating uncertainties and affecting crop yields.

The discussion so far has shown that smallholder farmers describe their farming systems in terms of agricultural land use systems and associated practices and technologies they employ to achieve desired levels of crop production to meet household consumption needs. The major reasons underpinning smallholder farmers' choice of farming systems in the area include: resource endowment, market incentives, production constraints, risk and uncertainties, and farm size. In the next section, I discuss how differentiated smallholder farmers are blending traditional and western farming practices and technologies to increase food crop production.

CHAPTER FIVE

5.0 INTEGRATION OF TRADITIONAL AND WESTERN AGRICULTURAL KNOWLEDGE SYSTEMS AND HOUSEHOLD FOOD SECURITY SITUATION

5.1 Introduction

A major theme in traditional knowledge research has been the need to purposely integrate traditional and western ecological knowledge, but integrating the two bodies of knowledge systems remains a challenge (Mercer et al., 2010). It is envisaged that purposeful integration of the two bodies of knowledge systems will contribute to improved livelihood outcomes (Mameu, 2011). This chapter examines how knowledge integration affects household food security situation of differentiated smallholder farmers. To do this, I structure the presentation into two sections. In the first section, I discuss how different smallholder farmers integrate traditional and western farming systems and how they rationalize their choice of blending farming systems. In the second section, I examine how blending farming systems affect household food security situation of differentiated smallholder farmers.

5.2 Integration of Traditional and Western Farming Systems

This section discusses key features of traditional and western farming systems and how different smallholder farmers are blending the two forms of knowledge systems and the rationale underpinning their choice of the different blend of farming systems. To this end, I proceed to discuss traditional farming practices and technologies in the study area.

5.2.1 Traditional Farming Practices and Technologies in the Study Area

Traditional knowledge systems play a key role in the process of adapting farming systems to the natural environment (Mameu, 2011). A participant through focus group discussion recounted how they acquired knowledge and skills in traditional farming practices:

> Since childhood when we used to follow our parents to farm, we learnt about farming as we accompanied them and even at a point you [child] were given your own hoe to farm along with your parents. As we grow, we actively participated in all the farming activities and begun to understand some of the reasons for the farming practices they used [Saboro, discussants, February, 2018].

The statement points out how traditional knowledge is acquired and handed down from generation to generation through practice. Common traditional farming practices and technologies identified during the survey include: bullock plowing, hand weeding with hoe, use of dibbling stick, mixed cropping pattern, crop rotation, recycling of own seeds, and animal/compost manure. The survey results presented in Table 5.1 shows that all the respondents used hand weeding with hoe as the common tool for weed control.

Table 5. 1: Traditional farming practices and types of farmlands

Traditional Farming Practice/Technology	Compound (*Kaduga*) Farmland	%	Lowland (Bollo) Farmland	%	Bush (Kara) Farmland	%
Hand weeding with hoe	122	100.00	46	38.02	37	30.58
Animal traction	106	87.60	22	18.18	26	21.49
Own seeds	99	81.82	31	25.62	25	20.66
Stick dibbler/hoe	94	77.69	36	29.75	31	25.62
Animal/compost manure	94	77.69	7	5.79	9	7.44
Mixed-cropping	86	71.07	8	6.61	15	12.40
crop rotation	17	14.05	7	5.79	2	1.65
Zero tillage	1	0.83	1	0.83	0	0.00
Slash & burn	0	0.00	1	0.83	1	0.83

Source: Survey Data, 2018

Depending on the crop under cultivation and method of land preparation, smallholder farmers are expected to follow a certain weeding regime to improve soil aeration and control weed. These weeding regimes are: first weeding (*girigim*), second weeding (*parim*) and third weeding (*tulemu*), and forth weeding (*gbarim*). Participants during focus group discussion explained that zero tillage requires three times weeding and twice weeding if the land is prepared with tractor or bullock. They explained:

> The use of bullock or tractor plow requires you do first weeding (*girigim*) and then second weeding (*parim*) to improve soil aeration. In the case of *kara* farms, the type of food crop grown influences the number of weeding required. For instance, maize and late millet (*zea*) cultivation often go with *girigim* and *parim* while groundnut goes with weeding once after the land is prepared. In the case of *bwolo* farms, weeding is minimal for the rice fields but the gardens could be more [Mirigu, discussants, January, 2018].

This shows that hand weeding with hoe is a dominant feature in smallholder farming systems not only used to control weed but also to loosen the soils for aeration and the number of weeding required is largely influenced by the method of land preparation and/or the crop under cultivation.

The next popular feature of traditional farming systems in the study area is animal traction. The survey results presented in Table 5.1 shows that 88 percent of respondents used animal traction for land preparation on compound farmlands but recorded relatively minimal use on lowland (18.18%) and bush (21.49%) farmlands. The relatively minimal use of animal traction in lowland and bush farmlands confirms smallholder's assertion during focus group discussion that tractor ploughing is more suitable for lowland and bush farmlands compared to *Kaduga* farmlands. Similarly, this finding validates smallholder reports in this study that animal traction is dominant in *kaduga* because it is reliable and affordable for

vale-didera and *achea* smallholder farmers to timely prepare their farmlands to take advantage of early rains.

Recycling of own seeds is another major feature of the traditional farming systems in the area. The survey results show that 82 percent of respondents recycled their own seeds on their compound farmlands, compared to 26 percent on lowlands and 21 percent on bush farmlands. These results suggest widespread use of own seed by smallholder farmers on compound farms relative to other farmlands. This is because compound farmlands are used for the cultivation traditional food crops such as early millet, late millet, and leafy vegetables mostly meant for household consumption. Consequently, smallholders rarely invest in seed but rely heavily on own seed (Kombiok et al., 2012). On the contrary, lowlands and bush farmlands are largely used to cultivate market value crops such as rice and maize respectively. Therefore, smallholders cultivating such crops rather invest in certified/hybrid seed because of the higher profitability associated with cultivating those crops. Participants during focus group discussion alluded to this in their remarks:

> As for the compound farms, we use our own seed which we have selected from our previous harvest to produce the food that the whole family depends on. For the other farms (*bwolo* and *kara*), the farmers who are better of usually buy the agric seed because of their large farms which they use to feed the family and also sell some when they need money [Kajolo, discussants, January, 2018].

This remark reaffirms the assertion that majority of low resource-endowed smallholder farmers predominantly in compound farmlands use their own seed to produce mainly to feed their household. Whereas, high resource-endowed smallholder farmers invest in market value crops which are largely grown on lowland and bush farmlands to feed the family and sell the surplus when necessary.

Another key feature of traditional farming practice in the area is animal/compost manure. The survey results presented in Table 5.1 show that 78 percent of respondents used animal/compost manure on their compound farmlands as compared to six percent in lowland and seven percent in bush farmlands. Discussants reported that compound farmland receives large proportion of animal manure or compost because of its proximity to the homestead and availability of organic materials. Discussants made these remarks during focus group discussion:

> The compound farms receive more manure because they are nearer so all the waste from the house and animal dropping from the *naboo* (kraal) are poured on compound farms. Some of us, especially those who are strong (referring to resources) are able to carry the manure to the bush farms and spread them before plowing. But when the bush farm is large, you cannot get plenty of the animal dropping for that farm [Punyoro, discussants, January, 2018].

The remark shows the type of farmland that receives the most of animal/compost manure. It suggests that compound farmlands receive more compost/animal manure because of nearness to homesteads while lowland and bush farmlands receive less because they are distant from homesteads. Farm size has also been raised as a factor to explain why lowland and bush farmlands receive less animal/compost manure.

Mixed cropping system is an important feature of traditional farming system which helps smallholder farmers to meet their household food diversity needs. The survey results (Table 5.1) show that 71 percent of respondents employed mixed cropping on their compound farmlands compared to seven percent on Lowland farms and 12 percent on bush farms. The high percentage of smallholder farmers adopting mixed cropping on compound farms is due to the fact that compound farms are the main farmlands of majority of smallholder farmers where they cultivate a wide range of food crops to feed their households. On the

contrary, mixed cropping is minimal on lowland and bush farmlands because such farms are mostly associated with the cultivation of market value crops such as rice, sorghum and maize under mono-cropping. Discussants shared this statement below:

> We usually plant several crops such as early millet, late millet, sorghum, groundnuts, Bambara beans, cowpea, maize, rice, and vegetables which we use for our soups. All these give us strength, energy and the blood we require for life [Mirigu, discussants, January, 2018].

This statement outlines the various food crops required for household consumption and points to the nutritional dimension for a healthy life. Usually, most households depend largely on own production for all their consumption needs. As a result, they engage in the cultivation of a wide range of crops to satisfy these consumption needs. Another view about mixed cropping systems highlighted during focus group discussion is the understanding that it enables smallholder farmers to adapt to drought and to cultivate certain traditional food crops which they use for other social events. Discussants made these assertions during the discussion:

> We have always planted early millet and late millet together for good reasons. The rains these days are unpredictable. It can rain for a good number of times to support plants growth. In other occasions, we will not experience any rains for a long period. So the planting of early millet and late millet is to ensure that we don't experience total crop failure in those events [Mirigu, discussants, January, 2018].

The cultivation of these food crops mentioned above is widespread among smallholder households in the area. They are mostly planted together on compound farms. These two crops are resilient to drought and provide some guarantee for households when drought occurs, hence their continuous cultivation among smallholder farmers.

Shifting cultivation was found to be limited in the study area. It was reported in communities that still have sufficient fallow lands available as a strategy to deal with poor soil fertility. The remark below was shared by discussants during focus group discussion:

> Some families have a lot of land both in *kaduga* and *kara*. As young men, we use the *kara* farm to cultivate maize. So when we notice that the yields are declining on that piece of plot, we move to other areas that can produce more food (look more fertile) to clear the stumps to cultivate maize. Nowadays, we don't leave the lands to rest (fallow) for a longtime like our grandfathers used to do because farmlands are no longer available like those days, so we return to them after a short while. Although it is often not yielding much we continue to farm on them because it is not easy to buy fertilizer [Gingabnia, discussants, January, 2018].

The remarks suggest that shifting cultivation is practiced in the Gingabnia community but at a very low scale and the period of uninterrupted cultivation is relatively short. That notwithstanding, a comparative analysis of the data from Gingabnia does not show any significant variations in technology adoption as compared to other communities with limited farmlands.

In spite of the positive aspects of traditional farming systems to smallholder crop production, discussants reported that some aspects appear ineffective in addressing emerging constraints that affect crop production. More specifically, they mentioned bush burning and the use of low yielding traditional sorghum and groundnuts varieties which they have since abandoned. Discussants explained that those traditional varieties have been abandoned because they are low yielding, long maturing and show stunted vegetative growth. Discussants had this to say:

> Our forefathers used to prepare their farmlands through burning and some of us have continued this practice till now. We now understand that, we need to leave everything on the farm to decompose to increase the fertility of our poor soils [Vunania, discussants, January, 2018].

Usually, farmers burn the left over straws on their farmlands as part of land preparation. The intension is often to get rid of possible pest and diseases on the farmland. However, in recent time, farmers have come to appreciate the need to desist from burning to allow those materials to decay to increase organic matter in the soil. Discussants intimated during the discussion that over relying on traditional farming systems in crop production will not enable them to meet increasing household obligations and other social commitments because more yields are required to be able to increase household incomes. Although discussants expressed concerns regarding the low yield potentials of some traditional food crop, they were also quick to admit that some traditional food crops are necessary for traditional meals and social events. They made this assertion:

> We need sorghum to prepare our *kwia* (i.e. malt) for *kassena - sana* (pito - local alcoholic drink) and also prepare mum-na (local beverage drink) for our household, visitors and for pouring of libation during traditional rituals. These make it difficult for us to completely abandon those practices [Vunania, discussants, January, 2018].

This statement suggests that traditional farming systems still have a role to play in smallholder crop production because certain norms and values make traditional farming systems resilient. Traditionally, *pito* (native drink) is central to social life for performing traditional rites and other social gatherings (Kansanga et al., 2019).

5.2.2 Constraint to Continuous use of Traditional Farming Systems

Discussants in focus group discussions outlined a number of constraints that make it difficult for them to continue to use traditional farming systems. The discussions showed that cow dung is an important source of manure to maintain soil fertility but its scarcity is posing constraints to its use in most communities. Discussants reported that livestock

numbers are dwindling thereby making it difficult to collect enough dung for manure. They remarked:

> It is true that cow dung enables us to get good yields. But you see, cow dung alone is not sufficient, it needs to be mixed with other things to decompose well before you can see good results and this takes a long time. Again large quantities are required to achieve meaningful yields but most households don't even have cattle in their *naboo* anymore so it becomes difficult to use animal manure nowadays. So if the money is there, you just go and buy fertilizer to avoid all these suffering [Saboro, discussants, January, 2018].

Cattle rearing is an important household activity that provides resources including dung to maintain soil fertility (Yaro, 2009). However, the numbers are dwindling largely because security for them has become a challenge. Children who used to take care of these cattle in open range are presumably in school because of widespread child education enrollment drive. Besides, most households are unable to provide the necessary security amidst increased incidence of cattle thefts in rural communities. As suggested in the statement above, preference for chemical fertilizers is increasing because of the constraints associated with compost preparation and application, especially when the farmlands are relatively large (Houssou et al., 2016).

Discussants during focus group discussions reported that they are unable to follow through the weeding regimes that their fathers taught them because of time constraints, even though they recognize the importance of each of those weeding regimes. According to them, the use of bullock, tractor and herbicides for land preparation and weed control has facilitated the discontinuous use of some of the weeding regimes. They noted:

> Our fathers taught us how to use hoes for farming. So depending on the type of crop you plant, you have to weed about three or four times using the hoe. These weeding are: *girigm* (first weeding), *parim* (second weeding), *tullem* (third weeding), and gharim (forth weeding). These practices are very

> important because they help to loosen the soils (*puona*) and increase aeration (*sieya*). But if you have three farms, it becomes difficult to follow these practices which will take several days to complete. But now, we don't have to follow all these stages if you plow with bullocks or tractor and if you have money to pump the chemical, you will not need to weed again [Saboro, discussants, January, 2018].

As suggested in the statement, smallholder farmers traditionally undertake four stages of weeding not only to control weed but also to loosen the soil and increase aeration to ensure plant growth and good yields. However, the introduction of mechanized farming and agrochemicals has introduced efficiency in land preparation and weed control (Kansanga et al., 2019). Introduction of herbicides for instance, has drastically reduced the use of hoe and cutlass for weed control (Kansanga et al., 2019). Multiple response survey results presented in Figure 5.1 show that 66 percent of respondents acknowledged that low yielding of traditional crops and scarcity of animal manure are the major constrains making it difficult for them to continue with traditional farming practices on their farms nowadays. Furthermore, more than half of the participants (55%) identified long maturing varieties of traditional crops as another important constrain that makes it difficult for them to continue to use traditional farming practice. Similarly, 19 percent of respondents alluded to the advent of efficient technologies such as tractors and herbicides as the reason for using traditional farming practice and technologies on their farmland compared to 16 percent of respondents who attributed it to time constraints associated with the use of traditional farming systems.

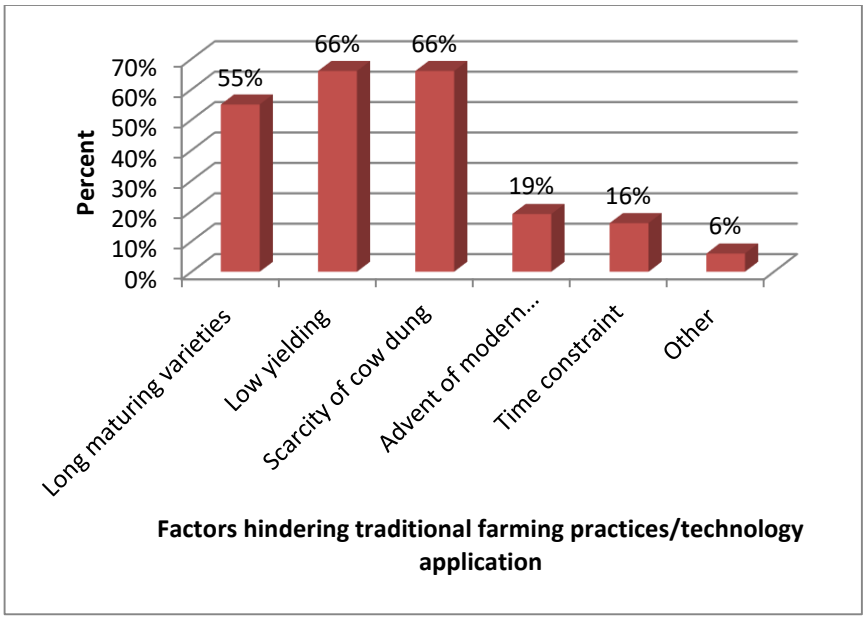

Figure 5. 1: Constraints inhibiting application of traditional farming systems

Source: Survey Data, 2018

5.2.3 Western Farming Practices and Technologies in the Study Area

Western agricultural knowledge systems are noted as indispensable systems to catalyze agricultural transformation in sub-Saharan Africa and Ghana in particular (Houssou et al., 2016). Western agricultural knowledge system is used in this study to refer to concepts, ideas, values, practices and technologies which are packaged as part of agricultural extension delivery by the state and NGOs and imparted in the minds of farmers. In pursuit of increased production and productivity to improve household food security and serve markets with surplus, agricultural activities under western farming systems usually include: mechanization, mono-cropping, application of inorganic fertilizer, use of agro-chemicals for insects or weeds control, use of hybrid and certified seeds (Houssou et al., 2016; Kansanga et al., 2019).

Focus group discussions revealed that extension agents over the years have promoted a number of western farming practices including the use of hybrid/certified seeds, chemical fertilizer application, row planting particularly for maize and soybean production, transplanting pre-germinated rice seeds using System of Rice Intensification (SRI) technology, where rice seeds are first nursed and later transplanted on a well prepared waterlog bonded field. The results presented in Table 5.2 show that respondents adopted all the farming practices outlined above except SRI technology.

A popular feature of western farming practice in the area is row planting. The introduction of new maize varieties required that farmers adhere to specific planting distance to achieve optimum yields. The results presented in Table 5.2 show that more than half of the respondents (51.24%) adopted row planting on compound farms, 28 percent on lowland farms and 16 percent on bush farmlands. The high adoption of row planting on compound farms is largely attributed to the large numbers of smallholder farmers cultivating on compound farms using bullock ploughing which create ridges and thereby facilitate planting in rows. However, adoption of row planting on compound farms does not suggests that farmers are adhering to recommended planting distance because dibbling sticks are often used to punch holes to aid planting. Largely, women also use hoe to facilitate sowing.

Table 5. 2: Western farming practices and types of farmlands

Western Farming Practice/Technology	Compound (*Kaduga*) Farms	%	Lowland (*Bwolo*) Farms	%	Bush (*Kara*) Farms	%
Row planting	62	51.24	34	28.10	19	15.70
Chemical fertilizer	15	12.40	61	50.41	30	24.79
Herbicides	15	12.40	36	29.75	20	16.53
inter-cropping	10	8.26	22	18.18	6	4.96
Certified/Hybrid seeds	8	6.61	16	13.22	12	9.92
Tractor plowing	7	5.79	30	24.79	28	23.14

Source: Survey Data, 2018

The use of chemical fertilizers is emerging as a useful soil nutrient enhancement technology among smallholder farmers. The survey (see Table 5.2) shows that 50 percent of respondents used chemical fertilizer largely on lowland rice fields, 25 percent on bush farmlands and 12 percent on compound farmlands. This finding suggests that smallholder farmers are investing more in chemical fertilizer on lowlands and bush farmlands compared to compound farmlands. This is because, lowland farmlands are relatively large and mainly use to cultivate rice and sorghum, both market value crops which provide incentive for smallholder farmers to invest in chemical fertilizers to increase crop yields for higher incomes (Mwangi & Kakuiku, 2015). Furthermore, bush farmlands are relatively large and mainly used to cultivate maize which depends heavily on chemical fertilizers for increased yields (Callo-Concha et al., 2012). Discussants during focus group discussion shared their views about chemical fertilizers:

> Fertilizer (i.e. *puupono*) is helping us in our farming so much. You just have to apply small quantity and your crops will look healthy and give you more food (yields). If we all had money to buy fertilizer, we won't experience poor yields at all. The previous year my son bought me *puupono* and so we got a lot of harvest. But this season, the crops didn't do very well because I could not apply [Punyoro, discussants, January, 2018].

The statement acknowledges the importance of chemical fertilizers in increasing crop yields but suggests that not everyone can afford to purchase chemical fertilizers. This implies that the cost of chemical fertilizer is an issue for widespread adoption. Consequently, many smallholder farmers use less than the recommended rates for many reasons including financial constraints and knowledge of their own soils (Kombiok., 2012). It does appear from the statement that without chemical fertilizer, good crop yields cannot be obtained.

The use of herbicides is also emerging as a regular agricultural input for land preparation and weed control (Houssou et al., 2016). Survey results (see Table 5.2) show that 30 percent of smallholder farmers use herbicides in *bwolo* as compared to 12 percent in *kaduga* and 17 percent in *Kara*. Focus group discussions revealed that herbicides are used for land preparation (non-selective) and weed control (selective). Discussants reported that herbicide has come to reduce labour time in farming activities. They shared their views on the use of herbicides:

> Most of the things we do on the farm is to ensure that the weed do not eat (referring to compete) our crops and cause us to harvest poor yields. So for our large farms, labour to control weed is costly so we pump the chemicals to kill the weed. When you pump, you see that the farm becomes neat and the crops grow well [Punyoro, discussants, January, 2018].

The statement shows that some smallholder farmers are using herbicides to control weed on farmlands that are relatively large in size. As pointed out in the statement above, selective herbicides are mostly used to control weed because the fields are relatively large and therefore more effective to use selective herbicides than manual labour which is scarce and expensive due to migration of the youth to southern Ghana and increased schooling resulting from enrolment drive by several initiatives in rural communities.

Furthermore, participants during focus groups reported that new crops and varieties of maize, soybean and rice have been introduced to them by extension officers. The survey results in Table 5.2 show that the use of hybrid/certified seed is generally low among smallholder farmers on compound farms (6.61 %), bush farms (9.92%) and lowland farms (13.22%). The survey suggests that more smallholder farmers adopt hybrid/certified seed on their lowland farms compared to other farmlands. This was confirmed by the remarks of an extension officer:

> As part of our mandate, we go to the communities to train them on improved technologies and agronomic practices that can help them increase yields. Using the right seed is critical, so we advise them to use certified seed or better still hybrid seed if they can afford. In some of these communities, we have established demonstration plots to facilitate dissemination of these technologies and the complementary agronomic practices to let them see the expected results for themselves to aid adoption. But many of them complain of the cost so adoption is low. However, few smallholders use maize and rice certified seeds [Navrongo, key informant, January, 2018].

The extension officer's account suggests that the use of certified seed is often promoted to increase crop yields and to some extent deal with rainfall variability because some of the varieties are draught tolerant and early maturing. The officer intimated that, in spite of rigorous efforts, adoption remains low largely because of the cost and uncertainty of the weather to guarantee good returns from investing in certified seeds. The extension officer further reported that, some farmers have had abysmally poor germination rate experience using "certified seed" and therefore prefer to select from their own grains.

Tractor ploughing is another feature of western farming practice used for land preparation in the area. Tractor plowing makes it possible to deal with hardened soils which are difficult to remove with the hoe and makes land preparation on large farmlands easier and faster (Kansanga et al., 2019). The results presented in Table 5.2 show that the use of tractor for

land preparation is more on lowland farmlands (24.79%), followed by bush farmlands (23.14%) and least on compound farmlands (5.79%). This pattern is due to the fact that compound farmlands are mostly small in size and fragmented and the soils are fragile thereby making tractor use inappropriate (Derbile, 2010). On the contrary, lowland and bush farmlands are relatively large and hard therefore makes the use of tractors suitable to deal with harden soils. Besides, mechanization service is mostly patronized by the relatively resource endowed who mostly cultivate on lowland and bush farmlands (Baiyegunhi & Hassan, 2018). Discussants during focus group discussions intimated that the use of tractors make farming easier for those who can afford. They shared their views on tractor use in the area:

> The use of tractor is beneficial if you have money. They are fast and enable you clear large farmlands within a short time. Something that would have taken you several days to be able do. These days, they even use them to shell maize done within few minutes and so farmers no longer spend days to prepare their lands of shell their maize [Mirigu, discussants, January, 2018].

It is emerging that tractor plowing and maize shelling are increasingly becoming standard farming practice in the area. It is perceived as effective in land preparation in reducing labour time and also breaking down hard soils (Kansanga et al., 2019). Due to its limited number in the area, there is often a rush for tractor service during the onset of the rains and cash payment for the service is a major constraint for some smallholders. Although tractor plowing is useful and beneficial to smallholder farmers, it is accounting for the disappearance of some traditional farming practices including ridging in maize farms and traditional weeding regimes (Kansanga et al., 2019).

5.2.4 Constraint to Continuous use of Western Farming Systems

In spite of the significant role that western farming systems play in reducing stress, labour time and increasing crop yields (Kansanga et al., 2019), respondents highlighted a number of constraints that hinder widespread application. Survey results presented in Figure 5.2 show that lack of finance is the major constraint restraining smallholder farmers from using western farming systems.

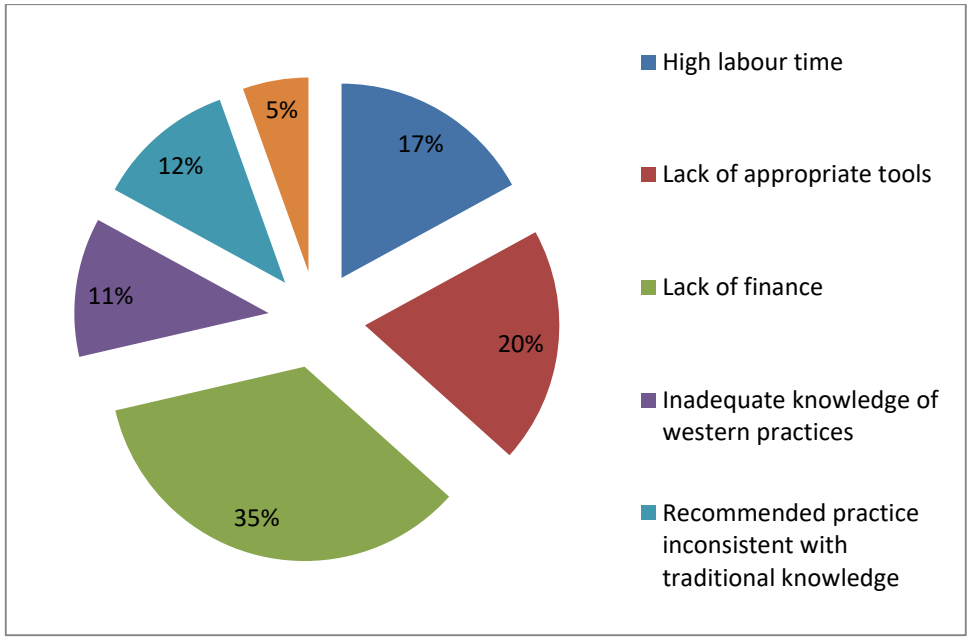

Figure 5. 2: Constraints facing application of western farming systems

Source: Survey Data, 2018

This finding corroborates results from focus group discussions where discussants were unanimous that poverty is the main reason for not being able to adopt western farming practices and technologies. Discussants shared their frustration in the following remarks:

> One of the reasons why we are not able to follow the advice of the agric officers is because some of us don't have the money to buy the fertilizers they want us to buy. They want us to buy their seed which is expensive. You need to buy medicine for the pumping and also pay the one pumping. So if

> you don't have money like those of us who are widows, you cannot do all these things [Saboro: discussants, January, 2018].

Generally, smallholder farmers are below the poverty line and therefore are often not able to raise the necessary capital to invest in agricultural technologies to increase production (Kombiok et al., 2012). Many of those affected by this situation are the widows who often do not have resource persons to support their farming endeavors (WFP, 2012). They perceive the cumulative costs of tractor service, fertilizer, hybrid/certified seed, and herbicides to be above their means. The few resource endowed smallholder farmers are able to use chemical fertilizer but not at recommended rates. As a result, adoption of many of the western farming systems remains low among smallholder farmers.

Another constraint hindering the use of western farming systems is lack of appropriate or complementary tools necessary to facilitate adoption. Figure 5.2 shows that lack of appropriate tools to facilitate adoption is the second most important constraint hindering smallholder farmers from using western farming systems. Participants during focus group discussions indicated that extension officers have taught them many western farming practices including plant spacing using ropes, compost preparation and application, and chemical fertilizer deep placement technology. According to them, lack of complementary tools to enable them implement these farming practices and technologies is a major constraint. These remarks were shared during focus group discussion:

> We like the agric orders (i.e. advice) but they are tedious and stressful. They came and showed us how to space planting using their machine (manual dibbler) and said that if we don't have money for the machine we can use ropes and be polling them around. But that is difficult to do and requires more people to support. So if you don't have people to help you that practice cannot be done [Vunania, discussants, January, 2018].

Other discussants remarked in similar lines but focused on chemical fertilizer application: They noted:

> They taught us to dig holes near the crops and then put the fertilizer there. They also taught us to dig and burry the stalks and other materials and water them regularly. After the training, many of us have not been able to follow these orders because they are tedious and time-consuming. If you follow them, you can't do any other farming work [Vunania, discussants, January, 2018].

Both remarks acknowledged that accurate plant spacing and deep fertilizer application technologies are useful but adoption is low because the relevant and appropriate tools to facilitate the process is lacking. Most smallholder farmers are unable to procure the appropriate tools because of lack of funds. As a result, they have to manually carry out such activities which they find tedious and stressful.

Furthermore, smallholder farmers assert that adoption of western farming systems is labour intensive hence difficult for them to use western farming systems. This assertion was a recurring theme during focus group discussions. Discussants intimated that some western farming technologies such as dig and burry method of fertilizer application and plant spacing are often labour intensive therefore wholesale adoption will mean that other equally important farming activities would have to be differed to be able to adhere to extension guidelines. Discussants' remarks below capture some of the constraints hindering the use of western farming practices and technologies:

> In fact, the agric officer's orders are good but are tedious and require a lot of labour time. Some of them waste so much time. They came to teach us how to sow. One person held to rope and another person held it to the other end of the farm while two people punched holes along the ropes and then others planted the maize. This practice is a waste of time because it takes much time and more people to plant a small farm. If you spent all the time

> doing this on *Kaduga* farm, how would you be able to work on the other farms? [Vunania: discussants, February, 2018].

This remark seeks to reiterate the point that optimal plant spacing to achieve optimum crop yields is a desirable outcome but the intensity of labour required to achieve this goal is the issue of concern to many smallholder farmers. This is because farmers have a number of farming activities to undertake within the relatively short farming season. Besides, farming may just be one out of a number of livelihood activities that smallholders engage in to obtain adequate food for their households. The fact that smallholder famers acknowledge that western farming technologies are good suggests that the 'waste of time' used in the remarks is in the context of effective deployment of labour but not in relations to possible outcomes of plant spacing.

The study has highlighted key features of traditional and western farming practices that smallholder farmers are using in the study area. Smallholder perceptions reveal that these two forms of farming practices and technologies have competitive advantages that can positively affect crop production. In the next section, I examine how different smallholder farmers are blending traditional and western farming systems to increase crop production.

5.3 Knowledge Integration among Different Smallholder Farmers

Some scholars content that both traditional and western knowledge systems embody rich notions, practices, knowledge, and competitive advantages that can be harnessed to achieve sustainable livelihood outcomes (Bohensky & Maru, 2011; Maweu, 2011; Briggs, 2013). Consequently, this section examines how different smallholder farmers are blending the two forms of knowledge systems to increase food crop production.

Evidence from the survey shows that smallholder farmers combine traditional and western farming practices on their multiple farmlands to improve crop production. Table 5.3 shows that 72 percent of respondents combined both traditional and western farming practices of which 42 percent are males and 30 percent are females. Of the 28 percent of respondents who did not blend both practices, 15 percent are males and 13 percent are females. These findings suggest that majority of smallholder farmers are blending traditional and western farming systems in the study area.

Table 5. 3: Differentiated smallholder farmers and knowledge integration

Knowledge Integration														
Different Smallholder Farmers	**Combined Farming Systems**						**Did not Combine Farming Systems**						**#**	**%**
	M	**%**	**F**	**%**	**#**	**%**	**M**	**%**	**F**	**%**	**#**	**%**		
High resource - endowed	15	57.7	8	30.8	23	88.4	1	3.8	2	7.7	3	11.5	26	21.3
Medium resource – endowed	20	47.6	13	31.0	33	78.6	5	12	4	9.5	9	21.4	42	34.4
Low resource – endowed	16	29.6	16	29.6	32	59.3	12	22.2	10	18.5	22	40.7	54	44.3
Total	51	41.8	37	30.3	88	72.1	18	14.8	16	13.1	34	27.9	122	100

Source: Survey *Data, 2018*

Generally, integration of the two forms of knowledge systems occurs in several areas of smallholder farming systems: land preparation, soil conservation, soil fertility maintenance, cultivation of different farmlands, cropping systems, and post-harvest management. In respect of how social differentiations of smallholder farmers are blending the two forms of knowledge systems, the survey results (Figure 5.3) show that majority (88.4%) of the high resource-endowed smallholder farmers blended farming systems compared to those who did not blend. Similarly, majority (78.6%) of the medium resource-

endowed blended farming systems compared to 59 percent of low resource-endowed. These findings suggest the obvious that majority of the high resource-endowed smallholder farmers are blending farming systems relative to few low resource-endowed smallholders. In the ensuing presentation, I examine how different smallholder farmers are integrating traditional and western farming systems on their different types of farmlands.

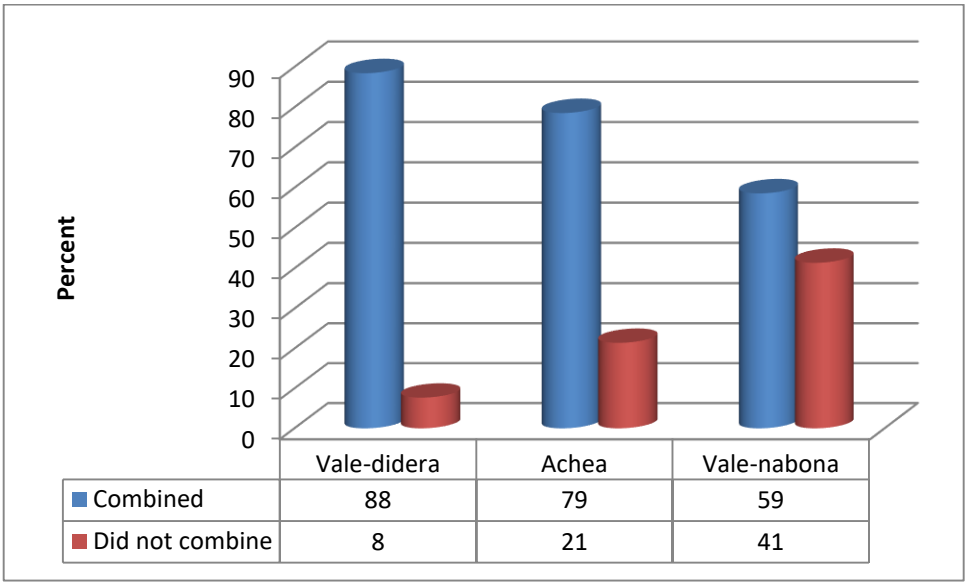

Figure 5. 3: Differentiated smallholder farmers and knowledge integration

Source: Survey Data, 2018

Analysis of the High resource-endowed smallholder farmers who combined farming systems reveals that 57 percent (13 out of 23) combined in lowland farmlands, 35 percent (8 out of 23) combined in *Kara* farmlands and 9 percent (2 out of 23) combined in compound farmlands. This pattern suggests high integration in lowland and bush farmlands and low integration in compound farmland. Below, I present a case of how high resource-endowed smallholder farmer blended farming practices and technologies on his multiple farmlands. This key informant was purposively selected to understand the issues that informed the choice of farmlands, blend of farming practices and technologies and the

effect on household food security. Selection was based on survey information suggesting that the informant blended both traditional and western farming technologies and practices and attained household food security. However, for the purpose of this section, the emphasis is on how the informant blended both traditional and western farming technologies and practices.

Box 5. 1: How Akanlise blended traditional and western farming practices on his multiple farms

Akanlise is a 69 year old retired educationist married with three children. He owns multiple farmlands in *kaduga* (less than 0.4ha), *bwolo* (0.4ha) and *kara* (1.2ha). He combined traditional and western farming practices on all his three farmlands as highlighted below.

On his *kaduga* farmland, he has fragmented it into two plots and plowed both with bullocks. On the first plot, he cultivated naara (early millet), zea (late millet), cowpea and Sorghum under mixed cropping. On his second plot, he planted maize in rows under mixed cropping with groundnuts. His wife planted leafy vegetables on the edges of the fragmented plots. *Akanlise* indicated that he used his own recycled seeds for all the crops grown in *kaduga* and controlled weed through *hand weeding with hoe* by weeding twice – that is, *girigm* (first weeding) and *parim* (second weeding). He applied minimal quantities of chemical fertilizer on his maize plot. This was his explanation: *"I didn't have enough money to buy fertilizer for all my farms. Therefore, I applied what I was able to buy on the farm that needs most of fertilizer. Apart from the maize which requires more fertilizer and more manure, the other crops of do well because the soil here receives manure during the dry season so it is able to support the food crops"*.

"My bwolo and Kara farmlands are where I often use more of the modern technologies and practices". On his *bwolo* farmland, *Akanlise* cultivated *Nerica* rice variety for household consumption and to sell to the market when he needs money. According to him, he plowed the land using a tractor and immediately planted using stick dibbler and then applied herbicide non-selective to ensure that weed are under control during germination. He explained that the muddy nature of the soil and size of his *bwolo* farmland necessitated the need to plow with tractor and apply herbicide to save time and lobour cost. *"If I am to weed this one acre rice farm with my small family, it will take us about four days or more while activities on other farms also need my attention." Akanlise* reported that he is aware that for one acre of rice, he is required to apply 2 bags (50kg) of NPK and possible one bag (25kg) of urea. But he is unable to afford these quantities therefore he buys what he can afford and apply on his field through broadcasting and hope that it would complement the existing soil nutrients to give him good yields. Harvesting of his rice field was largely done by his wife with support of other women

using hand sickles and threshed by beating the rice straws with sticks on stitched pieces of fertilizer sacks on the farm floor.

On his *Kara* farmland, he cultivated groundnuts on a small portion and maize under mono-cropping on his two acres farmland. His reason for cultivating these crops in the *Kara* farm is to have more harvest to feed his family and sell the surplus where necessary. On this farm, he plowed with a tractor and sowed his own seed selected from the previous year's harvest and used stick dibbler to punch holes to facilitate sowing. According to *Akanlise*, he earlier transported and deposited animal manure on his *Kara* farm towards the beginning of the rains and plowed when the rains begun. *"I know this is not adequate so I often buy one bag of NPK fertilizer to support the manure"*. Hand weeding with hoe is used to control weeds with labour support from his children and wife.

Source: Compiled from in-depth interview, *Vunania*, 2018.

The findings presented suggest that *Akanlise* blended more proportions of western farming systems on his lowland and bush farmlands relative to his compound farmland. On his compound farmland, *Akanlise* adopted row planting and minimal use of chemical fertilizer and adduced two main reasons to rationalize his decision. In the first place, he alluded to lack of funds to purchase adequate amount of chemical fertilizer to be able to apply the recommended rate on his farms. This has generally been the main constraint for most of the smallholder farmers who are unable to achieve optimal yields in crop production. Secondly, he points to the fact that compound farmlands often receive animal droppings and therefore able to support plant growth, except maize which requires more chemical fertilizer. This point seeks to confirm perceptions among smallholder farmers that the compound farm does not require expensive chemical fertilizers to meet acceptable levels of soil fertility to produce food crops for household consumption. Smallholder farmers during focus groups explained that, compound farmlands receive large amount of household waste and animal dropping from the pens and kraals in addition to waste materials from processing harvested crops such as beans pods and groundnut leaves, straws among others.

On his lowland and bush farmlands, Akanlise adopted high proportions of western farming technologies and practices including: chemical fertilizer application, row planting, use of hybrid seed, mono-cropping, non-selective herbicide, and tractor plowing. The traditional farming practices adopted include: use of stick dibbler, broadcasting of fertilizer, animal manure, hand weeding with hoe, mixed cropping, use of own seed, and hand sickles to harvest rice. He rationalized his decision for the choice of farming systems against the backdrop of seeking to maximize profit from production of market value crops. This appears to be the general trend of most smallholder farmers cultivating in lowland and bush farmlands, suggesting that market incentive is a key driver for blending high proportions of western farming systems relative to traditional farming systems. This is consistent with Houssou et al. (2016) who noted that market is a major factor for farmers to produce high-value crops and varieties to meet market demands.

In the case of the medium resource-endowed smallholder farmers, analysis of the survey shows that 15 percent (5 out of 33) blended farming systems on *kaduga* farmlands, 36 percent (12 out of 33) on *bwolo*, and 46 percent (15 out of 33) on *kara* farmlands. Elements of western farming technologies adopted include: tractor plowing, herbicides use, use of certified seed, mono-cropping, and chemical fertilizer application. On the other hand, traditional farming systems used include: using dibbling stick, own seed, mixed cropping, bullock plowing, and hand weeding with hoe. In the ensuing presentation, I provide a scenario of how some *achea* smallholder farmers combine traditional and western farming practices on their Compound and Lowland farmlands. The key informant was purposively selected to understand the rational underpinning her choice of farming practices.

Box 5. 2: How Kania blended traditional and western farming practices on her multiple farms

Kania is a 45 year old Lady married with 4 children without any formal education. She has farmlands in *kaduga* (less than 0.3ha) and *bwolo* (0.4ha) given to her by her father in-law to support her family. She made this remark: *"I don't farm at Kara (Bush farm), I farm my groundnuts here in kaduga and I don't farm maize because I'm not able to buy pupono (i.e. fertilizer). I rather farm rice in bwolo (Lowland farm) during the farming time and do garden during the dry season"*.

Her *kaduga* farmland is fragmented into two plots. On the first plot, she cultivates cowpea and sorghum under mixed cropping and on her second plot, she cultivates mainly groundnuts planted in rows. Both plots were sown with hoe using own seed under zero tillage system. She asserted that access to bullock service is limited in the community *"It is difficult to get bullocks to plow the field because the owners would have to plow for the family members so if wait for them you would be late in the planting and that would affect the harvest"*.

Vegetables such as Kenneth, rossell and okra were planted at the edges of the fragmented plots. According to *Kania*, they prefer to plant the vegetable at the homestead for easy access. She puts it this way: *"We plant out soups (i.e. vegetables) in kaduga because we use them very often so if they are on kaduga we can use them anytime we want. If you for instance plant okra in Kara then it would dry there because you can't go there always"*

She controlled weed by weeding twice – that is, *girigm* (first weeding) and *parim* (second weeding). *"We all farm this way, groundnuts do not want plenty weeding. You weed early so that the weed does not kill it and then you weed again just before it starts to flower to loosen the soil for the pods to form well and also present the stem from being eating by insects"*.

On her *bwolo* farmland, land tillage was by bullock traction to cultivate rice under mono-cropping during the rainy season. She leveled the field by flattening and making the basin surface horizontal and constructing bunds using hoe to conserve water. Seeding was by dibbling in rows with labour support from her children and other family members. She didn't apply fertilizer because of lack of funds. As a mechanism to scare birds, she places a model on sticks at strategic locations on the field. She used sickles to harvest the rice with labour support from other women.

Source: Compiled from in-depth interview, *Saboro*, 2018

These findings indicate that *Kania* adopted fewer proportions of western farming practices such as, row planting and mono-cropping compared to high proportions of traditional farming practices such as, the use of own seed, use of sickle to harvest rice, mixed-

cropping, bullock plowing, hand weeding with hoe, and sowing with hoe. Furthermore, *Kania's* remarks on weeding regime suggest that hand weeding with hoe remains a dominant feature in traditional farming systems and is deemed suitable for the cultivation of food crops such as legumes. This remark was resounded during focus groups suggesting that hand weeding with hoe neatly removes weeds and loosen the soils. However, it is obvious that hand weeding with hoe requires a lot of man-hours if practiced on large scale farmlands.

The study has shown that *vale-nabona* smallholder farmers are blending low proportions of western farming practices and technologies including row planting and minimal use of chemical fertilizer. It was noted that, using animal traction for land preparation facilitated row planting among smallholders. In the ensuing presentation, I examine how a 65 year old widow and a female head of household, purposively selected based on her status as female head of household to understand how she blended farming practices and the rational underpinning her decisions.

Box 5. 3: How Mma Talata blended traditional and western farming practices on her multiple farms

Mma Talaata is a 65 year old widow and a female head of household with six household members and no formal education. She has multiple farmlands in *kaduga* (less than 0.3ha) and about 0.2ha in *bwolo*. According to her, her *bwolo* farmland used to be large but she is unable to cultivate all because she is aging and doesn't have money to engage labour. As a result, she has given portions of the land out to other relatives.

Her *kaduga* farmland is fragmented into two plots based on a careful analysis of the soil properties. The first plot is used to cultivate food crops such as *naara, zea* and groundnuts under mixed cropping using her own seed. The land was prepared by gathering and burning the stalks and other materials on the farmland to pave way for direct seeding (zero tillage) with hoe by her two daughters. The second plot was plowed using bullock and used to cultivate maize and sorghum planted in rows under mixed cropping using her own seed. She planted Kenneth, rosselle, naari, and Okra at the edges

of the fragmented plots. According to *Mma Talaata***,** bullock traction was used to prepare the second plot because it creates ridges suitable for maize production and it is a fast means of preparing the land. He said: *"I could not use bullock on the other plot because I didn't have the 'strength'* (literary referring to money/cash) *at the time when I needed the plowing service".*

Mma Talaata applied animal dropping from her pen onto her maize plot with the understanding that maize requires more manure. She intimated: *"I usually collect cow dung from the kaduga farmlands as I walk around and goat dropping from my pen to spread on the maize farm. Even though it not always adequate but I use it like that because I can't afford their fertilizer"*

On her *bwolo* farm, she used bullock plowing to prepare the land. She said: *"my bwolo farm is on a low land area, not very muddy but loamy so the bullock was able to plow so well. I like the bullock plow because the plow does not go deep too much and it is able to create galleys which serve as bunds to hold water on the field"*

She explained that she plant her own seed using stick dibbler. *"Usually, I get support from my two children but only on weekends because they are both in school"*. She applied 5kilos (five bowls) of NKP to enhance soil fertility for higher yields. According to *Mma Talaata*, she sold two guinea fowls and used part of the money to buy the fertilizer. She understands that the fertility of the soil has declined overtime due to continue cropping but does not have the money apply the recommended rates therefore she buys the quantity she can afford. Just like other smallholder farmers, she harvests her rice using suckles and threshes on the farm floor by beating the rice straws with sticks.

Source: Compiled from in-depth interview, *Punyoro*, 2018

The statement above indicates that *Mma Talaata* adopted high proportions of traditional farming practices such as: own seed, bullock plowing, and mixed cropping compared to less proportions of western farming systems such as: limited chemical fertilizer use and row planting. These findings suggest that low resource-endowed smallholder farmers rely heavily on traditional farming practices which embody elements that can positively affect crop production if used effectively. For instance, animal manure or compost manure shows great promise in boosting crop yield and preserves the soils better for continuous cultivation. Similarly, multiple cropping has potential to utilize the soil more efficiently and helps to maintain soil fertility, minimizes the spread of pests and diseases, increases

soil cover, and above all reduces risk of crop failure (Wood, 2013). That notwithstanding, over reliance on traditional farming systems may have negative effective on crop yield (Alhassan, 2015). An important point emerging from *Mma Talaata*'s statement is the sale of poultry to purchase chemical fertilizer suggesting that livestock and poultry rearing by low resource-endowed smallholder farmers has potential to facilitate adoption of some components of western farming technologies to increase crop production.

Having established how different smallholder farmers are integrating the two forms of knowledge systems in crop production, I proceed to examine the challenges they face in integrating traditional and western farming systems with special focus on diffusion of innovations. To do this, I structure the challenges into institutional constraint, economic constraint, and socio-cultural constraints.

5.3.1 Institutional Constraints to Knowledge Integration

Agricultural extension plays a pivotal role in ensuring that farmers are supported and facilitated to address farming challenges through access to skills, information, and technologies to improve agricultural production and productivity for improved household food security (Zhou, 2010). In this light, the technical capacity of extension agents to drive diffusion of innovation and support farmers to achieve household food security is critical (Zhou, 2010). This study observed that agricultural extension approach and delivery by extension agents (i.e. government and NGOs) is largely focused on western scientific agricultural knowledge with little or no local content, even though these agents are 'locals' and are well aware of these local farming knowledge systems. In-depth interview with an extension officer in the study area revealed that traditional farming methods have not been part of their formal educational training at college. Rather, the knowledge was acquired

from their parents and also through interactions with farmers. The extension officer had this to say:

> Apart from farming systems like crop rotation, methods of compost preparation and others which I received from school, traditional farming systems as a whole were not part of my academic training because our curriculum is skewed and more western-oriented. So I learnt more of the traditional practices from my parents and interactions with farmers on the job [Navrongo, DoA, February, 2018].

The statement suggests that traditional farming systems have not received the necessary attention in academic training at higher institutions of learning. This implies that, the attitudes and interests of extension agents would largely be influenced by their training which indeed is western scientific oriented. The extension officer purported that the curricula and textbooks used at agricultural colleges and universities are biased toward western farming methods and market economics in line with the policy of modernizing agriculture which often does not take into account local needs, worldviews, cultural values, and concepts in extension delivery systems. As a result, the extension approaches are often far from participatory and agronomic concepts are often inappropriate and portray authoritarian attitudes.

Usually, governments and development partners seeking to transform agricultural production particularly in northern Ghana often target farmers who are largely into commercial or semi-commercial crops such as maize, rice, soybeans, and sorghum and deploy mainly western scientific agricultural technologies and practices through field demonstration, farmer field days, and inputs promotion events. Consequently, extension agents are unable to provide adequate support to build capacity of smallholders who largely cultivate traditional food crops such as early millet, late millet, groundnuts, cowpea, and

bambara beams, and also facilitate their access to appropriate innovations to improve their management practices in ways that lead to improved agricultural output.

Another important constraint to diffusion of innovation observed in the study area is reduced frequency and quality of interaction between extension agents and farmers. It is observed that farmer contact with extension staff is minimal due to high farmer-extension officer ratio. Information from the Department of Agriculture (DoA) in the study area (Kassena Nankana Municipal and West Districts) shows that there are four Agricultural Extension Officers (AEAs) each in the Kassena Nankana Municipal and Kassena Nankana West District. These AEAs are expected to provide extension services to about 19, 545 and 13,630 households engaged in agriculture in the Kassena Nankana Municipal and Kassena Nankana West District respectively. Using seven years projected population figures of the 2010 Population and Housing Census as base year (GSS, 2013), the extension agent to farmer ratio translates into 1: 4886 in the Kassena Nankana East Municipal and 1:3400 in Kassena Nankana West District as of March, 2018 as compared to the national extension agent-farmer ratio of 1:500 farmer[4]. This finding shows that staffing constraint is a major challenge facing extension service delivery in the study area and the country at large. This obviously has effects on extension outreach activities and the quality of interaction between extension agents and farmers to be able to provide technical knowledge and technological uptake support for smallholder farmers largely in rural areas. Besides staffing constraints, there are other factors which affect effective delivery of extension services. These are, inadequate funds, lack of transportation facilities, routine retirements without replacement

[4] Study report by Peasant Farmers Association of Ghana (PFAG) and SEND-Ghana reveals that AEA-farmer ratio stands at 1: 3000 (PFAG, 2012).

of personnel, and inadequate remuneration and motivation for staff. Consequently, many farmers are left out of reach of extension services and those few who have access to these services are superficially served. The consequences of poor extension service delivery to smallholder farmers have led to poor agronomic practices; post-harvest management challenges; inadequate use of inputs; abuse of pesticides; and inadequate access to auxiliary information that could help increase agricultural productivity in northern Ghana (PFAG, 2012).

Governments over the years have taken steps to address the challenges facing extension service delivery through the Youth in Agriculture Programme. It is not within the scope of this study to assess the performance of this initiative except to say that the initiative was confronted with a number of challenges which affected practical implementation. Critical among them is the fact that the youth were recruited as volunteers on monthly allowance that was inadequate to support their living expenses outside the regional capital where they were mostly posted. The few posted to the district level were constrained with accommodation and logistics challenges which affected their field operations.

Some extension officers suggested that, newly recruited extension officers would have to unlearn the “one size fit all” approach acquired from formal education to learn to work with farmers in a participatory manner to appreciate their aspirations, perspectives, needs, and take their social differentiations into account when developing extension strategies. They intimated that the top-down demonstration plot approach of extension services where demonstration protocol are predesigned by extension agents and handed down to farmers to adopt must change to a more flexible participatory joint-experimentation process between extension agents and farmers to strengthen local capacity to experiment and

innovate. According to them, this approach takes into consideration traditional farmer knowledge, local materials, farmers' ability to afford new innovations, and adaptation measures. Innovation platforms or networks at the community and district levels will heighten awareness of innovations, diffusion and learning among smallholder farmers.

Furthermore, they noted that diversity in extension service delivery will help to address the huge extension officer-farmer ratio. In this regard, the community-based extension volunteer approach was cited as an example and they claim it allows community members to nominate persons they deem suitable to be trained by MoFA extension agents to provide essential services appears to be very effective. What is required is an effective coordination mechanism by DoA to work together with NGOs to find new and more innovative ways to support these volunteers for sustainability to continually provide quality extension services that take into account the needs of differentiated smallholder farmers.

5.3.2 Economic Constraint to Knowledge Integration

Some of the challenges associated with knowledge integration which affects diffusion of innovation are largely economic. In section 5.2.3 of the study, lack of funds emerged strongly as a major reason for low integration among smallholder farmers. This assertion was made against the backdrop of the fact that western farming technologies and practices being promoted by extension agents have financial implications. For example, a farmer requires 7 kg Obatampa maize seeds at GHC 35.00 per 0.4 ha and is expected to purchase two NPK and one Sulphate chemical fertilizers at GHC 136.00 and GHC 63.00 respectively to achieve optimum yields. These costs bring a huge financial burden on smallholder farmers who mostly are in the two poorest wealth quintiles (WFP, 2012).

Besides, the appropriate complementary tools to facilitate effective adoption of the technology are relatively expensive. Usually, farmers are trained on improved methods of compost preparation to enhance the quality of compost for crop production. Discussants reported that the bulkiness of compost requires the need for a wheelbarrow or donkey cart to transport manure to distant farms such as *kara* farmlands. Similarly, they indicated that weedicide application requires an additional cost of hiring spraying service or purchasing a knapsack to ensure effective utilization. According to discussants, these costs make it difficult for smallholder farmers who contemplate to blend western farming technologies with traditional farming methods.

According to discussants during focus group discussion, there are several reasons why smallholder farmers are unable to raise sufficient funds to invest in agricultural technology. They had this to say:

> We are poor and don't have anyone to give us money to buy the chemicals. We can't go to the bank and no relative has enough to give to the other. Furthermore, there are no livestock to sell. The money to buy food when we ran short of food is no even there let alone to spend on chemicals [Saboro, discussants, January, 2018].

The remarks suggest that the people in the study area are generally poor and have limited numbers of small ruminants as their resource base and do not have any source of remittances. Also, they have limited access to credit or may be facing temporary cash flow challenges. They reported that the financial situations of smallholders are further compounded during the lean season when they have virtually ran out of food stock and have no money to meet their food needs. Consequently, any attempt by extension agents to promote the adoption of innovations among smallholder farmers will not yield any positive results because they lack the necessary funds to place effective demand. It is observed that,

despite the efforts of extension officers, the rate of adoption remains relatively low and far below expectation. Smallholder farmers openly recognize and accept the yield potential of applying western farming technologies and acknowledge the fact that western farming technologies are effective and efficient but the crux of the matter is that they are financially constrained to adopt such practices and technologies.

5.3.3 Socio-cultural Constraints to Knowledge Integration

The rate of diffusion of innovation within a socio-cultural system largely depends upon the nature of the cultural values and norms underlying the social system (Agarwal, 1983; Rogers, 1983). Numerous studies have demonstrated how innovations have failed to diffuse because of lack of compatibility with the existing norms or values of the socio-cultural system (Rogers, 1983). Focus group discussions revealed that funeral activities often hinder time available to smallholder farmers to adopt western farming practices such as planting according to recommended distance per crop variety and chemical fertilizer application using deep placement method. The following remarks were captured during the discussions:

> Our life in the community is surrounded with other activities that are also important like the food we are looking for. If death occurs in a house, everyone in the community would have to go and mourn with the bereaved family and support with burial activities. At that point, you can't go to farm. By the time you return to the farm, you would have lost some days so there is no time to follow what the agric officers are saying [Punyoro, discussants, January, 2018].

This remark shows that regular attendance to funeral activities within and outside the community may hinder the time available to blend certain western farming practices with traditional farming practices. This is because ample time is required to ensure effective application of some western farming practices and technologies. As a result of time

constraint occasioned by the desire to observe certain cultural practices in a collectivist society where strong ties exist, most farmers are unable to adopt western farming practices and resort to traditional farming methods. This point was further reiterated by discussants in the *Gingabnia* community to show how regular attendance to markets also hinders time necessary for agricultural technology adoption. Discussants shared this remarks:

> …… if you like to go to market regularly, you would not have time to apply the advice of the agric officers because almost every three days is a market-day. So if the agric officer wants to come and train us on a market day, he would not find anybody because most people will go to the market [Gingabnia: discussants, January, 2018].

This suggests that market-days are important social and economic events in the lives of rural people. However, regular attendance to markets serves as a major hindrance to time available for farmers to adopt western farming practices and technologies.

It is worth noting that taste of food is an important consideration for most households in the area to continue to cultivate traditional crop varieties. Participants in focus group discussion indicated that the taste of traditional varieties is superior to that of the hybrids. Discussants shared their views:

> When you use the agric food crop varieties to prepare food, the taste is often different from the traditional one, and you can't eat it the following day because it will spoil. But our food crops are good and they taste better and can be eaten the next day without any problem. Since we don't enjoy the taste of some of the new crop varieties, we believe that our ancestors would not like them as well, so we don't use them to prepare meals for sacrifice [Gingabnia: discussants, January, 2018].

This remark shows that taste is an important consideration in the choice of food crop to cultivate for household consumption in the area. Furthermore, the remarks indicate that food prepared from hybrid varieties often do not stay wholesome up to the next day. Leftover foods are often used as breakfast for the household. It does suggest that crop

varieties that do not have longer 'shelf life' may not be utilized by many smallholder households. Furthermore, the perception that food prepared from hybrids may not be accepted by their ancestors could also serve as a disincentive for smallholder farmers to adopt certain farming practices and technologies. These have implications on the type of food crops that farmers will willingly cultivate (Kansanga et al., 2019).

Besides the role of social norms and their effects on innovation diffusion and adoption decisions, individual value such as fatalism also has enormous potential impact on innovation adoption to a large extent. Fatalism in the context of this study refers to the extent to which an individual believes that happenings around him/her are predetermined by God rather than based on his/her own actions. People who belief in fatalism have the tendency to adopt passive attitude towards the future and accept circumstances around their life. In response to how social and cultural factors influence blending of farming practices in the community, discussants expressed their worldview as provided:

> In this world, every one of us came to the world with certain grace on the head for a purpose. Some came with the grace to be rich while others came with the grace to be poor. That explains why some people use hand weeding with hoe while others use bullock and better still others engage tractor plowing. So eventually, all these different people will definitely not harvest the same. As you are aware, it is said that all the fingers are not the same, some are short and others are tall. So it is only God who knows why he has created us to be different in what we have [Gingabnia: discussants, January, 2018].

What this means is that there is the tendency for people to accept their circumstance as given and virtually do nothing to change their situation especially when they begin to draw in the supreme God as all knowing who created everything perfectly for a purpose. This passive attitude is often based on the understanding that it will be pointless for a man to circumvent what God has designed and purposed in one's life, because no matter your path

of action, the outcome will be the same, since the results of one's action are predetermined before birth.

The study has shown that smallholder farmers are indeed aware of the existence of both traditional and western farming practices and technologies and some are using both knowledge systems in their farming endeavours. It is envisaged that blending the two bodies of agricultural knowledge systems will affect their food security outcomes (Maweu, 2011).

5.4 Household Food Security Situation

This section examines how knowledge integration affects household food security situation of differentiated smallholder farmers. To this end, I structure the presentation of findings in two parts. The first part presents findings on the various food sources pursued by smallholder households. In the second part, I present findings on how knowledge integration affects household food security situation of differentiated smallholder farmers.

5.4.1 Food Sources for Smallholder Households in the Study Area

Rural households depend on diverse food sources for their livelihood. Some studies have identified food sources for most part of northern Ghana, especially in the Upper East Region to include, cash purchases, own farm production, fishing/hunting/gathering, credit purchases/borrowing, and gifts (WFP, 2012; Alhassan, 2015). In addition to these food sources, this study identified others through focus groups including food supplies from relatives, community members, friends, government, and NGOs. Some of the sources are assumed to offer better and sustainable chances of success than others. Focus group discussions revealed that own food production and cash purchases are the most important

food sources for majority of smallholder households. Only a small proportion of households in the study area rely on borrowing/credit for their food source. Details of household food sources are presented in Figure 5.4.

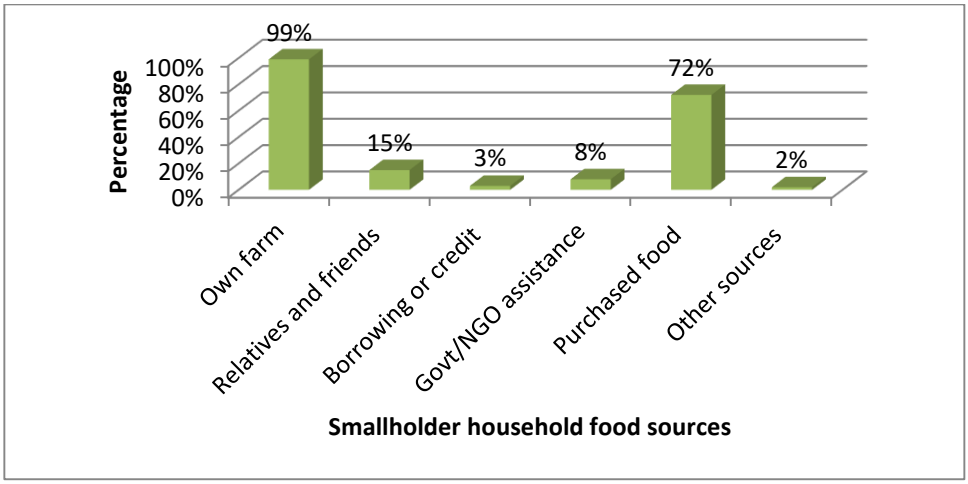

Figure 5. 4: Household food sources in the KNTA

Source: Survey Data, 2018

With regards to own farm production, Figure 5.4 shows that 99 percent of respondents ranked it as the major source of food for their households. This is because, majority of households depend on their own farm where they cultivate a wide range of food crops for household consumption. Although smallholder households engage in other livelihood activities such as livestock and poultry rearing and non-farm economic activities to meet household consumption needs, food crop farming remains the major livelihood for majority of smallholder households. Discussants during focus group discussion made this point clear with this remarks:

> We are all farmers and that is what our grandfathers taught us. If you don't farm, then you'll not eat because that is what the whole family depends on. If you even rear livestock and chicken, they will only help you to find food but you can't depend on them for your daily meals. Like the way the women

> are trading and doing other things to help feed the families. But farming is what we do to provide the food we need [Kajolo: discussants, January, 2018].

This remark indicates that crop farming is the primary source of food which has been handed down to them by their grandparents. The remark further suggests that other food sources such as livestock and poultry rearing and non-farm livelihoods also play key roles in helping households to meet their consumption needs. Even though smallholder households have diversified their food sources, own farm production remains the primary source of food for household consumption.

However, there are periods when households no longer have their own produced food stocks for consumption and therefore have to resort to buying grains from the market to support their consumption. Figure 5.4 shows that 72 percent of respondents ranked market purchases as a major food source for their households. This means that market is a major component in the food security chain suggesting that households who fail to obtain the required food stock to last the whole season can meet the shortfall through the market. This is true for households who can afford. This was highlighted during focus group discussion:

> If your house no more has food, then you have to buy from the market because the market has all the food stuff we need, if only you have money. If you don't have the money, what can you do? You have to sell your fowls or livestock for the women to enter the market and bring food for the family [Vunania: discussants, January, 2018].

This remark reaffirms the role of market in meeting shortfalls in own produced food stocks. It assumes that households should be able to sell poultry or livestock to purchase food from the market to meet consumption needs. However, this assumption is only true for households who have the resources to purchase from the market. Otherwise, the affected

household would have to resort to other sources including credit purchase or borrowing from relatives or better still rely on relief support from NGOs/government.

It is apparent from the findings presented in Figure 5.4 that only a small proportion (3%) of respondents rely on borrowing for their food source. This may be as a result of the stigma associated with pursuing such food source. Discussants shared this remark:

> Borrowing or depending on relatives and friends to feed your family will be an embarrassment and an insult which may be used against any member of your family in the future. You as head of the family would be seen as lazy and good for nothing man. You will lose respect before your own wife and among your peers. In fact, you [head of household] will not be able to raise your head in social gatherings [Kajolo: discussants, January, 2018].

This indicates that borrowing is not an attractive food source for people to pursue because it leads to loss in self-esteem and respect from within the household and the community at large. Obviously, critical loss of face is something that most head of households may want to avoid. There is usually a strong undercurrent for men to be seen as hard working and responsible, often demonstrated by ensuring that the household is food secure. As a result, many household heads, particularly males, will want to avoid being referred to as *"nonkayaa"*- literary referred to as "a useless person" in the local language.

However, some female discussants shared divergent opinion regarding the circumstance that may compel someone to resort to borrowing or sourcing food from a relative or friend. According them, household food shortage involving children often presents little choice than to do the obvious - that is, seek assistance from relatives or friends. They had this to say:

> Sometimes you look at the way the children walk around the compound showing signs of hunger and crying all around. As a mother, you will have to do something if it means borrowing or begging to ensure that you enter

> the kitchen to prepare something for them. Although it is embarrassing, but you have no choice [Kajolo, discussants, January, 2018].

This indicates how some mothers would stop at nothing to obtain food for their children. In rural communities, children are often with their mothers. As a result, they are the once who feel it most when children begin to express hunger situations. This also suggests that household exigencies need to be taken into consideration in deciding on the choice of food source to pursue for household consumption. Given that own farm production and purchases from the market are the two major sources of food for smallholder households in the study area, I proceed to examine household food security situation of different smallholder farmers who blend traditional and western farming practices and technologies in the next section.

5.4.2 Household Food Security Situation of Differentiated Smallholder Farmers

The Month of Adequate Household Food Provisioning (MAHFP) is an indicator that captures household's ability to ensure that food is available above a minimum level, all year round (Bilinsky & Swindale, 2010). Drawing on this indicator, participants were asked whether they experienced food shortages during the preceding harvest season, and subsequently asked to indicate the number of months they had experienced food shortages during the year.

The survey results presented in Figure 5.5 show that 72 percent of respondents experienced shortage of staple food compared to 28 percent who did not experience food shortage.

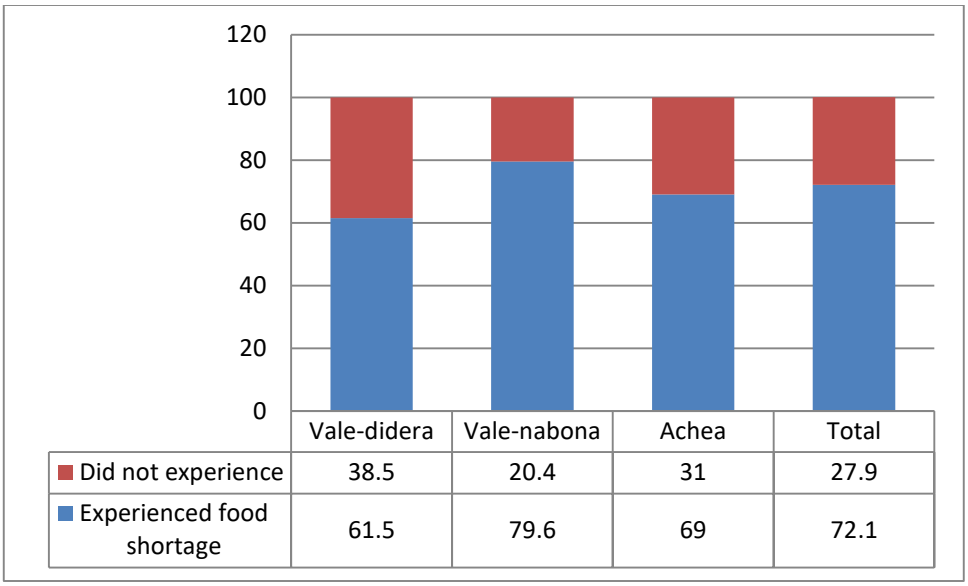

Figure 5. 5: Household food security situation of differentiated smallholder farmer

Source: Survey Data, 2018

This shows that majority of smallholder households experienced food insecurity in the study area. According to discussants in focus group discussion, some households who experienced food shortages went to sleep at night hungry because there was not enough food to eat. They had this to say:

> When the hunger period arrives, most families are not able to eat the kind of food they like. You don't see women putting on fire in the evening signaling that there is nothing to cook. Because of that some families often go to sleep sometimes without food [Vunania, discussants, January, 2018].

It shows that some households often experience food shortages and have to sleep without food. Focus group discussions revealed several reasons for the food shortages. The recurring theme were, decline in own farm production due to draught and rainfall variability, decline in own farm production due to the use of traditional crop varieties, large household size, poor planning and management of harvested food crop, and sale of farm produce to meet funeral and educational expenses.

In terms of food shortage distribution among different smallholder farmers, survey results presented in Figure 5.5 show that 62 percent of high resource-endowed households (16 out of 26) experienced shortages of staple food compared to 39 percent (10 out of 26) who did not experience any food shortages. With regards to Low resource-endowed households, the survey results show that 80 percent (43 out of 54) experienced food shortages compared to 20 percent (11 out of 54) who did not experience any food shortages. On the part of the medium resource-endowed households, the results show that 69 percent (29 out of 42) experienced food shortages while 31 percent (13 out of 42) did not experience any food shortages. Comparative analysis of food shortages among the differentiated smallholder farmers shows that more low resource-endowed (49%) smallholder farmers experienced food shortages followed by medium resource-endowed (33%) smallholders and high resource-endowed smallholders (18%) were the least to experience food shortages. This pattern suggests the obvious that resource endowment plays a critical role in household food security outcomes.

Subsequently, respondents who experienced shortages were asked to indicate the months within which their households experienced food shortages during the year. As illustrated in Figure 5.6, shortage of staple food in households largely begins from February through to August with peaks in May and June where all the respondent reported that they experienced food shortage the most. Majority (97%) of respondents indicated that they begin to experience decline in food shortages from July and August when they start to harvest early millets.

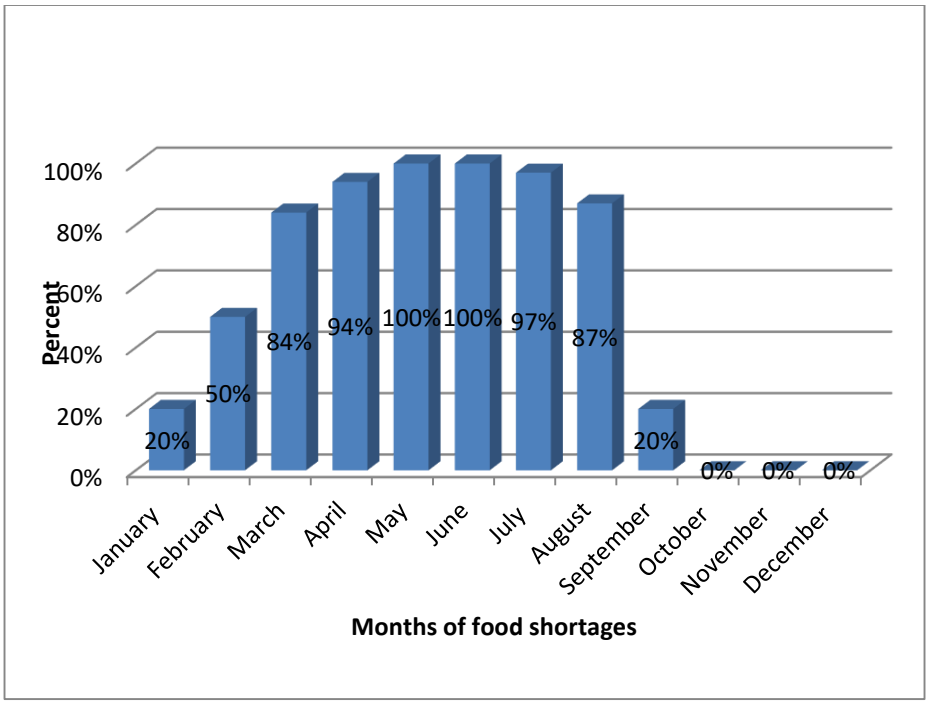

Figure 5. 6: Months of household food shortage

Source: Survey Data, 2018

The survey findings revealed that high resource-endowed households experienced food shortage periods spanning between three and four months, the low resource-endowed between three and seven months, while the medium resource-endowed spanned between three and five months. Having established household food security situation of differentiated smallholder farmers, I now proceed to examine whether integration of traditional and western farming systems has had any influence on household food security situations of the different smallholder farmers. To this end, I structure the discussion around each smallholder category to understand how knowledge integration has affected their household food security situations.

Knowledge integration and high resource-endowed household food security situation

The findings presented in Figure 5.7 show that 89 percent (23 out of 26) combined both traditional and western farming systems compared to 12 percent (3 out of 26) who did not combine. The study has also shown that majority of the high resource-endowed smallholder farmers blended high proportions of western farming systems relative to traditional farming systems on their lowland and bush farmlands and the patterns of use are stimulated by market incentives. Analysis of the results shows that of the 89 percent of high resource-endowed smallholder farmers who blended traditional and western farming systems, 44 percent (10 out of 23) did not experience any food shortages compared to 57 percent (13 out of 23) who experienced food shortages spanning for three months. The finding is rather counter-intuitive suggesting that more *Vale-didera* (high resource-endowed) smallholder farmers who blended traditional and western farming systems experienced food shortage.

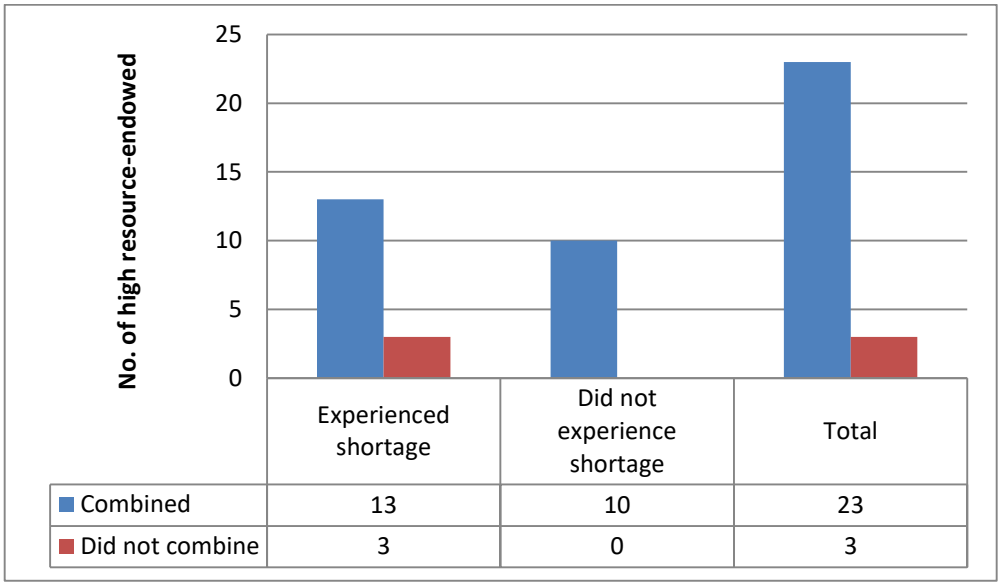

Figure 5. 7: Knowledge integration and vale-didera household food security outcome

Source: Survey Data, 2018

Therefore, to understand what might have accounted for the food shortage experience of the high resource-endowed smallholder farmers who blended the two forms of agricultural knowledge systems, I set out to investigate the issues and intervening factors that come into play to explain why some high resource-endowed experienced food shortages while others did not. To do this, I examined two high resource-endowed smallholder farmers who blended traditional and western farming practices but experienced different household food security situations. In the first scenario, I provide an overview of how a retired educationist combined traditional and western farming practices on his lowland and bush farmlands and how it influenced his household food security situation throughout the year.

Box 5. 4: How Akanlise blended farming practices and his household food security situation

In box 5.1, I examined how *Akanlise* combined farming practices on his *bwolo* and *kara* farmlands. The results showed that, *Akanlise* harvested 16 bags of rice from his *bwolo* farm and 4 bags of groundnuts and 8 bags of maize from his *Kara* farms.

According to Akanlise, his decision to blend farming practices has helped him to increase crop yields. He said: *"the use of tractor, chemical fertilizer and hybrid rice seeds combined with the traditional hand weeding with hoe enabled me to harvest more rice although I did not apply the recommended rates of fertilizer. On my Kara farm for instance, even though I did not apply the recommended rates, combining it with manure gave me high yields, which should be enough to feed the family for the whole year".* Akanlise indicated that, he did not experience any food shortages during the 2017 farming season. He said: *"after harvesting my produce from the bwolo and kara farms, I am not always in the hurry to sell because I am not under any pressure. Two of my children are teachers in Bolga and the last born is in the Polytechnic in Tamale. Also,* my *wife sells food at the Basic school here so she is always supportive of the housekeeping needs"*

Akanlise had this to say when he was asked why some *vale-didera* smallholder farmers experience food shortages: *"there are several factors involved. In the first place the weather plays a critical role. One can apply all the necessary farming technologies but when there is a drought for a certain period beyond measure, yields would be poor and therefore the vale-didera may not be able to harvest enough to feed the family. Secondly, some vale-didera have large numbers of family members and therefore may harvest more but because of the many mouths to be fed, his household would experience food shortages in the course of the year. Also, if the vale-didera has any funeral to perform*

and does not have livestock to sell to buy food stuff and other things for the funeral. It means that he would have to rely on the harvested food crops to perform the funeral. In that case, the family may run short of food before the next harvest."

Source: Compiled from in-depth interview, *Vunania,* 2018

This response shows how Akanlise blended traditional and western farming systems on his multiple farmlands and obtained adequate food for household consumption without experiencing any food shortages all year round. The response suggests that he used high proportions of western farming systems including hybrid rice variety, tractor plowing, herbicides, and chemical fertilizer on relatively large farms on lowland and bush farmlands. Although, *Akanlise's* household did not experience food shortage, his response reveals a number of reasons why some high resource-endowed smallholder farmers may experience food shortages in spite of blending farming practices and technologies. Key among them are, decline in own production, large household size, and depletion of own produced food stock due to household expenditures. The findings suggest that obtaining good crop yield from own production is critical to ensure adequate food stock available to households all year round. Besides, his response highlights household's management of harvest from own production as vital to attaining food security.

In the second scenario, I draw on the account of why a widow and female head of household combined traditional and western farming systems on her multiple farmlands and yet experienced food shortages during the course of the year.

Box 5. 5: Why Apoab blended farming practices and yet experienced food shortages

Apoab is a 55 year old widow and a female head of household of six children. She owns multiple farmlands in *kaduga* (less than 0.4ha), *bwolo* (0.8ha) and *kara* (0.8ha).

Apoab intimated that she was able to plough her rice field and control weeds at the right time to improve crop yields. She was quick to say: "*This season my harvest was good just like the previous year, so I was able to support my two daughters to go to school. One is in the Community Health School and the other is in the Senior High School here".*

According to her, though the yields for the season were very good, she experienced shortage of staple foods for about three months before the early millet was harvested. She reported that, even though she ran out of food, her household members did not sleep with hunger. She had to sell two goats and some guinea fowls to buy food stuff from the market. When asked why she got good harvest and yet experienced food shortages for the period of three months. Apoab had this to say: *"Hmmm, it is not always easy for widows who still have children to cater for rather than the children caring for them. Apart from my two daughters who are in school and their senior brother in Kumasi, the remaining three boys are not working so have become dependent on me for their daily food. So if your family is large, you may run short of food. Again, if you have more commitments and expenses to make due to illness or educational expenses, you have to fall on the food harvested if you don't have anything to sell. Also, some people may decide to always fetch some quantity of grains every market day to sell to get money to do other things or drink pito. Because you don't see the bottom of the silo, you would eventually come to notice that your grains are almost finished which would create food shortage for the family".*

Source: Compiled from in-depth interview, *Saboro*, 2018

Her response explains why she got good harvest from her multiple farms and yet experienced food shortages for three months. She intimated that her large household size and expenses incurred on school fees depleted her own food stock resulted in her food shortage experience for three months. Household size has a significant bearing on household food security, as it assumes that food shortages result from having more people to feed (Lavison, 2013). The case of this female head of household reflects the experiences of many smallholder households in the study area who have relatively large families. The findings therefore suggest that households who are unable to manage their harvest from own production are more likely to experience household food shortage at some point before the onset of the early millet which is often used to halt hunger.

Knowledge integration and low resource-endowed household food security situation

The findings presented in Figure 5.8 show that of the 32 low resource-endowed smallholder farmers who combined farming practices, 69 percent experienced food shortages spanning for six months (i.e. March to August) compared to 25 percent who did not experience any food shortage. Analysis of results on low resource-endowed smallholder farmers who did not combine farming practices revealed that 95 percent (21 out of 22) experienced food shortages as compared to five percent (1 out of 22) who did not experience food shortages. This finding suggests that low resource-endowed smallholder farmers who did not blend farming practices are more likely to experience food shortages compared to those who blend farming practices.

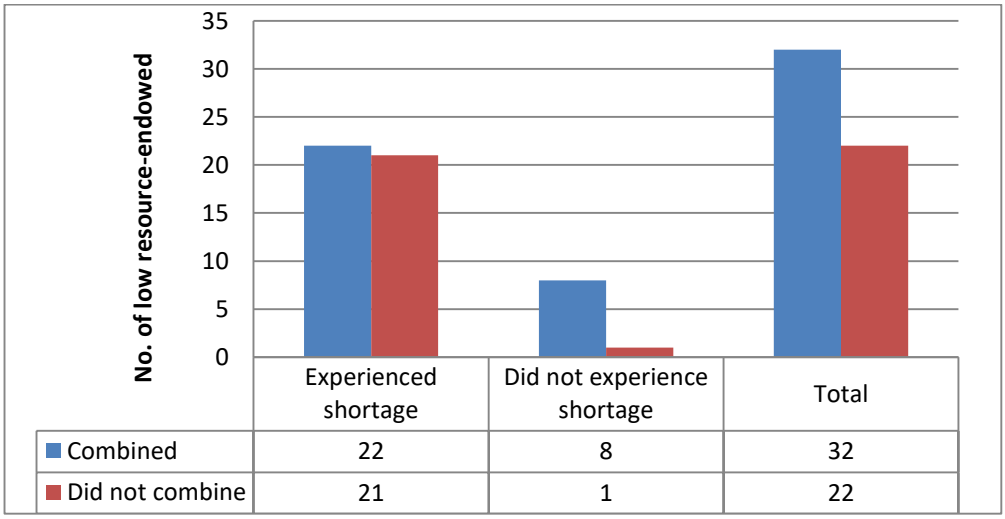

Figure 5. 8: Knowledge integration and vale-nabona household food security outcome

Source: Survey Data, 2018

However, the fact that some low resource-endowed smallholder farmers who blended traditional and western farming systems experienced food shortages while others did not, suggests that there are knowledge integration issues and intervening factors that come into

play. In the ensuing section, I explore further to understand the issues with knowledge integration and the factors influencing household food security situations of low resource-endowed smallholder farmers in the study area. To this end, I examined two low resource-endowed smallholder farmers who integrated traditional and western farming practices on their multiple farmlands and how that influenced their food security situations. In the first case, I examined how a 65 year old widow and a female head of household with six children and no formal education blended traditional and western farming practices on her *kaduga* and *bwolo* farmlands to increase crop production to improve household food security.

Box 5. 6: How Mma Talaata blended farming practices and yet experienced food shortages

Drawing from box 5.3, Mma Talaata – a 65 year old widow and a female head of household with 6 children cultivated a wide range of food crop on her *kaduga* farmland (about 0.3ha) and solely rice on her *bwolo* farmland (0.4ha).

She said: "*I don't have the strength (referring to money) to buy enough fertilizer to increase my yields. The agric officers tell us that we should bury the fertilizer but I'm not able to do that because it is tedious. Our fathers used animal manure but these days, most of the kraals are empty so it is not easy to collect cow dung. We know that the soils are no longer able to produce enough yields but there is little we can do. We are not able to adopt the white man's farming practices because they are expensive and we are also not able to follow our father's practices because of scarcity".*

When asked why some low resource-endowed smallholder farmers blend farming practices and yet experience food shortages, *Mma Talaata* had this to say: *"In my case for instance, I did not get enough food that we could feed on till the early millet is harvested so we experienced hunger. Our farms are not the same in this community, some have big and others have smaller. So you don't expect them to harvest the same. Even with that, it depends on how hard working each person is. If you decide to leave your farm to be taken over by the bush then you should not expect anything good from that farm. Also, some farmers don't depend on the farming alone. They earn income from whatever work or trade that they are involved in. Others also have livestock and chicken which they can easily fall on to buy food".* She reported that, her food shortage experience spanned up to 6 months and explained that there were occasions where she had to sleep at night without food. She intimated that her farm size is small to support her rather large family. She explained: *"my children are many and as a widow without much support, the small farm is not enough to cater for us".*

Source: Compiled from in-depth interview, *Punyoro,* 2018

The response from *Mma Talaata* shows how she blended high proportions of traditional farming practices relative to limited western farming practices including row planting and chemical fertilizer - less than recommended rates – resulting in food shortage experience for six months. Her response shows that she did not obtain good yields obviously because of limited use of soil nutrient management practices and other management practices such as weed management and cropping strategies that are vitally important to overall soil fertility. As a result, her food crop harvest for the season could not sustain her household food consumption up to the onset of the early millet. Furthermore, she intimated that her small farm also could not produce sufficient grains to meet her household consumption needs, suggesting that farm size has a role to play in household food shortages. With small farm size, smallholder households are unable to produce enough to last throughout the year. To this end, the commonly applied proposition that food security is a function of access to the primary factor of production seems to hold true. From her response, the role of non-farm and livestock rearing emerged as vital livelihood activities to mitigate household food shortages. The findings suggest that households who are unable to obtain adequate food from their own production are more likely to experience food shortages. However, the period of hunger may vary depending on household's resource endowments.

In the second scenario, I draw inspirations from *Ayeriwuje's* account to examine how low resource-endowed smallholder farmers blend farming practices on their multiple farmlands and their effect on household food security situation.

Box 5. 7: Why Ayeriwuje blended farming practices and did not experience food shortage

Ayeriwuje is a 47 year old male head of household married with 3 children. He has his farmlands in *kaduga* (less than 0.3ha) and *kara* (about 0.4ha). He combined both traditional and western farming practices on his *kaduga* and *Kara* farmlands.

Ayeriwuje reported that he did not experience any food shortage. He narrated how he was able to command adequate food for his household throughout the year. *"I do understand that the fertility of our soils has declined because they are no longer as they used to be during our forefather's time. So I take steps to maintain or improve the fertility of the soils in my kaduga and Kara farms through the use of animal droppings and compost which I prepare yearly in the naboo. Before the start of the rains, I carry them to the farm and then spread them. Because of this practice, I always harvest enough produce from the farm to feed my family till the next farming season without having to buy or sell my animals to buy food from the market".*

When asked why some farmers blend farming practices and yet experience food shortages, *Ayeriwuje* respondent that: "*there are several reasons, some of which are beyond us. The first one is that, agric officers come around to only teach use modern farming practices and technologies and tell use to use certain types of seeds if we want to increase yields but these are expensive so we are not able to adopt them. However, they fail to teach us the ways in which we can improve upon the practices our fathers taught us which many of us are familiar with. The second one is that, households without livestock find it difficult to get these animal droppings to fertilize their farms and are unable to buy fertilizer so do not get good harvest to feed the family. Households with bullocks are able to plow early to take advantage of the early rains to get good harvest. Those with goats and sheep are able to sell to buy agro-inputs or food when they run out of stock. Others to, because of some problems, they are not able to manage the little harvest. All these will cause the individual not to have enough food available to feed on till the following year".*

Source: Compiled from in-depth interview, *Saboro*, 2018

These responses from Ayeriwuje tell us about how he blended high proportions of traditional farming practices and technologies relative to western farming practices on his multiple farmlands to achieve household food security. His narration highlights a good understanding of the declining soil fertility situation in the area which has inspired him to adopt animal/compost manure and cropping strategies involving intercropping cereals with legumes to sustain soil health and increase crop production. His narration confirms some of the issues mentioned earlier regarding the role of poor yields and management of crop

harvest in household food shortages. However, his submission introduces diversity to some of the issues highlighted already.

His response highlights a number of knowledge integration issues that have influence on household food security. Firstly, the discussion with Ayeriwuje identified a major gap in current extension delivery system where the emphasis is on western farming systems to the neglect of traditional farming systems which are predominant among smallholder farmers. Consequently, local farmer knowledge and innovations are often not spotted for further development and up-scaling resulting in many of them getting extinct. Secondly, he highlights the significant role of resource endowment as a powerful tool in rural communities to ensure access to timely plowing service to take advantage of early rains and increase propensity to adopt new technologies to increase crop production to reduce the likelihood of experiencing food shortage or hunger.

Knowledge integration and medium resource-endowed household food security situation

The study classified 42 out of 122 survey respondents as medium (*Achea)* households. Result presented in Figure 5.9 shows that of the 42 *achea* smallholder farmers, 79 percent (33 out of 42) combined farming practices on their *kaduga, bwolo* and *kara* farmlands while 21 percent (9 out of 42) did not combine.

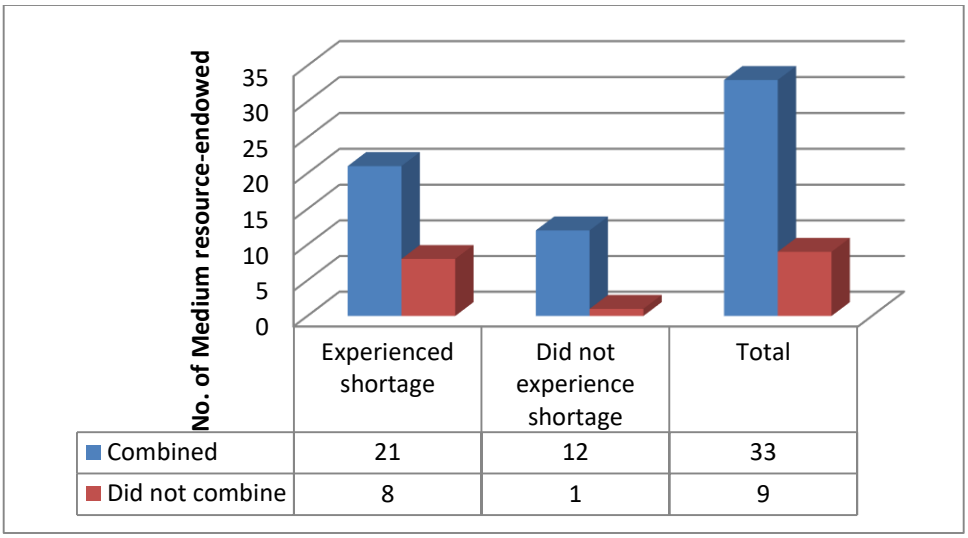

Figure 5. 9: Knowledge integration and Achea household food security outcome

Source: Survey Data, 2018

Elements of integration in these farmlands are largely in the areas of land preparation, soil fertility management, and cropping systems. In the area of land preparation, the *achea* smallholder farmers used more western farming practices such as tractor plowing and herbicides combined with traditional hand weeding with hoe to control weeds. Some *achea* smallholders sowed certified seed using traditional dibbling stick. In the area of soil fertility management, the *achea* smallholders applied chemical fertilizers and animal manure on some of their farmlands. Analysis of how knowledge integration influenced *achea* household food security situations shows that of the 33 *achea* households who combined both farming practices, 64 percent (21 out of 33) households experienced food shortages whereas 36 percent (12 out of 33) households did not experience any shortages. Further analysis of the nine households who did not combine farming practices shows that eight out of nine households experienced food shortages whereas one out of nine households did not experience any food shortages. This result suggests that, *achea* households who did not

combine farming practices are more likely to experience food shortages as compared to those who combined farming practices.

Analysis of the relationship between knowledge integration and *achea* household food security situation did not provide any significant variation or diversity in the emerging issues that have been discussed under the various scenarios of knowledge integration and household food security situation of the *vale-didera* and *vale-nabona* smallholder farmers.

5.4.3 Smallholder Differentiation and Copping Mechanism

Largely, smallholder farmers produce mainly for domestic consumption and sell surplus to meet other financial commitments where necessary. The findings presented in section 5.4.2 suggest that significant majority of smallholder households experienced food shortages at some point in the year. This section investigates what households do in order to survive when food stocks run out. Focus group discussants remarked how households prepare to avoid food shortages:

> It is not as if households wait doing nothing until they experience food shortages before they begin to act. Since we do not control the weather, our initial response to minimize food shortages is to cultivate a wide range of food crops so that we don't loss everything when the season fails [Vunania: discussants, February, 2018].

This remark suggests that smallholder farmers perceive farming as a risk which could result in household food shortage. Consequently, households attempt to respond to this impending food shortage by cultivating multiple food crops and risk-averse crops to deal with weather variability. Participants in focus group discussion indicated that during the period of food shortages, households use a wide range of mechanisms and communal support networks to cope with the

situation. Among these are, selling poultry and small ruminants, picking sheanuts, providing "by-day" services, cutting firewood, and household reduction in daily meal intake. Figure 5.10 illustrates how smallholder households survive when they experience food shortages. The survey results show that the three most important ways of obtaining food when households stocks run out are: selling small ruminants and poultry, providing "by-day" services and household reduction in daily meal intake. This finding corroborates other reports that sale of livestock to purchase food is the most important way of obtaining food when households ran out of stock (Yaro, 2009; Alhassan, 2015). The report shows that sale of livestock is critical in building resilience to food insecurity. According to Yaro (2009), there is a progressive sale of more valuable livestock as crisis deepens, where poultry and goats are the initial market candidates, sheep the second and cattle the third and only when the situation continues to worsen.

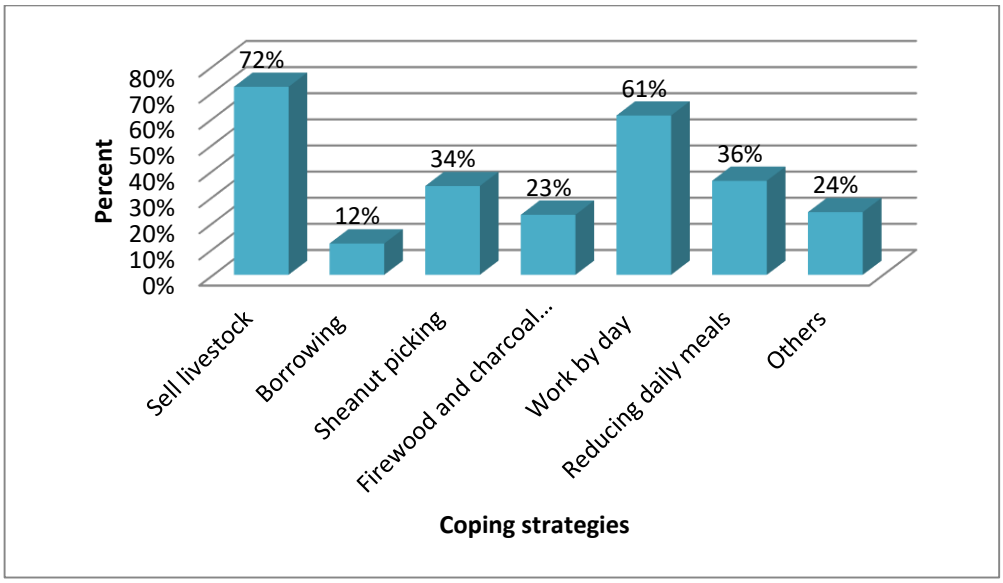

Figure 5. 10: Smallholder coping mechanisms

Source: Survey Data, 2018

The survey results show that all categories of smallholder farmers regard the sale of poultry and small ruminants as the most important way of obtaining food when households experience food insecurity as shown in Figure 5.11.

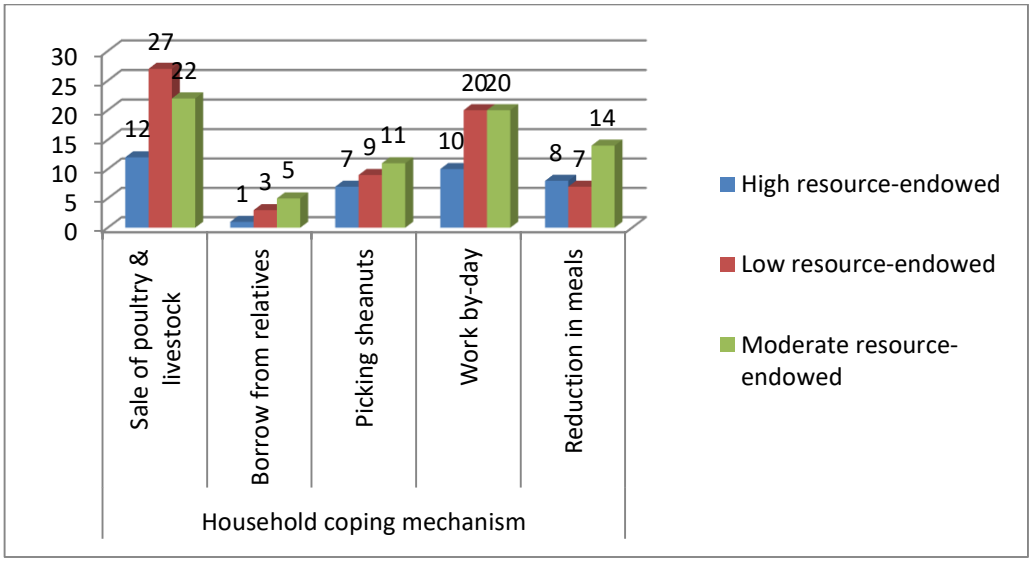

Figure 5. 11: Smallholder differentiation and coping mechanisms

Source: Survey Data, 2018

The survey results further show that all the categories of smallholder farmers regard working "by-day" as the second most important way of obtaining food when households stocks run out. Respondents indicated that working "by-day" often includes, fetching water for masons engaged in building construction, shea-butter processing and food joints while others participate in sand winning activities. The third important way of obtaining food to cope with household food shortages is reduction in household daily meal intake. Analysis of the results revealed that more of the medium resource-endowed households use this strategy relative to the high resource-endowed or low resource-endowed households. Participants in focus group discussions indicated that, usually adults are

compelled to eat smaller meals at the initial stages of food shortages and when it becomes severe, adults sometimes go to sleep hungry to allow their children to have something little to eat. They reported that during that period, it is common to find children cry spontaneously all the time and often hang around their mothers. They stated further that most households do not go to the market and even when they do, they bring nothing home. Besides, it is often the case that "no smoke comes from the kitchen" because there is nothing to put on fire. Under these circumstances, wild fruits such as sheanuts and others, which are free, become important household coping mechanism in stretching the little grain that is available for household consumption.

5.5 Discussion of Key Findings

Some scholars have resisted knowledge integration on the grounds that the conceptual models and ontologies of traditional and western science are sufficiently distinct to make these forms of knowledge systems incommensurable (Cruishank, 2005) and therefore conclude that some forms of integration can have unintended and undesired consequences (Fox et al., 2005). However, interest in integrating the two forms of knowledge systems is steadily growing along several lines (Agrawal, 1995; Aikenhead & Ogawa, 2007; Maffi & Woodley, 2010). Given that the two bodies of knowledge coexist, and in their different ways, are quite limited in their abilities to address emerging constraints facing crop production, sustainable agriculture will be better served by a system that unifies the two bodies of knowledge (Maweu, 2011).

The study has shown that majority (72 %) of smallholder farmers in the area are aware of the existence of traditional and western farming practices and technologies and are

blending both farming technologies and practices based on their circumstances. This finding is consistent with report by Briggs and Moyo (2012) that smallholder farmers are well aware of the existence and importance of the two bodies of knowledge but are making decisions to use particular methods based on their circumstances. If a particular piece of knowledge works for a farmer, and makes economic and socio-cultural sense, then it will be used, regardless of its providence (Briggs, 2013). In terms of social differentiations of smallholder farmers and knowledge integration, the results show that majority (88.4%) of high resource-endowed farmers relative to few (59.3%) low resource-endowed farmers are blending farming practices and technologies in the area. Generally, smallholder farmers in the area rationalized their decisions to blend both farming technologies and practices based on the size of farmlands and the incentives associated with market production. This finding corroborates report by other studies that farm size and market participation are important factors influencing agricultural technology adoption behavior among smallholder farmers in developing countries (Houssou et al., 2016; Baiyegunhi & Hassan, 2018).

Given that smallholder farmers are blending traditional and western farming practices and technologies in the area, it is envisaged that purposively blending both bodies of knowledge will result in improvement in their food security situation based on the assertion that both bodies of knowledge embody competitive advantages that can be harnessed to achieve sustainable livelihood outcomes (Maweu, 2011; Briggs, 2013). Generally, the study showed that majority (72%) of respondents experienced food insecurity in the study area. This finding is consistent with the conclusion of Alhassan (2015) that food security situation in the Upper East Region (UER) of Ghana is more pronounced. Similarly, Nkegbe et al. (2017) reported that food insecurity still persists in the SADA region at levels

unacceptable in modern society and that the UER is the worst affected of food insecurity as it experiences the longest food shortage period. The study noted that decline in own farm production due to poor soil fertility and/or rainfall variability leads to poor crop harvest and constitutes a major cause of household food insecurity in the area. This finding confirms report by Alhassan (2015) that poor crop harvest and weather vagaries are the major causes of food insecurity in the UER.

The study has shown that own farm production is a major food source for majority (99%) of the respondents in the study area followed by market purchases (72%). This finding contradicts report by Alhassan (2015) that over 72 percent of the people in the UER rely on food purchases compared to 22 percent on own production. However, the results suggest that sustainable farming practices and technologies are critical for own farm production to ensure sustainable food security in the study area.

In terms of how knowledge integration affects household food security outcomes of different cohorts of smallholder farmers, the study showed that even though majority (89%) of high resource-endowed farmers blended farming technologies, more than half (57%) experienced food insecurity spanning for three months period because they either could not obtain good crop yields or were unable to manage food crop harvested from own production. This finding corroborates report by Nkegbe et al. (2017) that high yields obtained by households decrease the probability of experiencing severe and moderate hunger and increases the probability of experiencing little or no hunger. The finding therefore confirms the assertion that obtaining good crop yields from own production is crucial for household food security (Alhassan, 2015). The potential for improving yields have been demonstrated with the use of hybrid seed varieties (Houssou et al., 2016).

However, the use of certified/hybrid seed appears to be low across the different cohorts of smallholder farmers. The findings show that majority (81.8%) of respondents are using their own recycled seeds selected from the previous season, a pattern that is consistent with that reported by Ragasa et al. (2013) that there is still wide adoption of traditional varieties in the Northern Savanna zone. Low adoption of certified/hybrid seed is largely attributed to associated cost and uncertainty of the weather to guarantee good returns. The informal seed sector is noted to be an important source of seed for majority of smallholder farmers and makes up over 80 percent of the entire seed sector in Ghana and arguably the most important production factor for crop production in Ghana and perhaps sub-Saharan Africa (Etwire et al., 2013).

The study showed that, some high resource-endowed farmers obtained good crop yields but still experienced household food insecurity. This suggests that, even though good crop yield is critical, it is not sufficient guarantee that households will be able to attain food security throughout the year because there are other intervening factors that come into play to influence household food security situations. The study revealed that household size is an important factor affecting food security situation of smallholder households in the study area. This finding corroborates Alhassan (2015) who assert that increased family size leads to more land fragmentation, hence low output per handholding. Similarly, Obayelu (2012) reported that household size significantly determines households' food security situation in Nigeria.

In respect of household food security situations of low resource-endowed smallholder farmers, the study has shown that majority (95%) of low resource-endowed farmers who did not blend farming practices and technologies but relied on only traditional farming

practices experienced food insecurity spanning for six months period. This suggests that smallholder farmers who do not blend farming technologies and practices but rely on traditional farming practices are more likely to experience household food insecurity in the study area. This finding corroborates the conclusion reached by Alhassan (2015) that over reliance on traditional methods of farming lead to poor crop yield thereby posing a greater challenge for households' ability to obtain food security. The study has shown that lack of funds is the major constraint restraining smallholder farmers from adopting western farming technologies. Consequently, majority of them are unable to use recommended rates of fertilizers which is emerging as a useful soil fertility enhancement technology among smallholder farmers (Houssou et al., 2016). Meanwhile, chemical fertilizer use has been noted as being detrimental to the activities of soil fauna and flora which are themselves seen to be crucial for soil fertility maintenance (Briggs & Moyo, 2012). Besides, evidence abounds to suggest that the use of organic manure combined with chemical fertilizers enhances nutrient availability, optimizes the soil environment and improves crop productivity (Abebe & Deressa, 2017). These studies confirm that the yields obtained by the combined treatments of organic and inorganic fertilizers are significantly higher than their sole treatment.

The study noted that mixed cropping system is a popular feature of smallholder farming systems. The finding shows that majority of low resource-endowed smallholder farmers are adopting mixed cropping largely on their compound farms and to some extent on their bush farms. Mixed cropping system allows smallholder farmers to cultivate a wide range of food crops to meet household food and nutritional security needs (Briggs & Moyo, 2012). Blending different crop species and different varieties together is used as a strategy

to reduce risk of crop failure, maintain and enhance soil fertility. Besides, the different crop/varieties being cultivated by smallholder farmers have different water demands and different growth stages. Which suggests that, adverse rainfall patterns may not affect the different crops equally (Wood, 2013; Callo-Concha et al., 2013).

However, the fact that some low resource-endowed smallholder farmers experienced food insecurity while others did not, in spite of blending traditional and western farming technologies and practices suggests that other factors come into play. The finding shows that low resource-endowed smallholder farmers are predominantly in compound farmlands cultivating mainly food crops on farmlands that are relatively small and fragmented, suggesting that such smallholder farmers are more likely to experience food insecurity because they are unable to obtain enough food that will last throughout the year. This finding confirms Nkegbe et al. (2017) who reported that farm households who are food crop producers are more likely to experience severe and moderate hunger and less likely to experience little or no hunger.

In terms of how smallholder farmers are able to survive when households ran out of food stocks, the study has shown that different smallholder farmers adopt a number of strategies in order to meet their household food requirement. The results show that sale of livestock is the most important copping strategy to deal with household food insecurity in the study area. This is consistent with the finding of Alhassan (2015) who reported that the most important way of obtaining food when stock ran out is through sale of livestock to purchase food. The report argues that sale of livestock is crucial in building household resilience to food insecurity. Similarly, Nkegbe et al. (2017) reported that livestock contributes to food

security through provision of cash income and assert that households with small ruminants are less likely to experience hunger.

The discussion has shown that high resource-endowed farmers are blending proportions of traditional and western farming technologies and practices relative to low resource-endowed farmers. However, the study noted that the manner of blending traditional and western farming practices and technologies is neither sufficient to induce sustainable agriculture nor bring about any notable changes to household food security. In the next chapter, I discuss strategies for blending traditional and western agricultural knowledge systems to ensure smooth diffusion of innovation for sustainable smallholder farming systems.

CHAPTER SIX

6.0 ENDOGENOUS APPROACH FOR ENHANCING KNOWLEDGE INTEGRATION IN SMALLHOLDER AGRICULTURE

6.1 Introduction

The use of traditional knowledge and western knowledge is increasingly advocated but there is as yet no clearly developed framework demonstrating how the two may be integrated to improve household food security (Mercer et al., 2010). This chapter discusses ways in which traditional and western agricultural knowledge systems can be integrated to facilitate smooth diffusion of innovation for sustainable crop production among smallholder farmers. To do this, I structure the section into two parts. In the first section, I present a model for integrating traditional and western farming practices to achieve sustainable crop production. The model outlines the process and practical strategies for integrating the two forms of knowledge systems. In the second section, I examine mechanisms necessary for effective integration at policy, institutional and farmer levels.

6.2 Knowledge Integration Model and Process to Improve Crop Production

There appears to be limited evidence to suggest that smallholder farmers on their own have systematically developed innovative ways that draw on the complementarities and synergies of traditional and western knowledge systems to address key production constraints such as poor soil fertility and rainfall variability. As a result, in-depth interviews were conducted on selected smallholder farmers and key informants to elicit views on ways to integrate traditional and western farming practices and technologies to increase crop production among smallholder farmers in a sustainable manner.

Analysis of the results shows a recurring recognition of 'participatory' approaches as an effective strategy to blend traditional and western farming practices and technologies to increase crop production among smallholder farmers. A senior MoFA staff had this to say:

> This approach [participatory] has proven to be effective in ensuring that the concerns and fears of the target beneficiaries are taken into account for successful implementation of any initiative with rural people. If you fail to involve them adequately, then be aware that the initiative will not be sustainable when the project resources end. Certainly, they will go back to their way of farming because they may not find the new ideas suitable in their context [Navrongo, key informant, January, 2018].

The quote from the MoFA staff also reflects the views of a food security expert. According to this key informant:

> If you ignore their (i.e. local farmers) ideas and social context and pose yourself as someone who knows it all, they would help you to fail. In fact, some of them have very rich technical knowledge, so by working together with other experts, things can work better for their livelihoods. The only issue about these farmers is that, only few of them are experimenting new ways of improving production on their own. It may also be that we as technocrats are not encouraging and supporting them. Rather, we promote more of the technologies that donors are interested in [Navrongo, key informant, February, 2018].

The account of these key informants encapsulates the importance of participatory approaches to sustainable development initiatives at the community level which has become a challenge and a concern for many development practitioners in northern Ghana. Their remarks highlight the role of local participation in development initiative to ensure that it takes local needs and context into consideration to facilitate adoption and sustainability. Furthermore, the second remark points out bias towards promotion of western farming technologies in crop production and the fact that much is not being done in food security initiatives to work with farmer knowledge systems as entry point to improve household food security. Analysis of the qualitative information from the

interviews suggests various possible ways for integrating traditional and western farming practices to increase crop production. In order to contribute to wider technology adoption and increased benefits, a five step knowledge integration process can be highlighted.

6.2.1 Getting started with a Deeper Understanding of the Socio-cultural Context

Generally, a recurring theme in the views of the key informants was that the process of knowledge integration should start with an understanding of the socio-cultural context of the communities involved, in terms of their socio-cultural values, worldviews and the resources they have and the way they value and use them. An agricultural production officer shared his thoughts on how integration should commence:

> An effective integration process must begin with an orientation for field officers to be willing to listen more, ready to learn more about the peoples' worldviews and appreciate their actions within the context of social values and others, so that you don't present yourself (referring to field officer) as an expert and begin to judge their actions as irrational. Some of us approach these local people as if they don't know anything. It is important but I can tell you that some of these people are full of ideas from which we can tap some good things [Navrongo, key informant, February, 2018].

This remark emphasizes the need for development agents to understand the worldviews and social context of local people to appreciate their aspirations and values to be able to support them appropriately. By understanding the socio-cultural context, development agents gain insights into the diversity of felt needs of the different categories of smallholders, their ways of reasoning, methods of experimentation, and the systems of learning and communication (Millar, 2014). This is particularly relevant against the backdrop of the fact that traditional farming systems may not have been part of formal training of most extension agents at the university or college level. As a result, their attitude toward smallholders is domineering and authoritative. An extension officer during the

interview intimated that, for knowledge integration to be practically relevant and useful for differentiated smallholders, they (i.e. extension agents) would require refresher training to gain practical working knowledge of smallholder farming systems to effectively diagnose constraints associated with crop production and prioritize farmers felt needs and working together to identify practical ways to address those felt needs. According to a senior MoFA officer:

> The strategy of self-preparation, orientation and self-discovery is a core strategy to jump-start any effective knowledge integration process. If not, people would not accommodate each other because of their orientation [Navrongo, key informant, February, 2018].

This remark suggests the need for development agents to have an open mind in dealing with beneficiaries of development initiatives. This is vital for building rapport and mutual trust in working with community members. A dominant theme that emerged as second step in the process of integrating farming practices is community consultation and problem identification.

6.2.2 Community Consultation and Problem Analysis

According to key informants, community consultations and dialogues are useful participatory tools that are often used as part of community entry strategies and help to design relevant actions that meet the needs and aspirations of the community. An extension agent remarked:

> Community consultations and dialogue are critical and useful to ensure that development initiatives adequately respond to the needs and priorities of the community and enhance interest, commitment and ownership of the initiative [Navrongo, key informant, February, 2018].

The extension officer's remark highlights community consultation as critical to ensure ownership of development initiatives. All the informants agreed that community consultations are useful and necessary to stimulate interest and ensure sustainability of the initiative. The participants alluded to the fact that these consultations and dialogues are effective in establishing a relationship of trust to gain access to local resources given that most communities have people with special knowledge and skills or interesting innovations or unique resources, which are either undervalued or 'hidden' from outsiders. The results show that consultations usually occur in two phases entailing a one-stage process or continue dialogue depending on the available time to continue in community engagements. According to a food security project manager:

> The first phase deals with community notification and sensitization about the goal and objectives of the initiative and the second has to do with community appraisals to identify the felt needs of community members [Navrongo, key informant, February, 2018].

The project manager talks about the focus of the first formal meetings and discussions with key community members to discuss the initiative which in the context of this study aims at integrating traditional and western farming practices and technologies to improve crop production and ensure household food security. Usually, extension agents play critical roles in facilitating community entry and scheduling meetings with opinion leaders of the community to discuss project initiative and the objectives to be achieved. Informants asserted that the success of such meetings often pave the way for planning a community-wide engagement. An extension officer intimated that the planning process should ensure greater diversity of households in the community including male, female and youth to build rapport and community acceptance. This view was consistent with the views of food security project managers interviewed. A project manager remarked:

> At the community-wide meeting, the facilitator (i.e. an experience community animator) introduces the initiative, objectives and the expected outcomes to be achieved and to elicit their buy-in. At this stage, the community members' experiences and concerns should be noted to build rapport and confidence in the process [Navrongo, key informant, February, 2018].

The project manager's remark shows how community consultations are conducted to create a common understanding of the initiative and the relevant information needed to help community members to decide on whether to participate or not. The project manager cautioned that at this stage field officers need to manage community expectations to avoid the risk of community members presenting problems covering all aspects of their lives with the hope of receiving 'handouts'.

The second phase highlighted by informants is 'needs appraisal stage' where the felt needs of the community members related to crop production are determined. They were unanimous that community members should be encouraged to go into groups as deemed appropriate to identify critical constraints that affect farming activities in the community and prioritize them. According to them, this would encourage freer discussion and safe spaces for the diversity of community members (i.e. women, men & youth). Each group is encouraged to nominate someone to capture the salient points in the group discussion to be presented in plenary session of the community for validation. The facilitator should moderate the plenary discussions in such a way to ensure that the identified constraints are exhaustively discussed and consensual. An extension officer remarked:

> This phase also involves discussion on the ways in which the community members have tried to deal with the problem on their own and the results achieved. This process offers an opportunity for community members to reflect and analyze farming constraints in the community and through concerted efforts attempt appropriate solutions to address those constraints. It also serves as capacity building to strengthen community members'

> capacity to identify and prioritize community constraints and possible ways of addressing them [Navrongo, key informant, February, 2018].

The extension officer's remark shows the process of problem identification and prioritization and possible solutions acknowledged for addressing the constraint. This process is important to the extent that it informs project design and planning to ensure that the initiative is responding to the needs of beneficiaries. The outputs from this phase, according to informants feed into the next phase – identification of innovations to test or experiment.

6.2.3 Identification of Innovations to Improve Crop Production

The finding reveals that this phase requires collaboration among key stakeholders, i.e. farmers, extension agents and agricultural experts to work closely together to identify appropriate innovations to cope with constraints affecting crop production among smallholder farmers. A senior MoFA officer shared this remark:

> For effective integration process that is bottom up, it should not follow a top down approach like the way NGOs often approach agro-chemical companies to sponsor inputs (technologies) that they think will be useful for farmers and then use such inputs to setup demonstration fields and organize field days to promote such technologies. This innovation identification we are discussing should begin with a dialogue among the key stakeholders taken into consideration the farming constraints to be addressed and other factors rather than a predetermined technology [Paga, key informant, February, 2018].

This remark suggests the need for broader consultation to ensure relevance of the technology that will be identified and the necessary conditions that would facilitate smooth diffusion of innovation. Bottom up approach is being suggested to identify innovations deemed appropriate. This is vital to ensure that beneficiaries can comfortably associate with the innovation to facilitate uptake. According to a senior MoFA officer, the first option

will be for a joint team to find out whether there are any local innovations within or outside the community to address production constraints. In the light of this, the officer reported that the joint team needs to develop innovation selection criteria which should consider innovations that are inexpensive, scalable, use locally available resources are accessible and meet the felt needs of the different categories of smallholder farmers, and has potential for further experiment through Participatory Innovation Development (PID). These views also reflect the views of other informants. According to a food security expert:

> Some farmers have very good ideas and reasons why they adopt certain practices. There are so many of these innovations in the communities. But for scalability, it will be useful to design criteria for selecting those innovations that are impactful to be supported for promotion and up scaling [Paga, key informant, February, 2018].

His remark points to the existence of various innovations in the communities but for the purpose of high adoption, he proposes a selection criterion to identify innovations with high potential for up-scaling. The second option involves identifying how existing relevant traditional and western farming methods/strategies can be purposely integrated to address the major constraints affecting smallholder crop production. In this regard, key informants shared the view that a joint team to discuss and share experiences and knowledge related to the constraints will be useful. According to them, the discussion should focus on identifying complementarities between traditional and western farming practices. A senior MoFA officer shared this remark to confirm the informants' views:

> Farmers have used certain technologies that have helped them before. So they need to discuss to see which ones are still relevant for them today. So if such farmers bring their ideas together with other experts who are knowledgeable in agriculture, that group should be able to share best practices that have worked well elsewhere to see whether they can be adopted here [Navrongo, key informant, February, 2018].

The MoFA officer's remarks indicate the need for a team of farmers and experts in agriculture to work together to identify relevant traditional farming practices and best practices in crop production and adopt or adapt to the local context. Key informants suggested that in blending farming practices, the strategy must take the following into consideration: the resource poor smallholders, risk levels, simplicity, accessibility, quick-win innovation, and should be socially and culturally acceptable. Once the innovation has been identified, the next step in the integration process would be to design a field demonstration program to demonstrate it use farmers to appreciate the expected results. Generally, the findings show that such demonstration program should be conducted on farmers' fields under farmers' conditions and management to facilitate smooth diffusion of innovation.

6.2.4 On-farm Demonstrations

Key informants intimated that on-farm demonstration activities aim at supporting smallholder farmers to test or validate new innovations to show the extent to which such innovations can address smallholders concerns and also serve as capacity building to train farmers how to apply the new technology on their own. According to an AEA, on-farm demonstrations serve as one of the most effective extension education tools. He remarked:

> Demo fields are a valuable tool in teaching farmers new management practices and appropriate technologies to increase production. Demo allows farmers, extension agents and agricultural scientists to learn how alternative management option (s) would perform on ordinary farmers' farms. With the demos, you are able to bring so many farmers to one location to learn about new technologies. [Navrongo, key informant, February, 2018].

The AEA's remark talks about the use of demonstration plots to train farmers and promote innovation diffusion. It is often said that farmers would not change their methods of

farming by just observing how farms are operated and managed by public officials, but that demonstrations conducted by farmers themselves on their own farms under ordinary farm conditions with external support may cause positive change in farming practices (Mariona et al., 2012).

The study noted from project reports that there are typically two types of demonstrations being established in the study area. These are, result and method demonstrations. According to the food security experts, it is very common to see demonstration fields that have incorporated aspects of both types. They indicated that, the specific objective of the demonstration determines the emphasis placed on the type of demonstration. They explained that, result demonstrations show what happens as a result of using a particular technology in the field. It focuses more on the expected outcome. On the other hand, method demonstration shows how to complete a task. It focuses more on process and techniques to show "how to". For the purpose of this study, analysis of the results revealed that three steps in sequence must be followed as part of the process of conducting on-farm demonstrations to facilitate smooth innovation diffusion. These are: planning, establishment and management, and field days for innovation diffusion.

The first step is planning. This begins with the selection of a demonstration committee consisting of extension agents, farmers, agricultural experts, and community leaders. To enhance the success of the demonstration, the committee must clearly define the goal and objectives of the demonstration to ensure that every member knows exactly what the demonstration entails and understands the methodology, plot layout, and treatments among others. If the committee members understand the potential value of the demonstration, they can explain clearly to the community to establish confidence in the innovation or new

technology. One of the responsibilities of the committee is to select relevant and manageable topics for the demonstration. Once the topic has been selected, the next step is to select a lead farmer to host the demonstration plot. A suitable host is critical to the success of the demonstration and therefore extreme care must be exercised in the selection. Usually, the host of the demonstration provides the land and manages the plot to ensure good farm hygiene. Eventually, the proceeds from the plot are given to the host. However, the inputs or resources required for the demonstration is the responsibility of the committee. The next stage after identifying the lead farmer would be to identify and select a suitable site for the demonstration plot. In selecting the site, due consideration should be given to the location of the site, accessibility to farmers in the community, and should be readily noticeable to attract maximum attention – often by the road or major footpaths. Visibility is also crucial. The demonstration plot should have a prominent signpost to depict what the demonstration is about, why it is being conducted, and what is intended to be accomplished. The use of smaller signposts to identify each treatment is also useful to farmers and others who informally may stop by to view the plots on their own.

The second step is establishment and management of the demonstration plot. This involves the actual planting of test plots on the farm of the host farmer. Monitoring from time to time should be conducted to ensure that every activity is being carried out according to plan and also note any unusual results that may show up for immediate action. These demonstration plots are often used to examine new variables, test possible solutions, verify recommendations, and demonstrate recommendations to farmers. A number of demonstrations can be established at strategic locations depending on the resources available to the demonstration committee. It is important to ensure that all the members of

the committee are actively involved in the establishment and management of the demonstration plots to observe the various treatments and how differences begin to show up as the plants grow. The committee should endeavor to keep detailed records of demonstration design, plot layout, among others

The third step is hold demonstration field days. These are usually organized to bring farmers within and outside the community to see how the new technology and practices have performed. The number of field days at a demonstration site will depend on the purpose and/or type of demonstration. Given that farmers prefer fellow farmers as the primary source of information and associate better with what they say, the host farmer may lead in the field day presentation and supported by other members of the committee to explain processes, results and any lessons learned and give ample time for participants to the field day to ask questions and seek clarifications regarding the new innovation/technology. These field days are important platforms for diffusion of innovations. Once farmers and extension agents are actively involved in the on-farm demonstrations, it is expected that they would develop innovations and practices that meet the felt needs of smallholder farmers and also serve as avenues for the diffusion of innovations and best practices. By monitoring farmers' opinions and use of the innovation, extension agents can improve their understanding of farmers' needs and preferences. Finally, it is important to ensure that lessons and experiences from the on-farm demonstration are documented and shared with all relevant stakeholders, particularly with those that are well placed to support the innovation diffusion process. More importantly, those lessons should be used to inform the next establishment of field demonstration.

According to key informants, the usefulness of this approach to technology diffusion and adoption among smallholder farmers is that, it directly manifests the felt needs of community people and embodies a store of indigenous knowledge and skills that is purposely combined with western knowledge to adequately address the core of their challenges. These views where confirmed by the remarks of one project manager:

> This process also allows for learning and adaptation of innovations. It places emphasis on close interaction with and involvement of the final user in the innovation development process. Because the ideas come from the farmers themselves through brainstorming, the innovation becomes more accepted especially if the resources used are local [Navrongo, key informant, February, 2018].

The project manager's remark shows how demonstration plots serve as platforms to promote innovations and opportunity to interact with potential users to share experiences on the innovation. His remark reiterates the need to use local resources to establish demonstration plots to facilitate adoption. For effective knowledge integration, there is the need to establish mechanisms to support the integration process. These mechanisms are discussed below.

6.3 Mechanisms to support knowledge integration in crop production

On mechanisms to support knowledge integration in crop production, the recurring themes that emerged from the key informant interviews were clustered into three levels: policy, institutional and farmer level.

6.3.1 Policy Level Mechanism to Support Knowledge Integration

As a mechanism to support the process of integrating western and traditional farming practices to promote sustainable agricultural production, all the key informants were unanimous that national development policy focus must recognize the role of traditional

knowledge systems within the framework of agricultural 'modernization' which has become the common mantra in agricultural development policy documents as part of a comprehensive solution to the socio-economic development of Ghana. The views of the informants suggest a re-orientation of Ghana's policy framework for stimulating innovations for economy development by recognizing traditional knowledge systems as a strategic policy issue for economic transformation. A food security expert had this to say:

> Our policy makers seem to be missing the point. There appears to be a disconnection between our agricultural policy and the realities on the ground. As a country we all agree that majority of our farming population are smallholder farmers mostly in the rural communities. But our policy keeps talking about modernizing agriculture with western farming methods in mind and so they focus on heavy equipment and other practices that most of the smallholder farmers cannot afford. Meanwhile, these farmers also have some technologies and practices that they have been using for all these years but our agricultural policy does not recognize those technologies and practices [Navrongo, key informant, February, 2018].

This remark by the food security expert indicates that smallholder farmers are the majority of the farming population in Ghana. However, the agricultural development policy which provides the framework for all agricultural programmes and strategies does not recognize relevant technologies and practices of smallholder farming systems. The lack of recognition stems from the gaps in Ghana's agricultural policy documents which seek to promote sustainable agricultural development (Darko & Afozone, 2013). Similarly, on agricultural financing, the key informants pointed out that agricultural policies do not recognize alternative sources of local savings mobilization mechanisms such as the Village Savings and Loan Associations (VSLA) in rural areas which is proven to be an effective savings mobilization mechanism and credit scheme for meeting the credit needs of smallholder farmers. According to key informants, this savings and loan scheme is proven

to be an important tool for women empowerment and for building resilience among smallholder farmers in northern Ghana. A project manager shared his observation:

> This VSLA concept is catching up like wild fire in many parts of northern Ghana. You would be amazed when you hear the value of money they have in those boxes during share-out. In fact, most projects are using this VSLA concept to promote smallholder investments in agricultural technologies to increase crop production. It is better than linking smallholder farmers to the Bank for credit given the high interest rates these days [Navrongo, key informant, February, 2018].

This remark indicates that although VSLA is widespread among smallholder farmers and helping is them to access critical services and inputs to increase crop production, it has not received the desired attention within the financial sector. This suggests that the agricultural policies with focus on modernization are probably not responding to the needs of the sector by creating the necessary environment for the less privileged farmers to participate in the modernization agenda. Recognizing the role of relevant traditional knowledge systems in agricultural development is therefore critical for sustainable crop production.

6.3.2 Institutional Level Mechanisms to Support Knowledge Integration

On institutional level mechanisms to support knowledge integration, the responses from key informants highlighted two areas of institutional arrangement that can support integration of traditional and western farming systems. These are, making agricultural college and university curriculum responsive and relevant to the needs of farmers and also establishing agricultural innovation platforms.

Key informants suggested that the curriculum of the agricultural colleges or universities should be reviewed to incorporate traditional ecological knowledge systems and

worldviews of local people to ensure that extension delivery is more responsive to the felt needs of different categories of farmers. A senior MoFA officer remarked:

> The agricultural colleges and universities should consider a regular review of their curriculum of study by engaging stakeholders to ensure that the knowledge they seek to impart their students will be relevant. This is important because, sometimes the fresh graduates don't appreciate what the local farmers know. They think that what they have learnt from school is superior to the farmer's knowledge [Paga, key informant, February, 2018].

The remark calls for regular review of the curriculum of agricultural colleges and universities through stakeholder consultations. According to key informants, these institutions should employ participatory approaches in the consultative process to engage wider and more diverse stakeholders in the curriculum development process to ensure that the felt needs and aspirations of the end users of extension services are sufficiently reflected in the study curriculum. Furthermore, they assert that the curriculum should be based on the concept of experiential learning and systematic approaches to problem solving.

The second institutional level mechanism to support integration of traditional and western farming practices mentioned is the establishment of multi-stakeholder platform (MSP) at the district level. Key informants pointed out that there are a number of such platforms already established in the study area. But in the context of this study, the engagement of different stakeholders in exploring and promoting local innovations to increase crop production and productivity in a sustainable manner should be the focus of the multi-stakeholder platform. They indicated that, the MSP will create a forum to promote and support integration of relevant traditional and western farming practices and technologies to increase crop production and productivity. A project manager shared his experience on MSP:

> One of the NGOs facilitated the establishment of a similar one but at the community level and it sought to bring stakeholders including Department of Agriculture (DOA), representation of selected FBOs, Scientist from SARI, and some other members. These members usually meet to discuss potential innovations to increase crop production in the area and to see how to spread such innovations [Navrongo, key informant, February, 2018].

His remark shows the composition of the MSP drawing from different stakeholders within the district. This platform will ensure effective research-extension-farmer linkage. According to participants, a forum should be organized to inaugurate the platform and outline the roles and responsibilities of members. For a successful and effective MSP, key informants indicated that care must be taken in choosing the chairperson of the platforms. An AEA remarked:

> The Chairman must have adequate knowledge about each stakeholder and should not let any power games to override discussions and resolutions. He/she should gain trust from platform members in order to be productive. He/she must understand that being able to work with all the platform members requires patience, calmness and management skills [Navrongo, Key informant, February, 2018].

His remark highlights good qualities of the MSP chairperson. The MSP is expected to engage stakeholders to identify critical constraints facing agriculture in the district; identify local innovations and support up scaling; create linkage with stakeholders involved in rural innovations; coordinate and harmonize rural innovation actions within the district and facilitate experience sharing and lessons learned; and organize fora to showcase rural innovations to improve sustainable crop production.

6.3.3 Farmer Level Mechanism to Support Knowledge Integration

At the farmer level, the recurring theme on how to support integration of traditional and western farming practices has been the establishment of farmer innovation platforms. Key

informants suggested that innovation platforms at farmer level will facilitate mutual understanding of the technology under consideration and bring the innovation development process close to the end beneficiaries. Besides, they intimated that such a platform will promote and support local innovation development. A project manager had this to say:

> Innovation platform at the community level is a useful platform for learning and sharing of innovations. I'm currently coordinating a project that seeks to promote local innovations in five African countries. So we established innovation platforms at the community level where agricultural scientists and farmers meet to examine innovations from diverse perspectives and agree on innovations that will be responsive to their needs, inexpensive, use mainly local available resources and above all scalable for experimentation. The output from the experiment is reviewed together and when the results are favorable, it is widely shared [Navrongo, key informant, February, 2018].

The Project Manager's remark shows how farmer level innovation platform offers opportunity for diverse stakeholder to examine local innovations from different perspectives with the ultimate goal of identifying innovations that are responsive to the needs of local farmers and affordable. This is critical for diffusion of innovation among smallholder farmers.

6.4 Discussion of Key Findings

The study set out to examine ways in which traditional and western agricultural knowledge systems can be purposely integrated to facilitate innovation diffusion for sustainable smallholder farming systems. The results show that a four-stage knowledge integration model and process that hinges on complementarities and synergies between traditional and western farming knowledge systems can empower smallholder farmers to identify an integrated strategy that would best improve their household food security situation. This model and process of knowledge integration is within the framework of endogenous

development which aims at local determination of the development process by drawing on available local resources, complementing them with appropriate external resources and retaining the benefits of development within the local area (Millar, 2014). It is a collaborative approach which does not neglect western knowledge systems buts starts and builds on the strengths of local farmers' knowledge (Haverkort et al., 2012).

The four-stage knowledge integration model and process is consistent with Millar (2014) who provided some empirical prerequisites for conducting endogenous development with rural communities, which demonstrate one way of conducting experimentation with farmers within the context of endogenous development. Furthermore, the knowledge integration model and process is similar to Mercer et al. (2010) who proposed a process framework that builds upon the benefits of both indigenous and scientific knowledge bases to empower indigenous communities in Papua New Guinea to identify an integrated strategy to reduce their vulnerability to environmental hazards.

Furthermore, the study shows that gaining understanding of the worldviews and socio-cultural context of smallholder farmers is a critical first step to build trustworthy relationship with rural communities to facilitate any meaningful exchange. This finding corroborates Millar (2014) who reported that it is necessary to build empathetic relationship with rural people and be familiar with the cosmovision and culture of the area to be able to engage in constructive dialogue. Similarly, Mercer et al. (2010) reported that establishing trust and rapport with a community is an essential first step prior to moving on to further steps in the framework for integrating traditional and western knowledge systems.

A key component of the model and process for integrating traditional and western farming knowledge systems is collective establishment of on-farm demonstrations to test and showcase innovations to improve smallholder farming practices. The study noted that on-farm demonstration will be an effective tool for diffusion of innovation and agricultural extension delivery as it provides a platform for learning and dissemination of agricultural technologies. This finding is consistent with Millar (2014) who asserts that experimenting is a very important component of endogenous development. Similarly, the finding corroborates report by Mariona et al. (2012) who assert that participation in on-farm demonstration has significant and positive effects on adoption of agricultural technologies.

Another unique feature of the model and process of integrating traditional and western farming knowledge systems is the establishment of mechanisms to support the integration process. This is against the backdrop of the fact that Ghana's agricultural development policy does not recognize the role of traditional knowledge systems in rural development (Darko & Afozone, 2013). Consequently, majority of smallholder farmers who rely heavily on traditional farming knowledge and practices are left out in the agricultural transformation agenda because of improper targeting and limited infrastructure (MoFA, 2007). The finding shows that establishment of multi-stakeholder platforms at the farmer and district levels will promote collaborative effort among associated stakeholders to facilitate mutual understanding of the technologies under consideration and promote innovation diffusion among smallholder farmers. This finding corroborates report by Gera, Moges, Zeleke, Tesfaye, and Ayalew, (2010) who argues that multi-stakeholder platforms provide suitable forum for consultation and collective action among different stakeholders who have common interest to work together to achieve a common goal.

The discussion thus far has shown that an endogenous development approach to knowledge integration that draws on synergies and complementarities between traditional and western agricultural knowledge systems will be an effective strategy to facilitate smooth innovation diffusion among smallholder farmers in the study area. It has further demonstrated that the use of a four-stage process that promotes an integrated approach can be an effective way to empower rural communities to harness local resources to improve household food security. Such actions promote the use of local and indigenous knowledge and empower rural communities to use their knowledge, supplemented with outside knowledge, to make informed decisions about adapting local resources to improve food security situation among smallholder farmers.

CHAPTER SEVEN

7.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

7.1 Introduction

This chapter presents summaries of the key findings, conclusions and recommendations. In the first part, I present the key findings per each research objective. In the second part, I draw significant conclusions that explicitly answer the corresponding research questions. The third part focuses on recommendations for policy and development practice.

7.2 Summary

Literature review has shown that the Upper East Region has the highest proportion of food insecure households in Ghana (Alhassan, 2015; Ekegbe et al., 2017) and The Kassena Nankana East and West are among the five districts with the highest proportion of food insecure households in northern Ghana (WFP, 2012). It does appear that efforts to improve food security in northern Ghana have not resulted in the expected outcomes. Consequently, some scholars and development practitioners have advocated the need to harness the synergies between the two knowledge systems to improve sustainable agricultural development (Bohensky & Maru, 2011; Briggs, 2013). However, it is unclear how smallholder farmers deal with the competition between traditional and western agricultural knowledge systems, harness the complementarities and synergies, make trade-offs, and rationalize their choices in blending the two bodies of knowledge to enhance household food security. In view of the aforementioned research problem, this study set out to investigate how socially differentiated smallholder farmers harness synergies and complementarities between traditional and western agricultural knowledge systems to improve household food security outcomes in the Kassena Nankana Traditional Area.

Methodologically, the study employed mixed methods approach. Data was generated through interviews, focus groups discussions, and survey. Eight focus group discussions were conducted with a maximum of twelve participants per group in eight study communities. The output from the focus group discussions informed the survey instrument designed and administered face to face to 122 respondents. Subsequently, household in-depth interviews were conducted with six farmers across the different cohorts of smallholder farmers and eleven key informants.

The first objective of the study focused on how smallholder farmers describe their farming systems showing how social differentiations among smallholder farmers define their choice of farming systems. The main findings were that:

- Smallholder farmers describe their farming systems in terms of agricultural land use systems and the associated farming practices and technologies they undertake to achieve desired levels of food crop production to meet household consumption needs. Key features in their description included cultivation of multiple farms, cultivation of a wide range of food crops under mixed cropping system to meet household dietary needs, and blending of traditional and western farming practices and technologies on their multiple farmlands.
- Traditional farming practices and technologies are predominantly on compound farmlands whereas western farming practices and technologies are typically on the lowland and bush farmlands.
- Social differentiation among smallholder farmers has considerable influence in shaping the choice of smallholder farming systems. Indeed, smallholder farmers are well aware of the existence of the two forms of farming knowledge systems but are

making decisions and rationalizing their choices of farming systems based on their socio-economic circumstances and broader meso and macro level factors.

- High resource-endowed smallholder farmers predominantly in lowland and bush farmlands because of the opportunities associated with cultivating market oriented food crops. As a result, they are able and willing to invest in farming technologies such as chemical fertilizers, herbicides, and tractor ploughing to increase crop production.
- Low resource-endowed farmers predominantly in compound farmlands because that is where the bulk of household food crops are cultivated to enable them attain the required household food sustenance needs.
- Risk aversion is an important factor that influences smallholder farmers in their choice of the different blend of farming systems. Mixed cropping system and cultivation of a wide range of food crops featured prominently in their choice of farming systems.

How differentiated smallholder farmers integrate traditional and western agricultural knowledge systems and how they rationalize their decisions was addressed as the second objective. The following key issues emerged:

- Smallholder farmers are aware of the existence of traditional and western farming practices/technologies and their decision to blend both traditional and western farming practices and technologies is circumscribed by their socio-economic circumstances.
- Majority of the respondents (72%) blended both traditional and western farming practices and technologies on their farmlands.

- Majority of the high resource-endowed farmers (92%) blended more proportions of western farming practices and technologies such as: the use of tractors, certified/hybrid seeds, mono-cropping, herbicides and chemical fertilizers relative to traditional farming practices on their lowland and bush farmlands and they rationalized their decisions based on the size of their farmlands and production of market value crops for household consumption and market.

The third research objective focused on key drivers and challenges of knowledge integration and how they affect diffusion of innovation. The following key findings emerged:

- Household resource endowment and market incentives play significant role in stimulating smallholder farmers to blend high proportion of western farming practices and technologies relative to traditional farming methods on their lowland and bush farmlands to increase crop production for household consumption and market. This suggests that proper targeting of input subsidies and overcoming market constraints to facilitate smallholder farmers' participation in output markets may positively affect diffusion of innovation among smallholder farmers.
- Farm size emerged as a major driver of agricultural knowledge integration given that high integration is positively associated with large farm sizes in lowland and bush farmlands where high labour cost coupled with time constraint makes it efficient to use herbicides and tractor to prepare farmlands. This implies that targeting food crops cultivated on large acreages with new technologies may be a superior measure to predict the rate and extent of adoption of agricultural technology.

In spite of these driving forces, the study identified a number of challenges associated with knowledge integration in the area. Critical among them include the fact that:

- Institutional constraint related to extension agent to farmer ratio translates into 1:4886 in the kassena Nankana Municipal and 1:3400 in the Kassena Nankana West District are considerably below the World Bank recommended extension agent-to-farmer ratio of 1:500. These ratios suggest severe staffing constraint facing extension service delivery in the study area and have implications on outreach activities and the quality of interaction between extension agents and farmers in the provision of technical support to improve uptake of agricultural technologies.
- Economic constraints are major reasons for low integration among smallholder farmers. Given that most households do not have cattle in their kraals anymore, it becomes difficult for smallholder farmers to use animal manure to improve soil fertility. Besides, the costs associated with certified seed and chemical fertilizers to enable a farmer achieve optimum crop yield bring huge financial burden on smallholder farmers who mostly are in the two poorest wealth quintiles.
- Socio-cultural practices hinder knowledge integration. The time spent at funerals and markets reduces the amount of time allotted to farm work and attendance to training meetings with extension agents. Besides the taste of food prepared from hybrid crop varieties does not appeal to farmers and their families and there is also the perception that food prepared from hybrid varieties does not keep well over-night. All these have implications for the kinds of food crops farmers are willing to cultivate and eventually food security.

The fourth research objective addressed how knowledge integration affects household food security situation of different smallholder farmers. The main findings were that:

- Own production is a major food source for majority of smallholder farmers (99%) followed by market purchases (72%). This suggests that sustainable crop production is critical for smallholder farming systems and affirms the role of market in meeting shortfalls in own produced food stock. However, this is only true for households who have the resources to purchase from the market.
- Majority of the respondents (72%) experienced food insecurity period spanning between three and six months mainly due to decline in own production or depletion of food stock as a result of large household size. It does appear that food insecurity still persists in the study area thereby raising concerns regarding efforts to address the situation.
- Even though majority of high resource-endowed smallholder farmers (92%) blended relatively more proportions of western farming practices and technologies (i.e. tractor ploughing, chemical fertilizers, and herbicides), more than half (58%) experienced food insecurity period spanning between three and four months. However, the results showed that smallholder farmers who blend more proportions of western farming practices and technologies are less likely to experience food insecurity.
- In terms of what smallholder households do in order to survive when food stocks run out, the findings revealed that majority of respondents (72%) rely on sale of poultry and small ruminants whereas 61 percent of offer 'by-day' labour services to obtain food when household stocks run out. This suggests that livestock rearing

reduces the risks associated with food crop production and represents liquid assets that can be realized at any time.

7.3 Conclusions

In response to how smallholder farmers describe their farming systems showing how social differentiation define their choice of farming systems, the study concludes that smallholder farmers describe their farming systems in terms of agricultural land use systems and associated practices where high resource-endowed farmers predominantly in lowland and bush farmlands compared to low resource-endowed farmers predominantly in compound farmlands. This is because smallholder farmers' knowledge of the nature and characteristics of the soil defines the type of farmland that supports the growth of the selected crops they cultivate. Even though risk aversion is an important feature in smallholder farming systems, social differentiation among smallholder farmers has considerable influence in shaping their choice of farming systems.

In terms of how differentiated smallholder farmers integrate traditional and western farming practices and technologies and how they rationalize their decisions, the study concludes that high resource-endowed farmers are more likely to blend more proportions of western farming practices and technologies relative to traditional farming practices and rationalize their decisions based on profit associated with market production. Whereas, low resource-endowed farmers largely rely on traditional farming practices and technologies due to lack of funds and the perception that compound farmlands do not require expensive chemical fertilizers to produce traditional food crops for household consumption. Indeed, smallholder farmers are aware of the existence of both traditional and western farming practices/technologies and are making decisions to blend farming practices based on their

prevailing circumstances. Even though a good proportion of households blend the two bodies of agricultural knowledge systems, the manner of blending is neither sufficient to induce sustainable agriculture nor bring about any notable changes to household food security.

The study further concludes that household resource endowment and market incentives are key drivers of agricultural knowledge integration and innovation diffusion. The study has shown that resource endowed farmers usually have relatively large farm sizes at lowland and bush farmlands where high labour cost and time constraints associated with land preparation make it more efficient to use tractor and weedicides (selective or non-selective). Besides, relatively wealthy households often have the ability to cope with production and as a result are more willing to adopt improved technologies to increase crop yields compared to poor households. In spite of these drivers, smallholder farmers are severely constrained by institutional support systems such as limited human resource and logistics, limited access to finance to purchase productivity enhancement technologies, and socio-cultural factors such as frequent participation in social events and fatalism.

With regards to how agricultural knowledge integration affects household food security situation of different smallholder farmers, two conclusions were drawn from the key findings. First, over reliance on traditional farming practices and technologies is adversely affecting household food security situation of smallholder farmers. This is because the use of hoes and cutlasses for weed control amidst scarcity of household labour due to youth migration often effect crop production. Besides, continuous use of low yielding and long maturing traditional crop varieties coupled with limited availability of animal manure often result in low crop yields and thereby affect household food security. Second, smallholder

households who are unable to obtain adequate food from their own production are more likely to experience food insecurity due to the fact that own production constitute a major food source for majority of smallholder households in the study area. However, the evidence has shown that obtaining adequate food from own production is not sufficient guarantee that household will attain food security because there are other intervening factors like household size and depletion of food stock due to funerals and other expenditures that come into play to influence household food security situation.

Consequently, the overall study conclusion is that there exist tremendous opportunities to blend relevant traditional and western farming practices and technologies to enhance agricultural production among smallholder farmers. This is because, both knowledge systems embody rich notions and competitive advantages that can be harnessed to improve household food security in the study area. Consequently, resource-endowed farmers are able to invest in western agricultural technologies to complement traditional farming practices to increase crop production. As a result, high resource-endowed farmers are less likely to experience food insecurity compared to low resource-endowed farmers who rely heavily on traditional farming practices and technologies. Nevertheless, agricultural knowledge integration issues and other intervening factors play critical roles in shaping household food security situation of different cohorts of smallholder farmers in the Kassena Nankana Traditional Area.

7. 4 Recommendations

Based on the literature review and empirical findings from this study, the following recommendations are made:

- For effective synergy in addressing emerging challenges of smallholder agriculture and climate change, the study recommends for both public and private extension agents to adopt the proposed knowledge integration model and process for integrating traditional and western agricultural knowledge systems to facilitate smooth innovation diffusion for sustainable agricultural development. This approach will empower smallholder farmers to better integrate global agricultural technologies to solve the problems facing local communities in the study area. The proposed model directly manifests the felt needs of community people and embodies a store of traditional knowledge and draws on collective capacities from internal and external resources. It is a collaborative approach which supports learning and shared understanding but more importantly, starts and builds on the strengths of local knowledge.
- Given that own production constitutes a major source of food for majority of rural households and poor soil fertility is their major constraint, this study recommends that agricultural development initiatives by government and development partners should emphasize and promote Integrated Soil Fertility Management (ISFM) practices that are technically and financially beneficial to different cohorts of smallholder farmers. This is due to the fact that neither chemical fertilizer nor organic manure alone is sufficient to address the constraints of crop production and productivity. The key is complementarity, whereas organic manure enhances the soil organic matter status, chemical fertilizer can be targeted at specific limiting nutrients.

- Given that resource endowment and market incentives are key drivers of agricultural knowledge integration and innovation diffusion, the study recommends that food security initiatives by NGOs should incorporate components of livestock rearing and market access into their intervention. Livestock rearing serves as a powerful tool in building household resilience to food insecurity. It does not only contribute to food security through provision of cash and nutrition but also enables smallholder farmers to mobilize manure to enhance soil fertility and serve as an affordable source of traction power among rural households. For access to markets, both public and private extension agents should develop linkages and strengthen relationships between the different cohorts of smallholder farmers and the appropriate input/output markets through market access interface meetings, business and finance dialogues.
- Considering the immense importance of the informal seed sector to majority of smallholder farmers which arguably is the most important production factor for crop production in the area, this study recommends for seed scientists and the donor community to support the informal seed sector to integrate with the formal seed sector to systematically upgrade some of its practices to produce high quality seeds, especially crops that are not catered for by the formal seed sector, but serve as the main source of seed for the large majority of smallholder farmers.
- Given that traditional knowledge systems form the basis for local decision-making and problem-solving strategies in agriculture and natural resource management, the need for agricultural policy makers to recognize the essential role of traditional knowledge as a useful tool for sustainable agricultural development, particularly in

rural areas, is critical. This recognition is necessary to ensure effective participation and targeting of the different cohorts of smallholder farmers in agricultural development policies and programmes that are driven by western scientific technologies. In line with the Sustainable Development Goal 2:- which seeks to end hunger, achieve food security and improved nutrition, and promote sustainable agriculture, it is imperative for the National Science, Technology and Innovation Policy of Ghana to recognize the significant role of indigenous resources, traditional knowledge and technology to ensure a holistic national development agenda.

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APPENDICES

APPENDIX I

Interview guide – Institutional Level

This question guide is to solicit information for the sole purpose of this study – "Traditional and Western knowledge systems in smallholder agriculture: harnessing synergies and complementarities for improved household food security in the Kassena Nankana Traditional Area".

All information provided will be treated as confidential and no statement you make will ever be identified with your personality. You are therefore humbly invited to answer the questions below:

- How will you categorize farmers in the Kassena Nankana traditional area? What criteria informed your categorization?
- Which categories of farmers are you working with and why?
- What farming practice/agronomic options/innovations are you promoting among the different categories of farmers and how is extension services delivered?
- What are your perceptions of these farming practices/innovations and the extension delivery systems?
- What are the challenges in promoting these farming practices?
- Does your outfit promote combination of 'traditional' and 'western' farming practices? If yes, how? If no, why?
- Were traditional farming methods part of your training at the agricultural college? Or did you acquire any training from other sources?
- What are the challenges (i.e. physical, technical, gender, approach, cultural, social, economic, time constraint, etc.) associated with combining the two farming practices and how do these challenges affect innovation diffusion?
- In which ways can the two be purposely integrated, and to ensure smooth innovation diffusion to achieve sustainable farming practices?
- What mechanisms can support/promote the integration process at the farmer, institutional and policy levels?

- Given your knowledge of the two districts (KNE & KNW), select two communities per district. The criteria for community selection includes: (i) a community that has reached its land frontier (that is, unable to expand farmlands any further within its own community boundary but may have access to land in neighboring communities) and (ii) a community that still has some virgin lands available for expansion or at minimum, sufficient fallowed lands.

APPENDIX II

Interview guide: Focus Group Discussion (FGD) – Farmers

This question guide is to solicit information for the sole purpose of this study – "Traditional and Western knowledge systems in smallholder agriculture: harnessing synergies and complementarities for improved household food security in the Kassena Nankana Traditional Area".

All information provided will be treated as confidential and no statement you make will ever be identified with your personality. You are therefore humbly invited to answer the questions below:
To describe farming systems showing how social differentiations among smallholder farmers define their choice of farming systems.

- What different categories of land use do you have in this community?
- What are the relationships with the different types of land use?
- Do you have different farms at different places within/outside the community?
- Describe the different kind of farms in terms of:
  - Size of plot, location, and distance from home?
  - Which ones are fragmented and why?
  - Methods of land preparation for the different farms i.e. mechanization, animal traction, hoe, slash and burn, weedicides, labor (family/hire) and why?
  - Crops/vegetable composition cultivated on the different kind of farms and why?
  - Cropping practices (i.e. multiple/mono-cropping/plant phasing) employed for the different kind of farms and why?
  - Input application i.e. seeds, fertilizer, herbicides, pesticides, etc. and why?
  - Methods of weeds control on the different kind of farms and why?
  - Strategies/technology to maintain/regain the fertility of the different kind of farms and why?
  - How different soil characteristics influence your choice of the different farms?

- Why it is necessary to have different kind of farms?
- Associated farming practices/technology applications for the different kind of farms?

- How would you categories/classify farmers wealth wise in your community?
- Can you describe the kind of farms owned by the rich group and those of the poor farmers – what accounts for this differences or similarities if any?
- What influences the different categories of farmers in their choice of the different farms?
- Mention three (3) most pressing constraints affecting crop production in your area? Do these affect the different wealth groups the same? What about gender too?

To examine how differentiated smallholder farmers integrate traditional and western agricultural knowledge systems and how they rationalize their decisions.

- What farming practices have you inherited from your parents/grandparents (traditional)? And what are your perceptions of these farming practices?
- Which of these farm practices are you using still and which have you stopped. Explain why? What makes it difficult for you to continue with them nowadays?
- What farming practices have you learnt from extension agents (western)? And what are your perceptions of these farming practices?
- Which of these methods do you use on your farms – which farms do you use these on and which ones do you maintain only traditional methods. Explain why?
- What makes it difficult for you to apply the modern methods in your farming activities?
- What new ways have you developed yourself to achieve good crop yields?

To examine driving factors and the challenges associated with integration with special focus on diffusion of innovation.

- How have you combined ‘traditional’ and ‘western’ farming practices at the various stages of production (i.e. pre-production, production & post-production)?
- What is the level of combination and why?
- What factors (i.e. physical, technical, gender, cultural, approach, economic, social, etc.) make it difficult for you to combine ‘traditional’ and ‘western’ farming practices?

- How would these factors affect the degree of innovation diffusion?

To examine how knowledge integration affects household food security situation of differentiated smallholder farmers.

- What are the sources of food for your household?
- Which food source do you consider as the most important?
- Does the crops/vegetables you cultivate able to provide adequate food for your household throughout the year?
- If no, which of the month/s of the year were you unable to provide enough food for your household?
- What may account for food shortages in your household?
- How is your household able to cope when you do not have enough food to feed?

To recommend strategies for effective blending of the two knowledge systems to facilitate innovation diffusion for sustainable smallholder farming systems

- In which ways can 'traditional' and 'western' farming practices be purposely combined to achieve good crop yields?
- What approach will promote smooth innovation diffusion to achieve sustainable agricultural practices?
- What mechanism/systems can support the combination process at the famer, institutional and policy levels?

APPENDIX III

Survey Questionnaire

This question guide is to solicit information for the sole purpose of this study – "Traditional and Western knowledge systems in smallholder agriculture: harnessing synergies and complementarities for improved household food security in the Kassena Nankana Traditional Area".

A n provided will be treated as confidential and no statement you make will ever be identified with your pe u are therefore humbly invited to answer the questions below:

Se onal Information

Dis				**Communit y:**		
A1 of l	**ad**			**Sex:**	1 = Male	2 = Female
A2	**us:**	1 = Married	2 = Not Married	3 = Widowed	4 = Divorced	5 = Separated
A3 sch	**l of d**	1 = No school	2= Primary/JHS	3=Middle/O'Level/Vocational/ Commercial	4 = A 'Level / SHS	5 = College/ Polytechnic/Univers ity
A4 hou	**of**	1 = 31-40	2 = 41-50	3 = 51-60	4 = 61-70	5 = 71-80	6 = 81-90

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Section B: Household Information

B1. No. of household members	**B2. No. of household members less than 15 years of age**	**B3. No. of household members between 15 – 65 years**	**B4. No. of household members above 65 years**

B5. How many of the following livestock do your household own? Tick	B6. How many of the following assets do your household own?
1. Adult male cattle/bull 2.Adult female cattle 3.Young cattle 4.Donkey 5. Pigs 6 7 8 9 1 l 1	1. Tractor 2. Thresher 3. Silo 4. Animal drawn cart 5. Bicycle 6. Motorcycle 7. Motor-king 8. Cell phone 9. TV Set 10. other

Se ning Systems and Social Differentiation of Farmers

C1 gaged in crop production? 1 = [ ] Yes 2 = [ ] No

C2 different types of farms? 1 = [ ] Yes 2 = [ ] No

C3 they located? 1 = within the community 2 = Outside the community 3 = within and outside the community 4 = o)

C4 e following farms/plots do you own? 1. Kaduga/Samane **(compound**) 2. Bollo/Borim **(valley**) 3.F **Bush)** 4. Other

C5 size of your different types of farms?

Different types of farms	Farm size (Acres)				
Kaguga/Samane	1= 0 – 0.5	2= 0.5 – 1	3 = 1 – 1.5	4 = 1.5 – 2	5 = 2.5 - 3
Bollo/Borim	1 = 0 - 1	2 = 1.5 – 2	3 = 2.5 - 3	4 = 3.5 - 4	5 = 4.5 - 5
Kara/Vatiim	1 = 0 - 1	2 = 1.5 – 2	3 = 2.5 - 3	4 = 3.5 - 4	5 = 4.5 - 5
Other					

C6.Which of these crops did you cultivate on your different types of farms this year?

SN	Crop	Type of farm and cropping system											
		Kaduga/ Samane	Mono-cropping	Mixed-Cropping	Inter-cropping	Bollo/Borim	Mono-cropping	Mixed-Cropping	Inter-cropping	Kara/Vatiim	Mono-cropping	Mixed-Cropping	Inter-cropping
1													
2													
3													
4													
5													
6													
7													
8													
9													
1													
1													
1													
1													
1													
15	Other												

C7.Which of these farming practices or technologies did you use on your different types of farms this year?

SN	Farming practices	Type of farm		
		Kaduga/Samane	**Bollo/Borim**	**Kara/Vatiim**
1	Animal (bullock) traction			
2	Slash and burn (shifting cultivation)			
3	olough			
4	eding with hoe			
5	sowing with stick dibbler/hoe			
6				
7	eedicide/herbicide			
8	nting			
9	ping			
1	ropping			
1	ation			
1	ertified seeds (Hybrid seeds)			
1	seeds (Own seeds)			
1	manure/compost			
1	r			
1	t			
1	age			
1	pecify)			

C8 normal crop yield for your different types of farms?

Crop(s) cultivated	Crop yield for the different farm types per 100 kg bag		
	Kaduga/Samane	**Bollo/Borim**	**Kara/Vatiim**
Main crop 1:…….			
Main crop 2:…….			
Main crop 3:…….			

3

C9. In order of priority, which of the following constraints affect your farming activities the most?

Production constraint	**Ranking**
Rainfall variability	1
Timely ploughing service	2
P ty	3
U arket	4
C	5

SE ntegration of traditional and western farming practices

D1 nbine traditional and western farming practices on any of your farms this year? 1. [ ] Yes 2. [ ] No

D2 our different farms did you combine both traditional and western farming practices?

1 nane 2 = Bollo/Borim 3 = Kara/Vatiim 4 = other (specify)

D3 s is difficult for you to continue to apply traditional farming practices on your farm?

N		**Tick**
1	al crops are long maturing varieties	
2	Traditional crops are low yielding	
3	Scarcity of cow dung	
4	Advent of modern technologies	
5	Time constraint	
6	Other (specify)	

D4. What makes it difficult for you to use western farming practices on your farm?

No.		Tick
1	Time consuming	
2	Lack of appropriate or complimentary tools to facilitate adoption	
3	Lack of capital to acquire such technologies	
4	te knowledge of recommended practices	
5	the recommended practices, such as 2 seeds of groundnuts per stand, is a waste of limited available	
6	ecify)	

D5 level of integration of traditional and western farming practices?

	l = a larger percentage of western farming practice has been adopted relative to traditional farming practice = a smaller percentage of western farming practice has been adopted relative to traditional farming practice

	Type of farms					
	Kaduga/Samane		Bollo/Borim		Kara/Vatiim	
Spe pra	**1**	**2**	**1**	**2**	**1**	**2**
Giv						

SE ood Security Situation of differentiated farmers according to levels of integration

E1. What are the sources of food for your household? Tick as applicable.

1	Own farm production	
2	Supplies from relatives and friends	
3	Borrowing or credit	
4	Government/ NGO assistance	
5	Purchased food	

6	other (specify)	

E2. Of the ones indicated above, which do you regard as most important: ……

E3. In the past four (4) weeks, were you or any household member not able to eat the kind of foods you preferred because of lack of resources? 1 = [ ] Yes 2 = [ ] No

E4 did this happen?

1	ce or twice in the past four weeks)	
2	s (three or ten times in the past four	
3	e than ten times in the past four weeks)	

E5 four (4) weeks, did you or any household member go to sleep at night hungry because there was not en

1 = 2 = [ ] No

E6 did the happen?

1	ce or twice in the past four weeks)	
2	s (three or ten times in the past four	
3	often (more than ten times in the past four weeks)	

E7. In the past twelve (12) months, did your household experience any food shortages? 1 = [ ] Yes 2 = [ ] No

E8. If yes, what were the main reason(s) for these food shortages?

No.	Reasons for food shortage	Tick as it apply
1	Decline in own farm production because of draught	
2	Decline in own farm production because of rainfall variability	
3	Decline in own farm production because of usage of traditional crop varieties	
4	Decline in food supplies from relatives and friends	
5	in household expenditures due to illness/funerals/educational expenses of household s)	
6	usehold size	
7	ning and management of food crop harvested	
8	ecify)	

E9 twelve (12) months, were there any months when your household did not have enough food to meet the ho d needs? 1 = [ ] Yes 2 = [ ] No

E1 cate which months your household did not have enough food to meet the household's needs?

J	MAR	AP R	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC

E1 your household able to cope when you do not have enough food to feed?

	ehold coping mechanism	Tick
1	Selling of livestock	
2	Borrow from other relatives	
3	Sheanut picking	
4	Firewood and charcoal burning	
5	Work by day to earn income	
6	Reducing the number of daily meals	
7	Other (specify	

APPENDIX IV

Interview guide: Household head in-depth interview

This question guide is to solicit information for the sole purpose of this study – "Traditional and Western knowledge systems in smallholder agriculture: harnessing synergies and complementarities for improved household food security in the Kassena Nankana Traditional Area".

All information provided will be treated as confidential and no statement you make will ever be identified with your personality. You are therefore humbly invited to answer the questions below:

Section A: General and Personal Information

District: …… Community: …….

Name of HH head: …… Sex: …….. Age: …….

Marital status: ……..… Highest school completed: ……

Section B: Household Information

- Number of HH members: ……. Number of HH members age 18 and above:.. …..

Section C: Farming systems of different categories of farmers

- Do you have different farms at different places within/outside the community?
- What method did you use for land preparation for the different farms and why?
- What type of crops/vegetable did you cultivate on the different kind of farms this year and why?
- What cropping patterns (i.e. multiple/mono-cropping/plant phasing) did you employ for the different farms and why?
- What other farming practices/technology did you apply on your different kind of farms and why?
- Why it is necessary to have different kind of farms?
- What informed your choice of the different farms?
- Production constraints – what are farmers' perceptions of the causes? What are the copping strategies to the risks and uncertainty

Section D: Integration of traditional and western farming practices

- Which of these farm practices are you using still and which have you stopped? Explain why? What makes it difficult for you to continue with them nowadays?
- What farming practices have you learnt from extension agents (western)? And what are your perceptions of these farming practices?
- Which of these methods do you use on your farms – which farms do you use these on and which ones do you maintain only traditional methods. Explain why?
- What makes it difficult for you to apply the modern methods in your farming activities?
- What new ways have you developed yourself to achieve good crop yields?

Section E: Challenges associated with integration with focus on diffusion of innovation

- Which of your farms did you integrate traditional and western farming practices?
- What is the level of integration and why?
- What factors (i.e. gender, cultural, approach, economic, social, etc.) make it difficult for you to combine 'traditional' and 'western' farming practices?
- How would these factors affect the degree of innovation diffusion?
- What are some of the benefits of integration?

Section F: Food security situation of the different categories of farmers

- What are the sources of food for your household?
- Which one do you consider as the most important source?
- Does the crops/vegetables you cultivate able to provide adequate food for your household throughout the year?
- If no, which of the month/s of the year were you unable to provide enough food for your household?
- What may account for food shortages in your household?
- How is your household able to cope when you do not have enough food to feed?

Section G: Strategies for effective integration/hybridization of the two systems

- In which ways can 'traditional' and 'western' farming practices be purposely combined to achieve good crop yields?

- What approach will promote smooth innovation diffusion to achieve sustainable agricultural practices?
- What mechanism/systems can support the integration process at the famer, institutional and policy levels?