

**UNIVERSITY OF GHANA
COLLEGE OF HUMANITIES**

**LOCAL FARMING SYSTEMS AND FOOD SECURITY IN THE
BUILSA AREA OF NORTHERN GHANA**

BY

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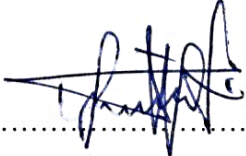
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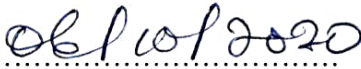
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DECLARATION


I declare that I am the sole author of this work, which was undertaken under the supervision of Professors Joseph Awetori Yaro, Joseph Kofi Teye, and Dr John Kusimi Manyimadin. All secondary sources in the work have been duly acknowledged.



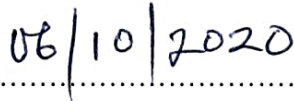
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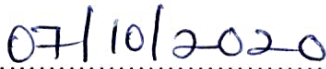
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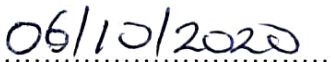
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DEDICATION

This work is dedicated to my wife Awenjaab Bertha Awentemi and my children Awenlie Awen-Naam, Awenkanaab Awen-Naam, Akantariwen and Akanpentiwen for their support and co-operation during my study.

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ABSTRACT

Societies are dynamic: so too are the farming systems that provide their food and other needs. The study examines transitions in farming systems and their contribution to food security at the household level. This is important as most people in rural areas rely on farming for their basic needs. These systems are under pressure from both external and internal forces with diverse impacts on food and livelihoods. A mixed-methods approach, which combined a survey with different qualitative strategies was used to investigate transitions, local conceptualisations of sustainable farming, and the contribution of local farming systems to food security. The results show important transitions in farming practices as most farm households are shifting from traditional to modern farm practices. These shifts, which involve the move to mechanical methods of tillage; the cultivation of new varieties of existing crops; the increasing use of external inputs; and increases in acreage; vary across space as access to these exclude poor households. The study additionally found that, locally, there are varied conceptualisations of sustainable farming; but most farm households generally considered sustainable farming as good yields at the end of a farming cycle. Markers of sustainability were derived from focus group discussions to measure the ecological, economic, and social domains of sustainable farming. Results from the survey showed that more than two-thirds of farm households did not perceive their farming systems as sustainable within all the domains of sustainable farming. Results from focus groups, informal conversations, and in-depth interviews show that farming systems in Builsa contribute differently to food security. The contributions of the various farming systems are very important because of the integrated nature of the livelihood activities of farm households. However, a probit regression model shows that farm households are better off if they combined the bush farming system with other systems in their pursuit of food security at the household level.

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LIST OF ACRONYMS

| | |
|-------------|--|
| AHP - | Analytical Hierarchy Procedure |
| CA - | Conservation Agriculture |
| CA - | Conjoint Analysis |
| CHPS - | Community-Based Health Planning and Services |
| CSIR-SARI - | Council for Scientific and Industrial Research/Savannah Agricultural Research Institute. |
| FAO - | Food and Agricultural Organisation |
| FAO - | Food and Agriculture Organisation |
| FSR - | Farming Systems Research |
| IFAD - | International Fund for Agricultural Development |
| MIS - | Management Information Systems |
| OA - | Organic Agriculture |
| SAPs - | Structural Adjustment Policies |
| SDGs - | Sustainable Development Goals |
| SI - | Sustainable Intensification |
| SQC - | Quality Control Charting |
| T.Z - | Tuo Zafi |
| UNICEF - | United Nations Children's Fund |
| WFP - | World Food Programme |
| WHO - | World Health Organisation |

CHAPTER 1

INTRODUCTION

1.0 Background to Study

Societies are dynamic as are the farming systems specific to them that form the base for the production and distribution of food and other ecological services that meet their needs. Farming systems in the tropics -are difficult to define due principally to their heterogeneity (Benneh, 1973; Mellor, 2014; Merzt & Knipscheer, 1981) emanating from the differential endowments in ecological, economic, and social resources and underpinned by both exogenous and endogenous influences (Houssou, Johnson, Kolavalli, & Asante-Addo, 2016; Schiere, Darnhofer, & Duru, 2012). However, for this study, the term farming system is used to denote households and their capabilities, with members appraising and efficiently applying both the biophysical (land) and socio-economic resources at their disposal to produce outputs for their immediate needs and surpluses for sale. Farming systems are dynamic systems evolving spatially and temporally with differential results to different categories of people in space and time (Schiere et al., 2012). This study provides an analysis of the sustainability of changes in farming systems among the heterogeneous farming population of the Builsa area showing how differential change factors and dynamics lead to different outcomes in food security.

Throughout history, there has been a rise and fall in the performance of farming systems with noted examples being the Mesopotamian and Western Europe in medieval times (Schiere et al., 2012). There are also recorded food and resource movement from the developing countries to the developed countries during the first food regime (1870-1930) and a reversal of this in the second (the 1950s -1970s) and third (1980s to the present) food regimes (Holt Gimenez & Shattuck, 2011; Ruttan & Harald, 1988). Within the current food regime, Africa alone is noted to spend around 35 billion annually on food imports (Thorp,

2014). This study is situated within the third food regime, which is witnessing production and distribution shortfalls in developing countries with most having their food needs being met through imports (Gomiero, Pimentel, & Paoletti, 2011; Payne, 2010). While on a global scale, there are transitions in farming systems that have produced more food on average, production gains differ across regions, nations, and households. The developed world has experienced a major transition in their agricultural sector from traditional to intensive input use, reliance on machine power, and research that produced surpluses for them (Kinney, 1990; Lang & Heasman, 2015). This is not the same for the developing world, which has most of its agricultural sector revolving around the traditional model and described as stagnant and incapable of providing enough food to feed the populace. Sub-Saharan Africa is, for instance, characterised by a declining food output per capita, a shrinking arable land size, reduced fallow periods, and declining soil fertility rates (Ellis-Jones et al., 2012; Meijer, Catacutan, Ajayi, Sileshi, & Nieuwenhuis, 2015).

Efforts by governments and development partners from the 1950s onwards were geared towards ending hunger in the developing world through a Green Revolution – agricultural led development approach (Schiere et al., 2012; Witcover & Vosti, 2006). This was aimed at improving output per unit input in agriculture to feed an increasingly hungry population. The attempt witnessed the introduction of technologies such as irrigation farming, improved seeds and external inputs in the developing world. Similar arguments are used to currently justify the transition to the use of genetically modified organisms in the developing world as an attempt to solve the food insecurity problem. These transitions, however, have some consequences for sustainable food production and access in rural areas as they tend to deprive rural people of access to critical productive resources or compromise the sustainability of their farming systems.

Scholars have advocated for studies into transitions in farming systems as it will help to improve better-performing ones and to discard those that are inimical to local ecological, economic and social systems (Benneh, 1972; Schiere et al., 2012). Yet, fewer attempts are made at analysing these changes at the local level and in assessing their sustainability and contribution to food security among smallholder farmers in rural areas. There have been changes in farming systems in Ghana since colonial times. These changes are not uniform and are skewed towards the commercialisation of non-food crops in the southern parts of the country with little or no improvements in the agricultural systems in northern Ghana. The only crop that was officially commercialised in northern Ghana was cotton. However, the cotton sector saw low patronage as a result of labour shortages due to deliberate policies by the colonial administration to encourage labour migration to mining areas in the south. Poor transportation networks made it difficult to convey goods to the markets, coupled with the fact that most peasants had no other way of meeting their food needs if they devoted all their efforts to cotton farming or commercial agriculture. These and other factors made this attempt less successful (Dickson, 1968; Sutton, 1989). Earlier observers have, thus, described the farming systems in the north of Ghana as ‘failed’, ‘unmodified’, and ‘problem-ridden’ as they could not meet the food needs of the local population since colonial times (Dickson, 1968; Sutton, 1989).

The Builsa area is within northern Ghana and characterised by smallholder farmers growing a variety of crops to feed themselves and only sell the surpluses on the local markets. The surplus sales are aimed at generating income to support other household activities. This area is noted to have benefited less from the gains the country made towards reducing poverty recently (Al-Hassan & Poulton, 2009). The farming systems from which most inhabitants draw their livelihoods are known to be transitioning in terms of implements used, crops grown and animals kept (Yaro, 2008). It has been observed that poverty is more of a rural phenomenon, although there are rising numbers of urban poor, and it is most concentrated

among food crop farmers in the northern parts of Ghana (GSS, 2012, 2014c). Poverty is also more concentrated among female-headed households in the Builsa area. This area has a relatively lower share of income generated from non-and-off-farm income activities. Most households receive income from remittances but that has been observed to be insignificant in triggering accumulation, although remittance can be an effective redistributive mechanism against poverty and food insecurity (Andersson, 2011). With weaknesses of diversifying from purely farm activities and remittances in meeting food needs of the people in the Builsa area, there is need to look into the state of the farming systems and how they can be made more sustainable. Sustainability of farming systems is crucial as the majority of people in this area rely on farming to meet livelihood needs.

The farming systems of the Builsa area relied mostly on natural means of restoring soil fertility (Benneh, 1972; Dickson, 1968; Sutton, 1989). However, globalisation and other capitalist forces are leading to changes in access to land and other resources for farming. While these forces in combination with internal processes create non-farm opportunities for farm households they also lead to patterns of displacement and dispossessions within the rural space (Amanor & Pabi, 2007; Hesselberg & Yaro, 2006). This makes it important to study the sustainability of the farming systems of the Builsa area from the perspectives of the local farm households.

1.1. Problem statement

Agriculture plays multiple roles for humans as it contributes to improved livelihoods, reduce poverty, generate income, serves recreation purposes, and provides other ecological functions globally and locally (Christiaensen, Demery, & Kuhl, 2011; Garnett, 2013; Zhou, Minde, & Mtigwe, 2013). Even more critical is its direct supply of food and income to most rural people in developing countries and noted to be capable of reducing poverty among the poorest of the poor (Alston & Pardey, 2014; Christiaensen et al., 2011; Demissie & Legesse,

2013; Dixon, Gibbon, Gulliver, & Hall, 2001; Foresight, 2011). Like most developing countries, agriculture is the main employer in rural Ghana and critical in providing the food and other basic needs of the rural population (GSS, 2014). However, there are fears that modern agriculture may not be able to continue to play its role properly under increasing population pressure, limited and degrading natural resource base, growing affluence and changing diets, neoliberalism, globalisation, global capitalism and with the neglect of the farming systems in rural areas by states in developing countries (Antwi-Agyei, Dougill, Fraser, & Stringer, 2012; Luabe, 2015; Mazoyer & Roudart, 2007; Yaro, 2008, 2013a). This situation has implications on the sustainability of the farming systems in the Northern parts of Ghana thus necessitating some form of studies since they directly impact the food needs of the local population. Additionally, there are transitions in these farming systems but much is not documented on the rate of change and their impacts on food security (Fresco & Westphal, 1988).

Recent works have observed transitions in the farming systems in Ghana towards agricultural intensification. The form of intensification in Africa is towards labour-saving rather than land-saving approaches contrary to what was witnessed in the Asian Green Revolution (Houssou et al., 2016). As farming systems are transitioning from traditional to conventional modes of food production, ownership of productive resources for subsistence production is being gradually shifted away from households to a complex food regime (von Braun & Brown, 2003). An empirical gap to be addressed here is the forms these transitions are taking in the Builsa area and which forms are contributing relatively more to food security. With hunger and malnutrition being persistent and of high prevalence in the developing world, doubts are cast on the ability of the current farming systems in guaranteeing a hunger-free and malnutrition-free world now and into the future (Welch & Graham, 1999). The need for agriculture to deliver sustainable and nutritious food for the

world's populace is not in doubt, but it is argued that the current form of agriculture, which delivers most of our food, needs to be transformed to be able to achieve such a feat without causing further damages to ecosystems and people (Fan & Brzeska, 2016; von Braun & Brown, 2003; Welch & Graham, 1999). As there is a consensus that agriculture needs to transform into a sustainable form there are debates on the route that transformation should take (Keating, Herrero, Carberry, Gardner, & Cole, 2014). These debates leave gaps that span from describing and documenting transitions in farming systems at the local level to what is to be considered as sustainable farming (definitional problems) and measuring what constitutes sustainable farming. The local specificity of farming systems makes my study relevant in the sustainability debate as this is capable of overcoming the one-size-fits-all approaches to heterogeneous farming systems in developing countries by conventional thinking.

It is contested by Wiggins (2000b) that most food produced and consumed locally in Africa is not captured by FAO statistics, and thus erroneously paints a gloomy picture of the food security situation in the region. There has however been evidence of the inability of the farming systems in developing countries to meet the food needs of the local population. Population growth in sub-Saharan Africa has been observed not to match food production since the 1960s (Alston & Pardey, 2014; Pretty & Bharucha, 2014; Pretty, Toulmin, & Williams, 2011; Vanlauwe, Coyne, et al., 2014). While there are yield increases in the top cereals in Africa per annum, a demand gap exists, with most of Sub-Saharan African' cereal needs to be met through imports (Van Ittersum et al., 2016). The agricultural systems of developing countries are thus viewed to be constrained by inadequate use of external input, deficient land tenure systems, inadequate infrastructure to facilitate access to capital and markets with little use of external energy (Callo-Concha, Gaiser, & Ewert, 2012).

Based on the low productivity of these systems, several options for meeting household food needs have been proposed. Some suggest the need to close yield gaps as differences exist between potential and actual yields in the farming systems of the developing world (Van Ittersum et al., 2016). Others argue for ecological intensification, which relies on the pursuit of methods that boost farming systems productive gains without compromising natural ecosystems while others advocate for sustainable intensification. The general debate on the pathways to achieve sustainable agricultural growth is between traditional and conventional approaches to agriculture development (Caron, Biénabe, & Hainzelin, 2014). While the former advocates for agriculture that mimics nature and uses less of external inputs by relying on local resources and indigenous knowledge (Caron et al., 2014), the latter is asking for more increases in output per unit input in agriculture by relying on external input. Proponents of the conventional approach have assumed that the increasing global population needs to be fed at all cost and this will require increasing outputs per unit inputs (Caron et al., 2014; von Braun & Brown, 2003). With the current agricultural system more aligned to the conventional approach, most proponents are asking for agricultural commercialisation, farm exits, livelihood diversification and a new green revolution for African farmers as new ways of solving the food security problem of rural people (Afework & Endrias, 2016).

It is also argued that an effective way of improving food security on a sustainable basis in the developing world is through ecological intensification (Tscharntke et al., 2012). Ecological intensification entails the friendly replacement of anthropogenic inputs with biological means of food production (Bommarco, Kleijn, & Potts, 2013). This claim has been contested as it is noted in some parts of West Africa that the natural way of replacing soil fertility is no longer adequate in meeting the food needs of households from own production (Kaya, Hildebrand, & Nair, 2000). Likewise, the processes of replacing natural nutrient cycles with inorganic fertilisers have been observed to pose both short- and long-term environmental problems. Beyond these, are issues of social justice, political stability

and the exclusion of poor farmers from the use of productive resources (Caron et al., 2014). A new paradigm is thus required to make farmers more resilient and agriculturally more sustainable. It has been advocated that agriculture should transition from a chemical regulation to a biological regulation (Caron et al., 2014).

A theory that has had much influence on the evolution of agriculture in the tropics is that of Boserup (1965), which was extended by Ruthenberg (1971). These scholars identified stages of transformation in local agricultural systems under the principal factors of population growth, land shortages, and technology. The evolution theory envisages agriculture to progress along a linear trajectory from shifting cultivation where land is abundant to permanent systems where land is scarce. This theoretical position has been criticised by some authors for not considering present circumstances in its account (Fischer-Kowalski et al., 2011; Guirkinger & Platteau, 2015). Beyond the evolution theories, entitlement and livelihood frameworks have been used to understand how people in rural spaces make a sustainable living. Sustainable livelihoods frameworks have been very broad making their applicability in understanding sustainable farming very cumbersome as observed by some scholars (Scoones, 2009; Yaro, 2004a).

Beyond these, attempts have been made in understanding how farm households perceived the sustainability of their farming systems. These attempts, however, observe differences in perceptions of sustainable farming among local farmers but failed to include a gender dimension (Cosyns, Van Damme, & De Wulf, 2013; Vilei, 2011). Also, attempts at explaining how different factors influenced a household choice of given farming practices and how that is linked to food security at the local level are not well articulated by many studies. Additionally, most studies on sustainable agriculture are indicator-based studies. While the use of indicators in measuring sustainable farming is arguably not a bad idea, the selection of indicators is overly concentrated within academics and experts' circles. This

study addresses these shortfalls by using a mixed-method approach that, in addition to generating a general pattern of the nature of the farming systems, elicits farmers' views on the concept of sustainable farming. Solutions to addressing sustainable farming are often debated among experts with little involvement of rural farmers (Keating et al., 2014; Kuyper & Struik, 2014). Farmers in rural areas are however those who can initiate change at the production stage towards a sustainable farming system (Ryan et al., 2016; Schiere et al., 2012). They are also the ones affected by policies from the results of these debates and yet, their views are hardly considered in the policy space. To address this gap, the focus of the thesis assesses how farmers in the Builsa area of Northern Ghana perceive of the sustainability of their major farming systems, the constraints faced and the differential contributions of these systems to local food security.

Additionally, it has been recognised that, although the differing management styles of farmers contribute significantly towards maintaining the ecology of difficult environments, policies do not often take this diversity into account (Morgan-Davies, Wilson, & Waterhouse, 2017). Frelat et al. (2016) are of the view that a better way through which policy can contribute to food security in Africa is to recognise and understand the diversity of livelihood strategies pursued by smallholder farm households instead of a single strategy. A study of the farming systems in the Builsa area will contribute empirically to identify the differential strengths of various farming systems and categories of farmers employing these. The homogenous ascription to local farming systems needs disaggregation to show how different sub-systems and those combining these in different proportions for various reasons achieve varying food security outcomes. This study shows how farming systems are transitioning over time, with different outcomes for different farmers with different characteristics. It specifically differentiates between farmers using ecological intensification or conventional intensification and hybrid systems. Previous studies have not systematically examined transitions in local farming systems and often in an ad-hoc manner described them

as either traditional or modernised without assessing the sustainability dimension, which is key to food security. Knowledge from this study provides quality inputs into policy and strategies in agriculture and rural development planning and meeting the sustainable development goals in Ghana.

1.2. Objectives and research questions

The main objective of this study is to assess changes in farming systems and how farmers perceive the sustainability of farming systems and their contribution to food security in the Builsa area of Northern Ghana. This research contributes to the understandings of the concept of sustainable farming. The research responds to the specific question of how farmers perceive the concept of sustainable farming and if their farming systems are sustainable and can contribute to their food needs. Empirically, it contributes to identifying farming systems and the elements that contribute to make them relatively sustainable and more food secure. In answering the main objective, transitions in farming systems were assessed and farmer's views solicited on how sustainable evolving farming systems are. This study is based on the assumption that there is a need for sustainable farming systems in rural areas and this can be done by allowing rural people to define what constitutes sustainability to them. The study addresses the following specific objectives and research questions.

1.2.1 Sub-objectives

1. To analyse the local farming systems and detail changes that have occurred over the past three decades.

Q1. How have farming systems transitioned in the Builsa area over the past three decades?

2. To assess the sustainability of the farming systems in the Builsa Area based on the perceptions of farmers.

Q2. How sustainable do farmers perceive their farming systems?

3. To discuss the forces influencing the sustainability of local farming systems in the Builsa Area.

Q3. What are the forces that affect sustainable farming practices in Builsa?

4. To measure and discuss the contribution of the local farming systems to food security of all categories of households.

Q4. Which farming sub-systems have a better promise of ensuring food security for the poor?

1.3 Significance of the study

The study contributes to our understanding of how different farm households interpret and respond to global and local dynamics influencing their farming systems. These interpretations help to explain how space, place and time are configured and reconfigured by macro and microeconomic, social and ecological drivers (Faulconbridge & Beaverstock, 2009). Socially, this understanding helps explain the effects of these drivers on the lives of rural people and to formulate policies that will enhance sustainable farming systems and food security in Builsa and other parts of the country. It is additionally important to guide farmers towards farming systems that are relatively more ecologically friendly, economically viable and socially productive.

Theoretically, more light was shined on pathways to pursue in the rural development debates. These pathways are often debated among experts with little input emanating from the local people. Keating et al. (2014), for example, sought experts' opinions on the pathways through which the demand and supply balance of food can be met for the next 40 years. This study integrates the views of local farmers on how they conceive of sustainable farming and if their farms are sustainable. It also addresses issues of the contribution of these systems to local food needs. Which models are more sustainable and can contribute to reducing the food security problems of rural areas? Concerning policy, findings from this study could contribute to providing an enabling policy framework to enhance or promote sustainable agricultural practices. The scholarship has documented changes in West African farming systems but such findings failed to influence agricultural policy (Amanor & Pabi, 2007). Additionally, it has been recognised that, although the differing management styles of farmers contribute significantly towards maintaining the ecology of difficult environments, policies do not often take this diversity into account (Morgan-Davies et al., 2017). Frelat et al. (2016) are of the view that a better way through which policy can contribute to food security in Africa is to recognise and understand the diversity of livelihood strategies pursued by smallholder farm households instead of a single strategy. This study will contribute to addressing this by identifying the most successful farming systems that are sustainable and need policy support at the local level.

In Sub-Saharan Africa, it is argued that food security challenges are the result of fallouts from ideology instead of implementing policies drawn from the experiences of farmers (Aerni, 2011). This work has contributed to developing sustainable agricultural policies drawn from farmer experience rather than merely ideology nor the history of foreign civilisations. In contributing to rural development policy this research explored which policies are enabling to the development of sustainable farming systems and which are not. The changes in agricultural organisation immediately after the post-independence period

saw the introduction of mechanised farms with high-yielding crop varieties and external farm inputs. This leads to issues of dispossession as wealthy households can take advantage of the communal land ownership systems to plough more lands and put them under continuous cultivation thus depriving the underprivileged ones (Amanor & Pabi, 2007).

1.4 The organisation of the dissertation

The study has eight chapters. Chapter One covers the background to the study. This includes an introduction, problem statement, research objectives and questions, justification and the organisation of the work. Chapter Two covers the literature review and theory. Here both ontological and theoretical underpinnings of the study are addressed. Chapter Three focused on the research design, which is mixed methods combining both quantitative and qualitative techniques and instruments in data collection and analysis. Chapter Four analyses transitions in farming systems in recent times. This was achieved through the use of descriptive statistics with results presented in tables. This chapter describes the main farming systems - compound, bush, valley and now riverine in the study area. It details changes in these systems in the past three decades. Chapter Five looks at how farm households conceptualised and measured sustainable farming. This was done within the ecological, economic and social domains of sustainable farming with variables for the assessment generated through focus group discussions. Chapter Six covers the forces influencing sustainable farming in the study area. Chapter Seven assess the contributions of the farm systems to food security with the last chapter (8) containing the conclusion and some recommendations for policy implementation in Builsa

CHAPTER 2

LITERATURE REVIEW AND THEORY

2.0 Introduction

This chapter reviews the literature on sustainable farming and its contribution to food security in developing countries. It also examines the nature of agricultural development before the Green Revolution and how that has changed after the revolution. Approaches that were used to support agricultural development are also reviewed. It concludes, by presenting a conceptual framework that attempts at defining and measuring the sustainability of farming systems at the local level.

2.1 Background to transitions in farming systems and food security

Paradigms to agricultural development, according to Yaro (2004b), have proceeded in a Kuhnian style, with one paradigm and its set of ideas and methods about agriculture research and development being replaced by another paradigm, albeit with the new paradigm not jettisoning all the ideas and methods of the old one. Before the 1960s, agricultural development in rural areas was mostly pursued using a traditional model that was geared towards self-sustenance in household food needs with little surpluses exchanged for household upkeep (Azman, D'Silva, Samah, Man, & Shaffril, 2013; Mansour, 1980). With self-sustenance as the driving force, the household becomes the basic unit through which food and other basic needs are delivered. This objective of farming had a farm management approach before the 1900s that was more holistic and multidisciplinary. It mimicked nature and adopted a non-exploitative philosophy with it in most developing countries (Mansour, 1980).

The traditional approach was succeeded in the last 100 years by an old production paradigm, marked by a heavy dependence on external input and new cultivars, which increased agricultural production in many countries globally (Mazoyer & Roudart, 2007; Nin-Pratt &

McBride, 2014; Welch & Graham, 1999). Even though this paradigm was successful in increasing global food per capita, it at the same time degraded the environment and threatened the very natural resource base on which agriculture thrived. It failed to link farming systems sustainability to food systems sustainability (Grove & Edwards, 1993; Welch & Graham, 1999). This resulted in increases in the number of malnourished people globally with a higher proportion in developing countries (Muttarak, 2018). In the 1980s, agricultural development theory shifted to the sustainability paradigm, which emphasised high productivity with an increase in environmental health and maintenance of the natural resource base (Welch & Graham, 1999).

Static theories and frameworks were used in analysing the performance of farming systems or land use before the introduction of Green Revolution strategies (Block & DuPuis, 2001; Horvath, 1969; Thünen, Hall, & Thünen, 1966). These theories were interested in how isolated places exploited the land and its related attributes in meeting farming needs. Static theories were succeeded by evolution theories following the discovery that no farming system existed in isolation. Improvements in technology overcame most of the initial assumptions of static theories concerning agricultural development. The evolution theory envisaged a linear trajectory of agricultural development influenced by population pressure and innovation (Ruthenberg, 1971). Ruthenberg (1971), for instance, theorised how farms in the tropics will evolve from shifting cultivation to bush fallow and permanent systems depending on the relationship between the length of fallow and years of farming. Associated with this theory is the modernisation of agriculture under the influence of urbanisation, population growth and growing wealth. However, following the failure of the evolution theory in accounting for or explaining the persistent food shortages of most households in developing countries amidst population growth and global food availability, the entitlement theory emerged. Entitlement has the assumption that issues around food security are not only restricted to production shortfalls but with people's access to food (Sen, 1981). Some

of its assumptions were made based on a sustained average food output per person after World War II achieved through the modernisation of agriculture while many in the developing world are still malnourished. This theory is described as being fuzzy and riddled with issues of market failures, the inability to attain paid work in rural areas as an alternative to own food production, the emergence of contingency situations and ascriptions of dormancy to inhabitants of rural areas (Yaro, 2004a).

Following these weaknesses, there was a need to look at the entire activities undertaken by rural people at different places in earning a living (Scoones, 2009). This ushered in the livelihood perspectives. Associated with these perspectives, is the role of the non-farm economy in contributing to food security in rural areas through income-generating activities (Hoang, Pham, & Ulubaşoğlu, 2014). It is, however, noted that rural areas cannot absorb most of their inhabitants in the non-farm sector. This framework is noted to be broad and often ignores governance and politics with a non-engagement with economic globalisation in its analysis (Scoones, 2009). As the entitlement and livelihood approaches blamed food insecurity on states and structures, they failed to see access to food as a human right resulting in the emergence of rights-based approaches to food through agricultural production. These approaches, especially, the food sovereignty movement conceives of food security not just as the availability of food but, self-food sufficiency by both states and households. The food sovereignty approaches emphasises the role of smallholder farmers in own food production as a way out of food insecurity rather than allowing corporate bodies to dominate this process (Aerni, 2011; Bernstein, 2014; McMichael, 2016). These are urging for agriculture that encourages biodiversity, is based on equity and socially just but not just replacing bad external inputs with good ones (Rosset & Martínez-Torres, 2012).

The current conditions in developing countries demand alternative ways of ensuring food security away from the emphasis on legal means and removing access barriers to food

espoused by the entitlement approach or concentrating on replacing natural means with artificial means of increasing agricultural productivity. But one that integrates all and has an aim of improving and sustaining all aspects of rural lives. Increasing population pressure, climate change, declining soil fertility and a reduction in land per capita of agricultural households in developing countries have pushed for a rethink of approaches that increase productivity to meet growing food needs in sustainable ways (Hoang et al., 2014). With persistent food security challenges in developing countries following the pursuit of these strategies, it is tempting to revert to the traditional paradigm. A paradigm, which uses low inputs and delivers agricultural outputs through smallholder farmers is, however, fraught with the challenge of producing enough to feed an ever-increasing global population (Bernstein, 2014).

The call today is for sustainable farming (Azadi et al., 2011; Pigford, Hickey, & Klerkx, 2018). Issues around sustainability gained prominence after the 1987 report on the environment, which was succeeded by the 1992 Rio Conference (Bockstaller, Feschet, & Angevin, 2015; Dillon et al., 2016; Sala, Farioli, & Zamagni, 2012). There was advocacy for the need for the global society to transition to sustainable production and consumption. This concerns itself with farm practices that produce enough output without bringing damages to food producers, consumers, and the environment. Modern farming systems are noted to have led to a paradoxical situation where about 1.4 billion people are obese and 850 million undernourished (Garnett, 2014). There is a need to reorient global food systems to nourish the populace sustainably and equitably. The debate is currently on the approach to be pursued to attain this global objective (Garnett, 2014). The new paradigm of sustainability is premised on overcoming the problems of the reductionist approach to an investigation into environment society interactions by integrating both political and social dimensions or adopting a holistic approach to sustainability (Sala et al., 2012). This can be done by bringing the views of smallholder farmers into the general debate. This raises

questions of what transitions are occurring in the farming spaces in developing countries. What is the nature of farming systems and how do farmers conceive of a sustainable farming system? How do farmers measure a sustainable farming system and from which ontological and theoretical positions can they assess the sustainability of farming systems is addressed in this review?

2.2 Models for agricultural development in the developing world

Models are described as representations of theories or reality. They are substitute or surrogate of natural systems (Mäki, 2005). Agricultural products are often attained under the guidance of a variety of production models (Quintero-Angel & González-Acevedo, 2018). A model is described here as an abstraction of reality and is often used to guide our understandings of how phenomena came into being, are pursued, modified and the effects of such modification on humans. In this regard, models to agricultural development are considered here to mean how agriculture is perceived and organised to produce outputs with its expected future growth trajectory. Scholarship documents two broad models to global agricultural pursuit - traditional and conventional. This aspect of the review seeks to highlight the different arguments that support each stand and their associated failures or criticisms.

2.2.1 The conventional approach (conventional intensification)

An often proposed approach for solving the challenge of feeding the increasing global population under growing pressure on biophysical and other resources within the last hundred (100) years is through the conventional approach of agricultural development (Grove & Edwards, 1993); agricultural modernisation strategies (Welch & Graham, 2000); and science-led agricultural development paradigm (Grove & Edwards, 1993). This approach to agricultural pursuit is premised on several assumptions. However, the central argument of proponents of this approach are that humans are food limited, thus, there is a

need for increased food production to feed an increasing global population. It also assumes that all rural inhabitants are farmers and have to invest all their income in agricultural technology; and that agriculture is supposed to be the driver of economic growth (Grove & Edwards, 1993; Mazoyer & Roudart, 2007). These assumptions focus attention on yield increases on staple grains such as rice, maize, and wheat. In order not to damage the environment through area expansion, it is argued that the increasing demand for food and other agricultural produce can be attained by producing more outputs per unit area and livestock. This can be done by intensifying the use of external energy, external inputs, technology and biotechnology on existing cultivated areas globally. This model of agricultural development is characterised by mechanisation and the use of synthetic input in the form of chemical fertilisers and pesticides with an aim of maximizing productivity and profitability through biotechnology (Azadi et al., 2011). It does not account for local circumstances since food increases globally will not necessarily translate into local increases because conditions differ.

A variant of this approach is Sustainable Intensification (SI), with varied interpretations and conceptualisations. It is premised that needs or targets are to be attained by groups. Among these are the need to increase food production, meet food demands on existing agricultural land as there are environmental costs to arable land expansion, take into account food security concerns when increasing production and the need for a new approach to be tested within biophysical and social contexts. It is, also, observed that sustainable intensification should be modelled to address hunger and malnutrition challenges, which are beyond aggregate production to improvements in both managed and natural ecosystem functions. This approach, it is argued, encapsulates how the intensification of agriculture could be sustained. This can, however, be done along with measures that incorporate higher yields

and predictability of these yields for smallholder farmers (Chamberlin, Jayne, & Headey, 2014).

Relatedly, it is observed that sustainable intensification in Sub-Saharan Africa can be delivered through conservation agriculture, which is governed by the principles of minimal tillage, soil surface covering, and diversified crop rotations (Vanlauwe, Wendt, et al., 2014). In addition to these, a fourth principle is proposed, which is to appropriately use fertilizers to generate the needed crop residue based on which conservation agriculture can be practised. Some models under this approach through which agricultural commercialisation could be delivered are, contract farming or out-grower models, plantations, and commercialisation models (Yaro, Teye, & Torvikey, 2017). While the plantation and commercial farm areas are associated with land scarcity, out-grower areas demonstrated increased access to and by indigene. It was however noted that food security is lower in out-grower areas compared to a plantation and commercial farm areas. Under these, farms are to transition from subsistence to commercial agriculture (Afework & Endrias, 2016). The view is held that the livelihoods of smallholders can be improved when agriculture is shifted from a subsistence base to market-oriented agriculture as it can increase income and welfare and could also lead to economic growth and poverty alleviation (Zhou et al., 2013). It is argued that most developing countries and thus rural people have not benefited much from the multifunctional nature of agriculture as they practice subsistence agriculture, which excludes them from the market.

Commercialisation is an indispensable pathway to improving the welfare of rural people as it contributes to increases in household food security, welfare and the tendency of reducing poverty in general (Mitiku, 2014). But, the path to this is constrained by such factors as inadequate capital, basic skills, high transaction cost, inadequate infrastructure, and education. If these constraining factors are taken care off, commercialisation will yield a

desirable outcome. Empirical evidence, however, shows that not all farmers benefit equally from commercialisation as those who are very poor are negatively affected (Mitiku, 2014).

Another view is the modernisation of the agricultural sector in developing countries. This view holds that there is a need for developing countries to specialise in agriculture. By specialising, they move from the use of primitive tools and smallholder farms to the use of modern technology with large farms that are mono-cropped (Bellemare, 2015). Additionally, the mode of delivery of agricultural goods should also depart from the old order into a new order of vertically integrated value chains (reducing interaction between producers and consumers). This has resulted in a shift of focus by researchers and policymakers on agricultural research to contract farming and agricultural value chains. To achieve this, smallholders must want to participate in contract farming.

This view has, however, been questioned. It is seen as a reinvention of colonialism, which sought to dispossess the poor of their rights to feed by controlling not only their socio-economic resources, which include their labour but also their biophysical resources critical for their survival. It prevents smallholder access to knowledge and does not allow them to naturally replace soil fertility as this is done through the use of chemical fertilizers. It additionally prevents them from owning seeds and other inputs within their farming system.

This strategy has been observed not to be sustainable since it contributes to declining soil fertility, increases soil erosion and pest infestation, leads to the displacement of labour, especially in countries where labour abounds (Moles, 1989). There are also doubts about the ability of conventional intensification to achieve food security without harm to the environment. It has contributed to biodiversity decline, degradation of ecosystem services, and climate change (Kuyper & Struik, 2014). The Green Revolution, a strand of conventional agriculture, limited the number of crops grown and attempted to encourage mono-cropping (Gaba et al., 2015; Mellor, 2014). Its major weakness has been observed to

include the reduction in biodiversity in general and depriving smallholder farmers of nutritious diets with the narrow crop focus and the artificialisation of nature (Quintero-Angel & González-Acevedo, 2018). Conventional agriculture is focused on the flow of materials and labour towards industry and urban areas and to some extent the flow of inputs to farming areas (Zhou et al., 2013). However, agriculture has been observed to play multiple functions. This includes its contribution to socio-economic development through income growth, food security, household livelihoods, gender empowerment, poverty alleviation and environmental sustainability (Pingali, 2010).

2.2.2 Ecological intensification

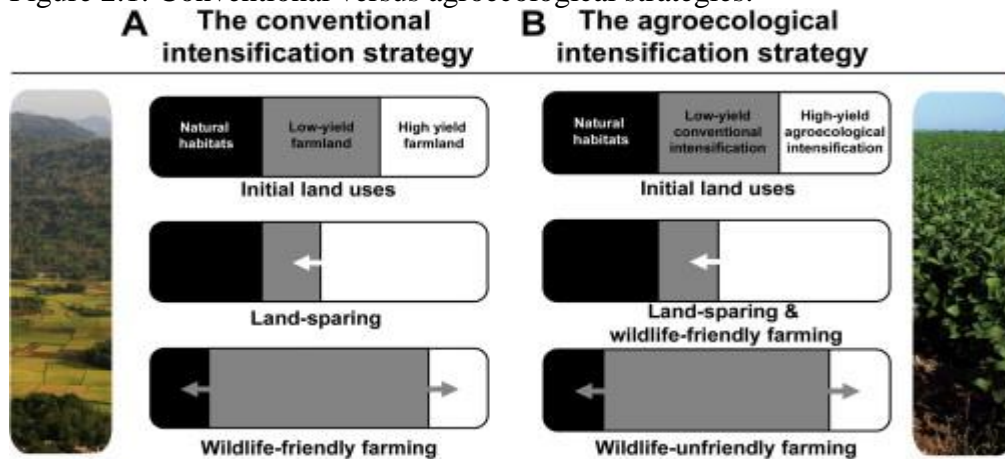
A term, first coined by Cassman (1999) was used to encapsulate a set of principles deployed to improve the yields of major cereals globally within agroecosystems. It entails the intensification of ecological processes in the cultivated space to enhance performance (Caron et al., 2014; Thornton et al., 2018). Initially, the aim was to address yield gaps and deployed strategies such as precision agriculture that focused on the biophysical nature of crops (Tittonell & Giller, 2013; Tittonell et al., 2016). The concept, however, now covers agricultural practices that lead to increases in output, and at the same time maintain the productive capacity of ecosystems through the use of biological means rather than a reliance on external inputs. This conception has, however, been widened to cover issues revolving around organic or ecological farming. Ecological intensification refers to an approach to agriculture intensification that relies on ecosystem functions to improve output and maintain the environment.

This model operates on the principle of providing local solutions to global problems as it addresses local challenges to increased outputs (Tittonell et al., 2016). Ecological intensification entails replacing anthropogenic ways of maintaining soil fertility based on the use of chemical fertilizers with ecosystem measures to improve yields. Some scholars

have, however, warned of an imminent failure of the ecological model if intensification is to focus on only increasing the availability aspect of food security without integrating the other pillars of access, equitable distribution and empowerment (Loos et al., 2014; Tiftonell et al., 2016). Ecological intensification is noted to be beneficial in maintaining ecosystems services and increasing biodiversity, which is important for the functioning of global agriculture (Leifeld, 2012; Mansour, 1980; Smith, 2013; Tscharntke et al., 2012).

A strand of the ecological approach is organic agriculture (OA). This form of agriculture, which relies on the use of local resources and limited external inputs, is noted to comparatively produce lower quantities of outputs in the short run. It is, however, resilient and serves as a pool of adaptations with the capacity of producing outputs on a sustained basis (Azadi et al., 2011; Leifeld, 2012). It is additionally capable of addressing global agricultural problems such as climate change, soil degradation, and pest infestations. Fig. 2.1 draws a contrast between conventional intensification and ecological intensification by Tscharntke et al. (2012) in which it is demonstrated that ecological intensification has multiple contributions to improving the welfare of humans beyond increasing yields. It contributes to increased biodiversity necessary for food production and sustainable in the long run. Ecological intensification supports the peasant way of production, which is deemed to contribute more to social justice as it advocates a model of food production that puts control of inputs and outputs in the hands of smallholders (Bernstein, 2014).

Figure 2.1: Conventional versus agroecological strategies.



Adopted from Tscharntke et al. (2012, p. 5)

The image contrasts the conventional intensification strategy with the agroecological intensification strategy. The drive to produce more food without a plan for long term sustainability of agricultural systems is described as a cruel hoax (Moles, 1989). Moles (1989) argues along with a neo-Malthusian view, which espouses that, with time, the increasing numbers that this model encourages and supports will suffer from malnutrition and hunger as it is bound to fail. The need for sustainable agriculture has been summarised as:

1. Agriculture cannot be sustained by the conventional model of external input-driven production
2. Shortfalls in fossil fuels or external energy, which drives the agricultural sector, will lead to food insecurity issues for both developed and developing countries
3. Biological ways of food production are more sustainable into the indefinite future (Moles, 1989).

Most of the developing world is deemed to have had a partial Green Revolution and thus need a new one to solve their persistent food problem (Holmén, 2006; Welch & Graham, 1999). There are however fears that the New Green Revolution will generate the same negative consequences in the areas where it was not widely adopted (Mazoyer & Roudart, 2007). The New Green Revolution could concentrate food production in the hands of 50,

000 industrial farmers globally supposing they have access to the best lands, subsidize inputs and market access. Fears are that these industrial producers will not produce food sustainably; and how can the over 2.5 billion smallholder farmers who will be displaced by such a move, meet their food needs (Holt-Giménez & Altieri, 2012)?

2.3 Transitions in developing countries' farming systems

Transitions in farming systems is a concept used to describe changes in farming systems and the thinking that drives these changes over space and time (Schiere, Lyklema, Schakel, & Rickert, 1999). By transition in farming systems, it means changes in farm systems but not farm exits as construed in some works within agricultural transitions (Lobao & Meyer, 2001). Farming systems transform over time and space with observed global changes from the Neolithic time to present. These transitions are accompanied by the use of different strategies at specific places in time such as the use of fire, slash and burn, open grazing and intensification to achieve agricultural outcomes (Harwood, 1996). These changes are observed to have taken the form of forest-fallows under low population density to bush-fallows and permanent cultivation somewhere around the sixteenth century under population pressure and other factors (Harwood, 1996; Mazoyer & Roudart, 2007; Pingali, Bigot, & Binswanger, 1987). Scholarly work supports a movement from farming-based activities under low population pressure to non-agricultural employment as a country's population increases and its economy grows (Ecker, 2018; Lobao & Meyer, 2001). Theoretically, there are two explanations to the transition in farming systems all under the influence of anthropogenic forces. The old theory believes that humans started with hunting and gathering with little to no use of tools. This was succeeded by nomadism as their number increased, and then to agriculture. This view espouses that nomadism precedes agriculture. The new theory believes otherwise and postulates that nomadism rather follows agriculture as it is when the forest is cleared paving the way for the emergence of bushes and grassland that animals are introduced (Ruthenberg, 1971). As these arguments are necessary at the

theoretical level in bringing new understandings to how farming originated and its trajectories, the concern of this study is with the current dispensation that is marked by attempts at modernising all farming systems globally.

In the tropics, evolutionary theories have been used to explain changes in farming systems. These theories are espoused principally by Boserup (1965) and Ruthenberg (1971). They postulated that farming systems will evolve from shifting cultivation under low population pressure to the intensification of farmlands or permanency of cultivation under high population pressure. All things being equal, farming systems, according to this theory, will transition from forest-fallow to bush-fallow and grasslands under population pressure and more recently markets, technology and the development of better transportation networks (Harwood, 1996). Important to this theory is how other variables co-evolve with the physical states of farming systems. Labour requirement will for instant change with changes in the farming systems leading to decisions to invest in either land or labour-intensive technologies. These decisions are associated with transitions from the hand hoes to the ploughs and tractors as marked by evolutions from bush-fallows to annual cultivation (Pingali et al., 1987). These changes are sequenced as from forest-fallows – bush-fallows – short-fallow – annual cropping and multi-cropping in terms of intensity of land use (Boserup, 1965). She observed that most global agricultural systems transitioned from extensive to intensive systems of land use with multi-cropping being the most intensive form of land use.

Transitions in farming systems are noted to occur in one of two ways in developing countries. These are either farmers following what has been designed by experts or academics and pushed by global funding agencies through nation-states known as default trajectories (top-down) or with stakeholders designing their systems based on choice (bottom-up) (Schiere et al., 2012). Farming communities may thus accept default evolutions

with their associated consequences or can exercise choice in designing a more sustainable farming system. However, the choice of farming communities can be constrained or enabled by context – migration, new skills, markets, technologies and policies (Schiere et al., 2012). Based on this, others have observed, that global forces play a key role in changing farming systems in developing countries (Mortimore et al., 2005). Most transitional farming systems in developing countries are imposed rather than through farmer innovation or motivated transitions as happened through attempted implementations of Green Revolution solutions by some states in Africa through a modernisation process.

The Green revolution is identified by several characteristics but epitomised by increases in yields per plot and inputs per livestock. Green revolution technologies, since the 1960s are driven by animal draft or motorised power and mechanisation (Demont, Jouve, Stessens, & Tollens, 2007; Mazoyer & Roudart, 2007; Pingali et al., 1987). These forms of farming have their corresponding gains and associated biophysical and socio-economic trade-offs as they are noted to have degraded the environment and resulted in distributional inequalities in developing countries (Amanor & Pabi, 2007; Ramankutty et al., 2018; Schutter & Vanloqueren, 2011). Overall, Green revolution technologies have fantastically increased global food per capita, this has not reflected in eliminating hunger, neither has it lessened the levels of undernutrition among people in developing countries (Schutter & Vanloqueren, 2011; Thornton et al., 2018). The modernisation of farming systems, generally referred to as the productivist paradigm did not spread uniformly with most developing countries benefiting less.

The productivist paradigm, which encapsulates the use of new cultivars and agrochemicals, including both chemical fertilisers and pesticides aided by machine power and irrigation water to boost desirable outcomes in agricultural production have yielded differential outcomes to farmers (Grove & Edwards, 1993; Norman, 1978). Gainers are mostly based in

the developed world with some gains associated with rich businesses or advantaged people in developing countries, leaving out most smallholder farmers as they could not afford the technology or are deprived of land on which they can produce food (Mazoyer & Roudart, 2007; Welch & Graham, 1999, 2000). The productivity paradigm and its associated Green Revolution prescriptions are criticized for not considering environmental sustainability and farmers views in its silver bullets solutions to solving food security problems in the developing world. Although its initial focus was to avert glaring mass starvation awaiting humanity, it failed to address the challenges of farming and food systems in developing countries (Welch & Graham, 1999, 2000). It, for instance, centred its progress on staple grains like rice, maize, wheat and soya beans, which benefited Africa less (Grove & Edwards, 1993). This reduced the potential production and consumption of some micronutrients contained in alternative crops leading to hidden hunger or micronutrient related food insecurity (Nin-Pratt & McBride, 2014; Nyantakyi-Frimpong & Bezner Kerr, 2014; Thornton et al., 2018; Welch & Graham, 2000). It also failed to address the gap between agricultural recommendations and farmers' reality (Fresco & Westphal, 1988). This approach to food production has issues to do with equity, ethics, safety, and the displacement of rural people (von Braun & Brown, 2003). Also known as industrial agriculture, it contributed to increases in greenhouse gas emissions, declines in pollinators and biodiversity, pollution by the use of chemical fertilisers and pesticides, soil degradation and poses health risks to humans (DeLonge, Miles, & Carlisle, 2016; Quintero-Angel & González-Acevedo, 2018). This leads to a situation of increasing food insecurity among most people in developing countries.

To overcome the challenges of the Green revolution, it has been argued that the application of agro-ecological principles in food production should be embraced. This involves the use of agricultural production strategies that mimic nature, do not only increase production but protects associated production environments (Altieri, Nicholls, & Montalba, 2017; Schutter

& Vanloqueren, 2011). It has however been observed that agro-ecologists have two important choices to make in transforming agriculture from its current state to a more ecological friendly state. One is of a reformist form, which co-opts agro-ecological strategies into the New Green Revolution; and the other is of a radical form, which centres agroecology within a political movement involving the use of peasants to secure food sovereignty (Holt-Giménez & Altieri, 2012, p. 92). Current agricultural development policies and programs in developing countries have been observed to be oscillating between agroecological principles and that of the new Green Revolution (Kansanga et al., 2019).

The New Green Revolution seems to be gathering momentum in place and does not discard the feature of the old one but has “added transgenic technologies, global markets, environmental concerns, and a leading role for the private sector” (Holt-Giménez & Altieri, 2012) Currently, most practices towards increasing food production globally are based on an intensification rather than an agroecological agenda (Altieri et al., 2017). The way forward is a proposed mix or marriage between agroecology and the new Green Revolution. This it is envisaged could close yield gaps while at the same time reducing environmental footprints of agriculture through efficient use of external inputs and the use of climate-smart genetic varieties. Some of the new strategies include integrated soil management, while agroecology is spread by NGOs, farmer movements and university projects, official agricultural plans dwarf these efforts across the globe thus making it difficult to scale up these strategies (Holt-Giménez & Altieri, 2012).

In Ghana there have been attempts at implementing Green Revolution strategies and these come in the form of provision of improved inputs (tractors and fertilisers), increasing access to credit for small scale farmers and input dealers (Kansanga et al., 2019). These efforts have resulted in improvement in the use of tractor services and other forms of mechanised agricultural practices among smallholder farmers with about 77% of maize farmers noted to

have been using tractor services for land preparation in the Northern parts of Ghana (Kansanga et al., 2019). These improvements are, however, noted to have implications on the cultivation of staple crops, which are noted for sustaining local food cultures and environments. The new technologies additionally exclude the poor from self food production.

2.3.1 Transitional farming systems with an emphasis on northern Ghana

Livelihoods, described as the different ways in which people at different places make a living (Scoones, 2009), long existed in Ghana before its contact with Europe. Before Ghana (formerly Gold Coast) contact with Europe, subsistence farming and trade in different items formed a major aspect of livelihoods (Dickson, 1968). European contact, coupled with the abolition of the slave trade, ushered in different forms of livelihood patterns in colonial Ghana (1874 when the Gold Coast Colony was established), with a shift from subsistence farming to cash crop farming. These shifts were not uniform throughout Ghana as Europeans interest was in the southern parts, which had favourable agro-ecological conditions for cash crop farming (Kansanga et al., 2019). Crops such as Cocoa and Oil Palm were favoured, while the north remained stuck in subsistence farming (Yaro, 2013c). The north was not part of the Gold Coast economy until 1952 (Kansanga et al., 2019).

Up to the latter part of the 1960s, it is reported that local farming systems in northern Ghana still relied on obsolete implements geared towards subsistence production (Dickson, 1968). Colonial policies were southern-bias and thus neglected the development of infrastructure and agriculture in the northern parts of the country (Brukum, 1998; Dickson, 1968; Kansanga et al., 2019; Yaro, 2013a). This can be attributed to two reasons: first, the north serving as labour for cash crop farming in the south; and second, to avoid competition with the Asante colony. The north became labour-deficient following the need to voluntary and involuntary force labour migration to the Ashanti area and the colony as there was a demand

for labour to support the new cash crop economy in Southern Ghana and to take part in European trade (Konings, 1981, 1984; Yaro, 2013a). There was also a deliberate attempt by the colonial government not to develop the productive sectors of the Northern territories to compete with the southern economy of Ashanti and the colony by starving it of development funds and control of their lands (Konings, 1981). Despite the north being endowed with the potential of cultivating crops like cotton, cereals, shea, tobacco, groundnuts, and rearing of livestock, priority was given to the supply of labour to the south of Ghana than developing these potentials (Yaro, 2013).

Labour migrations to the south, supported by colonial policies, had an implication on agricultural development and food security in Northern Ghana. It retarded productivity, as farming was left to the aged with the youth and energetic attracted by the new Southern economy. It also siphoned farm produce to the south with benefits accruing to southern middlemen who exploited northern farmers. This situation had affected the production and availability of sufficient food in the northern territories during the colonial era in Ghana (Konings, 1981; Yaro, 2013a; Yaro, Teye, & Torvikey, 2016).

Around the early 1900s, not much was done in developing the agricultural potentials of Northern Ghana with the only cotton industry then facing serious setbacks as a result of colonial neglect (Dickson, 1968). Livestock rearing as a commercial model was introduced in the Northern Territories of the Gold Coast around the 1930s. But this model was not able to generate the desired impact due, largely, to dispersed ranches and the long distances taken to get to these ranches (Veihe, 2000). There were also no measures at increasing the landraces, which were also met with low prices. The shea butter industry was also prevented from thriving due to the refusal of the colonial government to grant concessions to companies with the wherewithal to invest in this sector. This was done at the expense of the development of local agriculture in the northern territories. From the 1940s there was some

shift in policy direction to encourage food crop production in Northern Ghana (the establishment of the Gonja Development Corporation in 1949) to respond to growing food demand locally and from increasing urbanization in the southern parts of Ghana (Kansanga et al., 2019). This shift witnessed the introduction of yield-increasing, soil-conserving, and mixed farming approaches.

Ghana's post-colonial governments were concerned about food sovereignty (Kansanga et al., 2019). In an attempt to solve the food security problem agricultural mechanisation was strongly introduced by the post-colonial government (Konings, 1984). This, they thought, could be done through state-led agricultural development policies. The Nkrumah regime sought to develop the north in general by providing infrastructure, including irrigation and other social services. Pursuing a socialist development model, a collectivisation agricultural development model was advocated for. The foci of the programme were the formation of organisations such as the Workers Brigade, State Farms, Young Farmers League and the United Ghana Farmers' Co-operative Council. The Kwame Nkrumah government attempted to mechanise agriculture and provide credit to farmers (Grischow & Weiss, 2011; Yaro, 2013a; Yaro et al., 2016).

This however faced a lot of challenges. The failure of mechanised farming to ensure food security, coupled with the promotion of private enterprises by subsequent governments provided the context for capitalists production in the north and other parts of Ghana (Konings, 1984). The capitalist' farmers were made of the educated elite and businessmen whose activities were supported by the foreign exchange to import agricultural machinery and inputs and backed by subsidies. It is noted that the subsidy on fertiliser rose from 50% in 1970 to 81% of the cost price in 1976 (Konings, 1984). This policy did not benefit the peasantry much as they could not mobilise themselves to enjoy the services of mechanised

agriculture. They either had inadequate knowledge of it or lacked the financial and political connections to access these services.

To address some shortfalls in food provision and the general wellbeing of people, especially in most developing countries following global economic downturns in the 1970s, the government of Ghana implemented the International Monetary Fund (IMF) and World Bank programs in the 1980s (Brydon & Legge, 1996). While the role of these programs in transforming the agricultural landscape of Ghana is not in doubt, their effects in contribution to food security are contestable. For some, under Structural Adjustment Policies (SAPs), Ghana's agriculture, as other African countries is noted to have shifted from its traditional exports as it faced competition from Asia. It additionally suffered a loss in productivity gains and quality as a result of the removal of subsidies and the withdrawal of the state. This resulted in shifts to crops with quick or regular year-round returns (Bryceson, 2002). Other observed that SAPs have contributed to increasing productivity after the 1970s downturns and have led to an increase in the use of technology by smallholder farmers in the Northern parts of Ghana (Kansanga et al., 2019).

The SAPs, linked to the policies of global financial institutions coupled with the forces of urbanization and neo-liberalism are noted to have lowered the quality of life at the micro-level (Kansanga et al., 2019). These are driving changes in land ownership in the Northern parts of the country especially in urban areas. The phenomena are taking land away from poorer households with important implications for food security. It is also creating new contours of farming as several interventions are made on the agricultural landscape in the Northern parts of the country. After some decades of neglect of the agricultural sector following the implementation of the SAPs, there have been a revamp in the sector with the introduction of mechanised services (Benin, 2015) improve seeds, input subsidies on

fertiliser and other services. These interventions have implications on traditional farming systems and their contribution to food security at the micro-level.

2.4 Drivers of transition in farming systems of developing countries

Broadly, there are several drivers of land-use change in developing countries of which agricultural change is a part. However, this study will attempt to group these into two categories. Some scholarly works have identified drivers of transitions in farming systems in the developing world (Afework & Endrias, 2016; Ebanyat et al., 2010; Mortimore et al., 2005; Spore, 2001; Wiggins, 2000a). These are macro (external) and micro (internal) drivers of transitions in farming systems of developing countries (Houssou et al., 2016). These drivers are categorised further under the socioeconomic and biophysical domains. It is, however, important to note here that both the socioeconomic and biophysical drivers have their corresponding macro and micro aspects. This discussion has thus centred on only the socioeconomic and biophysical drivers. Drivers come in the form of a hierarchy impinging on the farming systems in Africa. External drivers like the preferences of international consumers, global agribusiness decisions and information technology are mediated through various stages at the market and policy levels to produce responses at the farm gate. The decisions of farmers are thus not taken in a vacuum but a response to both external and internal forces exerting pressure on their farming systems.

2.4.1 Socioeconomic drivers

A socioeconomic driver such as population growth, in a neo-Malthusian view, has long been held as a principal culprit in negative environmental changes and land degradation resulting in farming systems failure and food insecurity in most developing countries (Aniah, Kaunza-Nu-Demb, Quacouc, Abugred, & Abindawe, 2016; Benneh, 1973; Ebanyat et al., 2010; Hayati, Ranjbar, & Karami, 2010; Nyantakyi-Frimpong & Bezner Kerr, 2014; Payne, 2010; Webber, 1996). Africa's population has witnessed tremendous growth and is expected

to increase relatively more than in other regions globally (Bradshaw & Brook, 2014; Lutz, Butz, & Samir, 2017). Sub-Saharan Africa, which had a population of 850 million in 2012 is projected to be home to 2 billion people by 2050 (Garrity, Dixon, & Boffa, 2012). These observations, often augmented with yield stagnations and environmental degradation are used to support the role Africa's population has played and will continue to do in limiting food supply now and into the future.

Contrary to the neo-Malthusian view, population growth is noted to induce investment and innovations in farming systems (Pender, 1998). There are other suggestions that population growth is not the sole cause of environmental degradation and land-use changes as land-use decisions in the developing world are the result of interactions between population growth and other factors. Farming systems thus undergo transitions based on the prevailing macro and micro socio-economic, ecological and household conditions within specific geographical spaces (Ebanyat et al., 2010).

In assessing the role of population induced innovations and investment in Africa, some scholars associated population growth with reduced fallow periods and intense use of land but not with the increased use of fertilizer or irrigation. There is also little evidence of non-farm diversification in response to domestic or international income sources (Headey & Jayne, 2014). People respond to land constraints in Africa by intensifying agricultural production, diversifying out of agriculture (farm exits) into the rural non-farm sectors or employment opportunities from labour markets or reducing fertility (Headey & Jayne, 2014). It is noted that since the pioneering works of Malthus and the ensuing debates of Boserup (1965) little is done to extend the debate on the linkages between demography, land availability and food security (Headey & Jayne, 2014). The model does not explain the response to land pressure in tropical Africa as intensification is not backed by the development of irrigation, agricultural infrastructure and the intense use of chemical

fertilizers with the draft or motorised power. It has been additionally observed that in North-east Ghana, population growth has not been able to yield sustainable agricultural development as happened in the Machakos (Webber, 1996). Relatedly, increasing population is not likely to usher in a reduction in labour cost and intensification in land use in Africa as happened in Asia following the Green revolution technologies. This results from the structural difference in economic and ecological conditions (Nin-Pratt & McBride, 2014). These conflicting evidence about population growth and transitions in farming systems demand a holistic approach that brings on board all the drivers of transitions in farming systems.

Another socio-economic driver of changes in land use is labour (Bhandari, 2013). Household labour availability has long been held as a driver of agricultural land-use change. The Russian agricultural economist, Chayanov (1966), has tied the demographic cycle of a family to the area of land it could cultivate. Although this is contested, labour availability was a barrier to prosperity, thus more children and high female fertility were embedded in the culture of people in the context of abundant land. In the savannah farming systems of northern Ghana, it is observed for instance that the decision to plant hybrid rather than landrace varieties of crops is influenced by labour availability. Some improved seeds, especially maize has been noted to be labour demanding in terms of cultural practices and thus needs a timely availability of labour to succeed (Nyantakyi-Frimpong & Bezner Kerr, 2014). Thus, a household decision to plant either landrace or hybrid is dependent on the availability of labour. Migration, especially of young energetic men, has also been found to influence the planting or not of hybrid seeds as landraces can withstand delayed weeding without a significant drop in yields. The planting of hybrid seeds have been noted to unevenly distribute household work as women and younger men are noted to work harder than others in the household. Some responses to these have been in the form of labour

withdrawal by junior wives and younger men by delaying their return from seasonal migration (Nyantakyi-Frimpong & Bezner Kerr, 2014).

Both formal and informal institutions are noted to play an important role in the decision to adapt to environmental changes (Yaro, Teye, & Bawakyillenuo, 2015). Land tenure, for instance, has been recognised to be a barrier to sustainable livelihoods for female and migrant farmers in the rural areas of Ghana (Antwi-Agyei, Dougill, & Stringer, 2015). In most parts of West Africa, where it is assumed that the tenure systems guarantee equal access to land among rural people, Yaro et al. (2016) found inequalities in access to land. Guided by a liberal framework, which believes that titled lands guarantees productivity, access to land for agricultural purposes under the customary tenure system is slowly crumbling and this has implications for the choice of crops to grow and land management practices. Also related to tenure is land fragmentation, which has been noted as a discouraging factor in farmer investments or participating in agricultural innovations in south Asia (Niroula & Thapa, 2005).

Technology has been recognised as one of the major drivers of changes in agriculture (Amanor & Pabi, 2007). To alleviate poverty, technology has been used to develop drought-resistant crops like sorghum, peanuts, millet and cowpea in Africa (Ahmed, Sanders, & Nell, 2005). It is however observed that most of the world' poor do apply little profitable agricultural technology and farm inputs (Abay, Blalock, & Berhane, 2017; Alston & Pardey, 2014). External constraints such as limited access to credit, transaction cost, and market imperfections are said to be the contributing factors to this phenomenon (Abay et al., 2017). However, the locus of control associated with personality traits influences economic and behavioural outcomes. Psychological factors are rather accountable for the adoption of technology in developing countries. Farmers with an internal locus of control are a better adopter of technology than those who do not have (Abay et al., 2017).

Farm household demographics such as education level of household head, family and wage labour, and consumer units have significant effects on land-use change (Ebanyat et al., 2010). Human capital related variables (age, gender, number of children, number of economically active family members and educational status of households) are observed to be strongly associated with the participation in non/off-farm employment opportunities (Mitiku, 2014). Markets in Africa are noted to be imperfect with prices of agricultural outputs varying from year to year. This situation discourages farmers from increasing output as the incentive to produce more is reduced by the nature of these markets (Andersson, 2011). Rural producers are also noted to practice subsistence agriculture because of imperfect markets such that in terms of market failure, they will rely on self-produced food. The lack of infrastructure and coordination makes surpluses coexist with shortages as it becomes difficult to move food to market centres. Additionally, most smallholder producers are known to suffer from the collusion of middlemen in price determination (Yankson, Owusu, & Frimpong, 2016). Positive markets aided by an infrastructure can result in changes toward cultivating improved varieties of crops and the vice versa. People residing within the rural-urban dichotomy are divided between what is called survival strategies and accumulation (Andersson, 2011; Yaro, 2006). It is argued that improving market access and off-farm job opportunities are better ways of enhancing food security than concentrating on production gains and closing yield gaps (Frelat et al., 2016).

2.4.2 Biophysical drivers

The biophysical drivers include the biological and physical components of farms such as climate, soil and its properties, topography and microbial interactions with these physical properties. Natural resources and climate change are noted to be prime biophysical drivers of transitions in farming systems in most developing countries. Population growth and climate change interacting with the natural resource are noted to lead to either intensification

or expansion into marginal or reserve areas (Dixon et al., 2001). Climate change will cause reductions in crop yields in some developing countries with some evidence that it leads to food insecurity as people are compelled to migrate (Afifi, Liwenga, & Kwezi, 2013; Kleemann, Celio, Nyarko, Jimenez-Martinez, & Fürst, 2017; Sultan et al., 2013). Farms, described as open systems are subject to influences from their environment. Climate change affects the conditions within which farms exist, forcing farms to co-evolve within them to remain relevant and beneficial (Kaine & Cowan, 2011). The agronomy of crops is noted to influence changes in varieties grown. It is noted for instance that hybrid plant canopy does not allow for interplanting with legumes and other cereals compared to landrace maize (Nyantakyi-Frimpong & Bezner Kerr, 2014). Farmers will thus prefer to cultivate crops that allow for a mixture in meeting their food needs than relying on crops that only improve yields. Farming systems in developing countries have transitioned with a reduction in the number of crop varieties, loss of biodiversity in domestic animals and a reduction in the agricultural land since the 1960s (Dixon et al., 2001).

2.5 Food security/insecurity in developing countries

Food security like many other concepts has an evolving meaning defined by time. Early notions of the concept were around the ability of humans to produce enough food to meet daily dietary requirements (Pinstrup-Andersen, 2009). This led most scholars, agencies, and states to place much emphasis on the availability or the supply side of food. However, following the ground-breaking works of Sen (1981), it came to light that food availability does not equal access and utilisation. Global or regional availability does not mean all can command that food and having enough calories do not assure a healthy and nutritious diet (Pinstrup-Andersen, 2009). This ushered in new conceptualisations of the term food security. The World Food Summit, for instance, conceptualised food security to existing when all people have physical and economic access to sufficient, nutritious and safe food to meet their dietary needs and food preferences for a healthy life (FAO, 1996). This definition

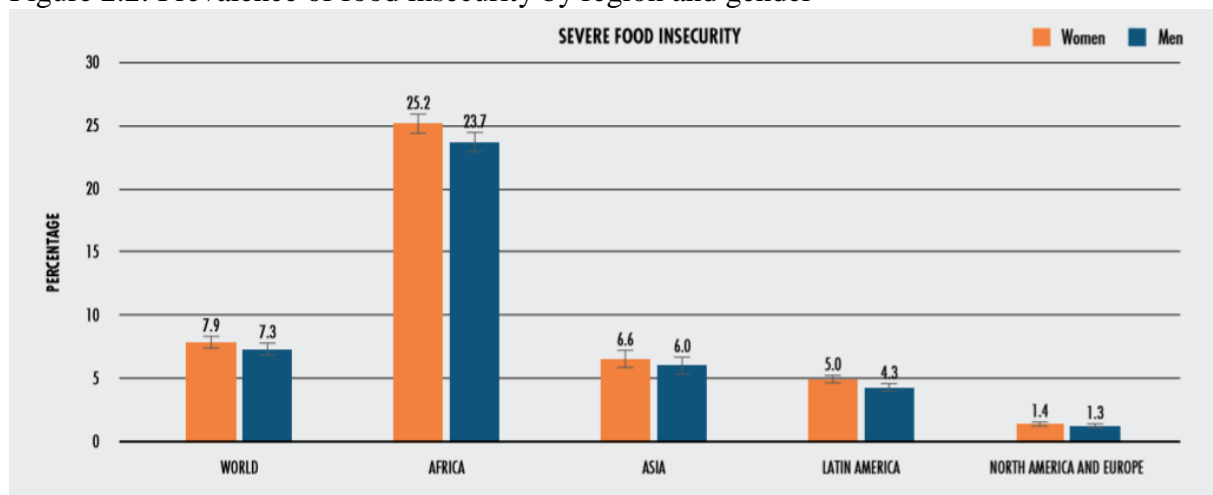
moves us beyond availability and access to safety and the nutritional value of food consumed. It additionally includes the production and eating of preferred foods thus making food security place, household and individual specific. Relatedly, Yaro (2004a, p. 23) conceived of food security as “secure access by households and individuals to nutritionally adequate food at all times and procured in conformity with human aspirations and dignity”. This brings out the cultural elements of food security. Food insecurity, which describes the lack of access to food, can be chronic (permanent) or transitory (Pinstrup-Andersen, 2009; Quaye, 2008). The former occurs when a household is continuously deprived of access to adequate food and the latter when the household cannot respond to temporally shocks on their sources of livelihoods. There also exist hidden hunger described as the lack of essential micronutrients needed for a healthy and active life in people’s diet with an estimated two billion or more people suffering from this condition globally (Fan & Brzeska, 2016; Pinstrup-Andersen, 2009).

In the scientific literature, food security is defined with four seemingly separate but interrelated aspects in terms of availability, utilization, access and stability (Carletto, Zezza, & Banerjee, 2013; Schmidhuber & Tubiello, 2007). Availability describes the supply of sufficient quantities of food of appropriate quality and supplied through domestic production, imports and food aid (Carletto et al., 2013). Food access is the ability to command all resources (entitlements) at your disposal to acquire food for a nutritious diet. Entitlements are all the commodity bundles that a person can command in the context of all the social, legal, economic and political arrangement in the society (Carletto et al., 2013; Sen, 1981). Food utilization is about using food to attain physiological needs. Food should be used with clean water, in a clean environment and should be a clean diet. Food stability is the ability to acquire food at all times even in the events of shocks. This includes seasonal food insecurity, especially during the hunger season.

2.5.1 The prevalence of food insecurity

Progress has been made in reducing global hunger and food insecurity since the 1960s, but with uneven outcomes (Dixon et al., 2001; Weis & Weis, 2007). The exact numbers of global hungry and food insecure have been contested. Some estimates are around 800 million undernourished people (Tomich et al., 2018). Others state that about 2 billion or more people are malnourished if it is accepted that micronutrient deficiency is part of food insecurity (Mazoyer & Roudart, 2007; Pinstруп-Andersen, 2009; Weis & Weis, 2007). This work accepts the conceptualisation of food security beyond the four pillars of availability, access, stability and utilisation to include micronutrient deficiency. These numbers are not evenly distributed with Sub-Saharan Africa being home to most of the global poor and food insecure (FAO, IFAD, & UNICEF, 2018; Li & Zhang, 2017; Sibhatu & Qaim, 2017). Fig. 2.2 shows the prevalence of food insecurity by region and gender. Women are more food insecure than men with Africa topping the regional list of the proportion of food-insecure people in the world. Most of the inhabitants of this region suffer from both malnutrition and undernutrition with a high prevalence of these in rural areas (Kleemann et al., 2017).

Figure 2.2: Prevalence of food insecurity by region and gender



Source: (FAO, 2018)

In Sub-Saharan Africa, about 1 in 3 people are hungry and the number of food-insecure observed to be increasing at an alarming rate and accounting for about half of the global

poor (Chagomoka et al., 2016; Dixon et al., 2001; Sibhatu & Qaim, 2017; Tomich et al., 2018). Most food producers in this region are smallholders who are at the same time the most food insecure (Sibhatu & Qaim, 2017). It is thus observed that much needs to be done in this region to achieve the 2030 Sustainable Development Goal 1 (SDG1) target of eradicating extreme poverty (Tomich et al., 2018)

The imbalance in poverty and food security reflected globally has corresponding local patterns where the prevalence of food insecurity and poverty in Ghana is unevenly distributed (Cooke, Hague, & McKay, 2016; Drafor, 2017). Ghana has made progress toward reducing poverty from the 1880s. The prevalence of poverty is declining nationally on the average with 1991/92, 1998/99 and 2005/6 marked by the prevalence rate of 51.7, 39.5 and 28.5 incidences of poverty, respectively (Novignon, Nonvignon, Mussa, & Chiwaula, 2012). Poverty in Ghana fell by half between 1992 and 2013, thus achieving the MDG1 target of halving poverty by 2015 (Cooke et al., 2016). However, poverty and food insecurity in Ghana are rife in the northern parts of the country, which comprises the Northern, Upper East, North East, Savannah and Upper West Regions. The incidence of poverty and food insecurity in the North of Ghana is high and shows no signs of declining (de Jager, Giller, & Brouwer, 2018; Novignon et al., 2012). Again, poverty is more of a rural problem and estimates show that it is about 4 times that of urban poverty in Ghana. To overcome this, suggestions are either smallholder agriculture should be encouraged as it directly provides food, fibre and can contribute to the overall growth of the rural economy (Sieber et al., 2018) or farms should be commercialised to make them more productive. These strategies are assumed to spur growth, which will, in turn, absorb the excess labour through both farm and non-farm sectors. For now, what is known is that the rural non-farm sector cannot absorb the excess labour. Other knowns are that the subsistence sector contributes more to the calorie of people in rural areas (Drafor, 2017). Some of the

unknowns are how farmers perceive their farm enterprises to be sustainable and which enterprise contributes more to household food security. Since the option now is for smallholders to produce their food, then there is a need to assess the sustainability of their farm enterprises.

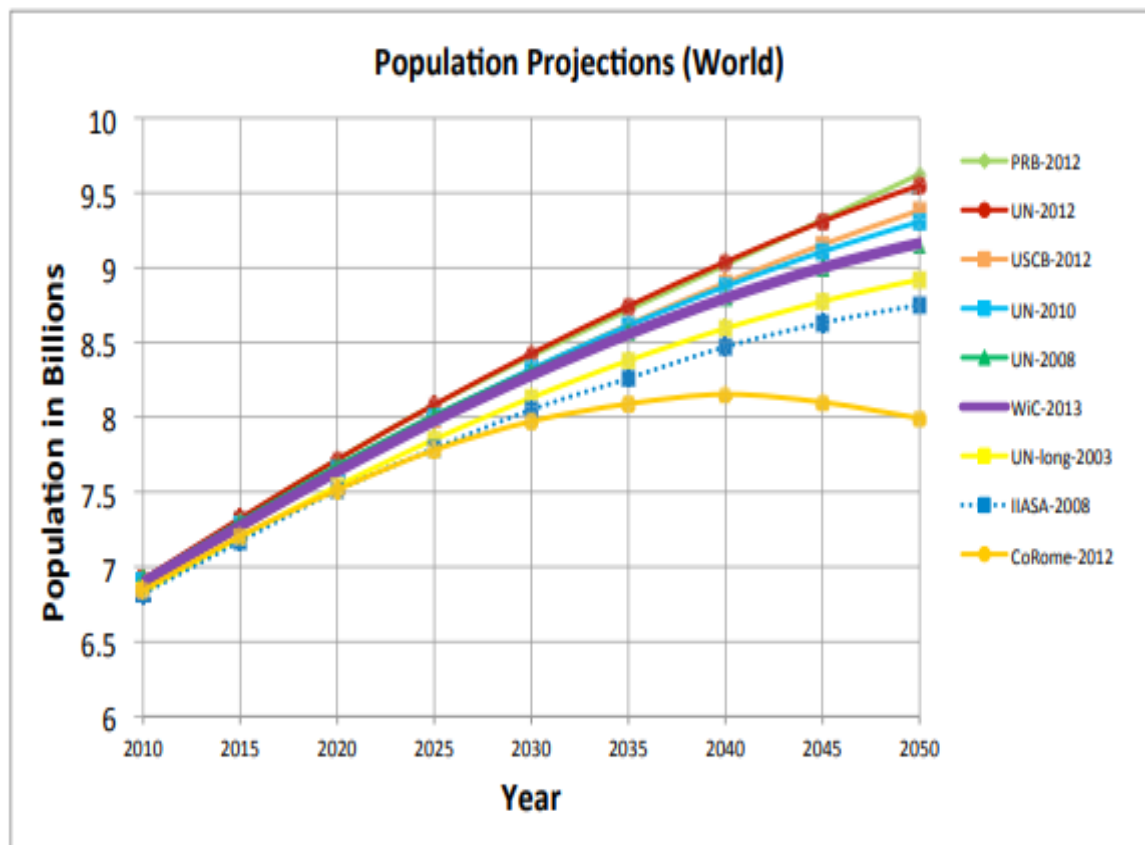
2.5.2 The nature of tropical farming in Africa and the food challenge

Farming systems in the tropics are heterogeneous and characterised by irregularities. These come from both natural and socioeconomic factors. Naturally, the systems are constrained by climate, edaphic, other biophysical factors, weeds, pest and diseases (Ellis-Jones et al., 2012; Yiran & Stringer, 2016; Yiran et al., 2016). The socioeconomic factors are mostly population growth, institutional related issues like tenure systems, difficulties in accessing improved seeds, credit and market failure (Callo-Concha et al., 2012; Garrity et al., 2012; Luabe, 2015). Empirical evidence shows that socioeconomic factors lead to increases in farm sizes, reduction in grazing areas with farms diversified over time while natural factors are linked to reductions in crop yield (Ebanyat et al., 2010).

African farming systems are noted to be held by poor smallholder farmers, marked by low yields, limited commercialisation, productivity not increasing rapidly with a non-declining population land ratio (Collier & Dercon, 2014). These systems are additionally rain-fed and associated with increased food security threats resulting mostly from population pressure and environmental degradation (Stephens, Jones, & Parsons, 2018). Farms are expected to transition to rapidly more productive enterprises to meet the food needs of Africa's population. What is debatable today are the forms of transition African agriculture should take. Some are proposing a move away from smallholder focus to farm commercialisation models led by well-motivated farmers with vertical integrations (Collier & Dercon, 2014). Others have observed that increasing food output by conventional methods does not equal access and utilisation (Mazoyer & Roudart, 2007; Sen, 1981). Many are malnourished today

in the presence of abundant global food. Also, as the global population continue to rise, shown in Fig. 2.3, there are concerns over the quantity and quality of food consumed per person. Some small-scale farmers have been forced off their lands as a result of the inability to apply the new technologies due largely to cost (Amanor & Pabi, 2007; Thornton et al., 2018).

Figure 2.3: Population Projections (World)



Source: Lutz et al. (2017)

There are also issues with the acceptance of the new technologies in remote and marginal areas as some are tedious and laborious compared to local farm practices. It is, however, argued that the benefits of the Green Revolution are more than the challenges there are to be addressed. With a current population of more than 7 billion people and a projected world population of around 9 billion or more by 2050 (Christiaensen et al., 2011; Headey & Jayne, 2014; Mazoyer & Roudart, 2007; Welch & Graham, 1999), or between 9.6 and 12.3 billion in 2100 (Gerland et al., 2014), a second Green Revolution is being proposed to cater for the

food needs of about 4-6 billion people mostly of developing countries as these are the areas to experience an enormous increase in population.

In developing countries, households are noted to be most vulnerable to climate change because of their ecological condition and have the less adaptive capacity (Tambo, 2016). Seasonal and permanent migrations, growing of new varieties of crops and use of irrigation water are some of the documented response strategies to these threats (Tambo, 2016). There is a need to, thus, build the resilience of households in these areas as that will enable them to resist, cope with and recover from shocks and stressors. Food shortages, juxtaposed with an expected increase in population in Africa will call for both area expansion and intensification of agricultural production inland abundant and land-scarce African countries, respectively. In low-density Africa, it is still unclear whether smallholders or large farms contributes the most to food security and how to sustainably implement the pathway of choice (Chamberlin et al., 2014). Productivity in these farming systems is noted not to meet demand from population growth as they exhibit declines in per capita food needs over the years. This it is envisaged will lead to hunger and starvation among some vulnerable groups in rural areas (Callo-Concha et al., 2012; Li & Zhang, 2017).

These challenges notwithstanding, about a third of all food consumed in developing countries and more than half of global caloric needs are contributed by smallholder farmers in developing countries through diversified farming systems (Samberg, Gerber, Ramankutty, Herrero, & West, 2016). Based on different criteria such as location, topography, edaphic factors, population density, presence of rural infrastructure, tenure systems, etc., scholarship has identified several types of farming systems in the developing world. In Africa, about thirteen (13) to fifteen (15) farming systems have been identified with a variety of crops grown and livestock kept within these systems (Callo-Concha et al., 2012; Garrity et al., 2012; Hall, Dixon, Gulliver, & Gibbon, 2001). These systems have no

clear-cut demarcations among them but each is noted for some dominant agricultural activities and contribute differently in meeting household food needs. In relative terms, poverty is concentrated in the maize-mixed farming system compared to the other systems identified. This system is additionally noted to have the highest farmer population and serves as the food basket and driver of agricultural growth in Africa (Garrity et al., 2012).

The major staple crops grown within these farming systems are maize, sorghum, millet, cassava, sweet potato, paddy rice, yam, plantain, etc. with the major export crops being Cocoa, Coffee and Cotton (Garrity et al., 2012; Hall et al., 2001). Over the years there are observed declines in the allocation of arable space to some traditional staple crops like sorghum and millet with increases in the production of maize. These crops are cultivated within different sub-systems and this study is located within the ‘cereal-root crop mixed’ cropping system (Callo-Concha et al., 2012; Samberg et al., 2016).

The Guinea Savannah Zone within which this study is sited supports three farming systems however consideration was given to the mixed cereal-root crop farming system and the root and tuber crops farming system as both are in West Africa (Garrity et al., 2012). The root crop systems are practised in the southern wetter parts of West Africa. The presence of poverty is limited to moderate in these systems. They are noted to have great potential for export crops and demand for root crops in urban areas with the advantage of the expansion in the non-farm sector (Hall et al., 2001). These systems have a bimodal rainfall pattern with crops not risking rainfall failure compared to the cereal-crop mixed farming systems found in the northern parts of West Africa (Hall et al., 2001).

The cereal-root crop mixed farming systems cover the Upper East area of Ghana. The sub-systems are the cereal (millet, sorghum, maize), legume (groundnuts and cowpea), cotton and root crop (yam and cassava) (Callo-Concha et al., 2013). The millet and sorghum sub-systems within this system are noted to contribute more to household food but have been

declining over the years with the legumes supplementing the proteins of households with a strong market value. It is noted for supporting high livestock numbers especially cattle and characterised by low altitude, high temperatures, low population density, abundant cultivated land, poor transportation and communication infrastructure. The main source of vulnerability to these systems is drought (Hall et al., 2001). Rainfall variability and poor soils make it challenging to work within these systems. However, after agricultural success in more challenging environments in some South American countries, it is argued that the right investments in African farming systems can make them more productive and capable of creating businesses for smallholder farmers.

It is however noted that poverty is relatively high among smallholder farmers in these systems as about half of farmer population live on less than USD 1.25 a day (Garrity et al., 2012). The farming systems in Africa are generally noted to be incapable of meeting food needs of the populations as this is supported by food imports over the past 40 years and yield declines over time (de Graaff, Kessler, & Nibbering, 2011; Hengsdijk & Langeveld, 2009).

There is thus a need to focus on increasing food production in places where food is most needed and additionally grant access to food ownership for those vulnerable population who have no other means to acquiring food to meet their dietary needs. With the number of undernourished people increasing in Sub-Saharan Africa over the years shown in Fig. 2.4, there is urgent need to concentrate on own production if the SDG 2 is to be achieved by 2030, which is to “end hunger, achieve food security and improved nutrition and promote sustainable agriculture” (FAO, IFAD, UNICEF, WFP, & WHO, 2017, p. 3).

Figure 2.4: Number of undernourished people in Africa

| | Number of undernourished (millions) | | | | | |
|--------------------|-------------------------------------|-------|-------|-------|-------|-------------------|
| | 2005 | 2010 | 2012 | 2014 | 2016 | 2017 ¹ |
| WORLD | 945.0 | 820.5 | 805.7 | 783.7 | 804.2 | 820.8 |
| AFRICA | 196.0 | 200.2 | 205.2 | 212.5 | 241.3 | 256.5 |
| Northern Africa | 9.7 | 8.5 | 17.6 | 17.8 | 19.5 | 20.0 |
| Sub-Saharan Africa | 176.7 | 181.0 | 187.6 | 194.7 | 221.9 | 236.5 |
| Eastern Africa | 113.5 | 119.1 | 113.3 | 117.1 | 129.6 | 132.2 |
| Middle Africa | 36.2 | 36.5 | 36.4 | 36.1 | 40.8 | 42.7 |
| Southern Africa | 3.6 | 4.2 | 4.2 | 4.6 | 5.2 | 5.4 |
| Western Africa | 33.0 | 31.9 | 33.7 | 36.9 | 46.3 | 56.1 |

Source: (FAO, 2018).

About a third of the population in Africa is experiencing food insecurity and crisis-driven chronic hunger despite progress made in trade liberalisation and in strengthening institutions that are supposed to address this challenge. It is thus argued that smallholder food production is key to reducing poverty and hunger (FAO et al., 2017; Garrity et al., 2012). Most rural people in Africa make a living by producing a range of agricultural products based on rainfall. It is however observed that global environmental change and other socio-economic factors are going to stress smallholder farmers who are less flexible due to their context. This context must be taken into consideration in the design and implementation of solutions geared towards addressing food security issues. The food security challenge is not uniformly spread among smallholder farmers with areas that have high populations, degraded lands and a slow economic growth mostly affected. Attention is needed on household income growth through smallholder farming as that is noted to contribute about two to four times more to income growth than the non-farm economy. It has a multiplier greater for smallholders compared to large farmers as small farmers spent more on local goods than large farmers (Garrity et al., 2012).

To play a functional role, and be part of the wider society, smallholder farming systems will have to transition in response to both external and internal stressors. Transitions in farming

systems towards sustainability can take several pathways. Pathways to sustainability are described as alternative ways or competing strategies for sustainable development (Beland Lindahl, Baker, Rist, & Zachrisson, 2016). How natural resources can be efficiently managed globally and at the local level had always been a contested issue. Thus, generating different conceptions of sustainable farming and how to achieve it. To address food insecurity among smallholder farmers, for instance, the debate is the pathway to pursue. This raises the question if large-scale or smallholder farming is good for rural areas (Lay, Nolte, & Sipangule, 2018). Even within these frames are either to pursue sustainable intensification or ecological intensification with different proposed strategies under each. Along with these trends is the attempt by the donor community, international financial institutions like the World Bank with support from states in developing countries at modernising farming in developing countries. Agricultural modernisation strategies are however noted to have benefited some privileged farmers while leaving the masses behind (Amanor, 2010; Amanor & Pabi, 2007; Teye, Yaro, & Torvikey, 2016; Yaro et al., 2016).

2.6 Conceptualising and measuring sustainable farming systems

The complexity and heterogeneity of farming systems in developing countries compound the problem defining the term farming systems (Benneh, 1972; Whitfield, Dixon, Mulenga, & Ngoma, 2015). Besides, there is differences in the use of the terms - farm systems or farming systems (Fresco & Westphal, 1988). Beyond these, farming systems are often interchangeably referred to as agricultural systems (Giller, 2013; McConnell & Dillon, 1997). Whitfield et al. (2015), however, noted that most definitions on smallholder farming systems in Africa are centred on the farm or household as their basic unit of analysis. This work will use the term farming systems to denote the level of the hierarchy of analysis suggested by Fresco and Westphal (1988) who conceptualised a farm as comprising a farm household with cropping and livestock systems.

Benneh (1973) conceived a farming system as individual farmers who appraise the biophysical and socio-economic resources at their disposal with decisions taken regarding what to produce and the techniques to be used in light of their assessment. In this vein, he viewed farming systems as dynamic with appraisal as a process that is contingent on the farmer's context. The definition points to the existence of components within a farming system as Norman (1978, p. 184) concurs that, by referring to a farming system as a "result of a complex interaction among several interdependent components" that work together to achieve given outputs. To attain a farming system, individual farmers allocate resources they have access to in the form of labour, capital, land and managerial skills to the enterprises of crops, livestock and off-farm employment opportunities in a manner that will maximise the goals to be achieved based on the knowledge possessed (Fresco & Westphal, 1988; Norman, 1978; Shaner, Philipp, & Schmehl, 1982).

What can be drawn from these conceptualisations of farming systems is the existence of a manager, who apply resources with some ultimate objectives to be attained. In delineating a farm system from a farming system, McConnell and Dillon (1997) opined that a farm system is related to the structure of an individual farm while a farming system relates broadly to similar farm types in a specific geographical area. Giller (2013, p. 150) reinforced that opinion by defining farming systems as a "population of individual farm systems that may have widely differing resource bases, enterprise patterns, household livelihoods, and constraints" (p. 150). This definition contrasts the FAO definition, which has been noted to be widely adopted but criticised for its attempt at homogenising all rural farm systems to be delivered from low productivity with a silver bullet solution (Whitfield et al., 2015).

Zinck et al. (2004), to separate an agricultural system from a farming system, further opined that one or more cropping systems, sometimes combined with other activities such as livestock or handicraft, is considered a farming system. Kuivanen et al. (2016, p. 131) sides

with the concept of farming systems as a complex collection of resources that are arranged and managed by households who make decisions on the choice of crops grown, livestock kept, on-farm and off-farm enterprises. This definition compared with the previous shows that the concept of farming systems keep evolving in space and time as current conceptualisations incorporate and emphasises dimensions of non-farm and off-farm employment activities in line with recent theorizations of livelihood security.

However, common to most definitions of farming systems is the recognition that there exist components (economic, social and environmental) that are managed by a person or group of peoples (household) to use inputs to produce desired outputs (Kinney, 1990; Merzt & Knipscheer, 1981; Meyz, 1980). Critical to the performance of farming systems are the roles played by both macro and micro-level structures. The macro drivers and constraints interact with local (micro) social, economic and biophysical context to produce diverse farming systems. Not all smallholders face the same challenges, have the same opportunities and with the same purpose for their activities (Keys & McConnell, 2005; Whitfield et al., 2015). Any attempt therefore to understand smallholder farmers is to acknowledge their temporal and spatial heterogeneity.

In this study, a farming system is conceptualised as made up of people and their biophysical and socioeconomic resources. The people apply these resources judiciously in producing desired outputs with concomitant maintenance and improvement upon these components to satisfy the needs of current and future generations. This study thus distinguishes a farming system from an agricultural system by restricting farming systems to the bundle of all assets used in livelihood pursuits by farm households towards attaining diversified goals while the aggregation of these at a larger spatial scale then becomes an agricultural system.

2.6.1 Conceptualising sustainable farming systems

The concept of sustainable farming is modelled after that of sustainable development. It conceives sustainability as efficiently extracting and using resources in ways that do not compromise the productive capacity of systems in meeting today and future needs. It also entails notions of not limiting sufficiency and options to resource access and use by future generations and the ability to equitably provide access to scarce natural resources for all with benefits from development distributed equally (Tao & Wall, 2009). It supports economic progress and at the same time takes serious accounts of the scarce environmental resources. Also linked to the concept of sustainability is generosity, which is associated with progress without damages to the natural environment and governance (Gerlagh, 2017).

There have been disagreements to the exact meaning of sustainable development as it varies according to differing interests, values and needs of the individual, group and the larger society (Eckerberg & Mineur, 2003; Esquer-Peralta, Velazquez, & Munguia, 2008; Kates, Parris, & Leiserowitz, 2005; O'Toole, Wallis, & Mitchell, 2014). Most scholars have accepted the view that, just like other broad and complex concepts, sustainable development has no specific meaning and can be applied contextually (Deytieuxa, Munier-Jolainb, & Caneillc, 2016; O'Toole et al., 2014; Schaller, 1993; Vilei, 2011).

Like sustainable development, scholars view sustainable agriculture as a concept with no precise definition or meaning (Binder, Feola, & Steinberger, 2010; Deytieuxa et al., 2016; Hayati et al., 2010; Moles, 1989; Schaller, 1993; Veisi, Khoshbakht, & Sabahi, 2013; Vilei, 2011). In terms of what sustainable agriculture should do, environmentalists are overly concerned about the ecological issues of sustainability with a major aim of maintaining the biophysical elements of the ecosystem (Binder & Feola, 2010; Ryan et al., 2016; Simpson & Radford, 2012) while others are concerned with how issues of sustainable economic

growth can be used to alleviate poverty (De Schutter & Vanloqueren, 2011; von Braun & Brown, 2003).

In terms of what it looks like, sustainable agriculture has been conceptualized as an alternative to conventional farming and an umbrella term, which subsumes farming strategies such as organic farming, biological agriculture, alternative agriculture, ecological agriculture, biodynamic agriculture, regenerative agriculture, permaculture, and agroecology. Also termed alternative agriculture, some of its key values are decentralization, community-based, independence, harmony with nature, diversity, and restraint (Beus & Dunlap, 1990). Agricultural sustainability has also been conceived of in terms of the ability of agricultural systems to provide enough and quality food for a population without damaging the environment, maintaining the income and quality of life of farmers and contribute to the development of the local economy (Deytieuxa et al., 2016; Sajjad, Nasreen, & Ansari, 2014).

Sustainable agriculture is additionally viewed by others as an evaluative tool made up of a collection of indicators within given frameworks for assessing the performance of agricultural systems (Bockstaller et al., 2015). As a practice, sustainable agriculture, according to Flora (1992), encompasses a set of dynamic practices with the usage of technology that brings minimum damage to the environment and simultaneously able to provide a long-term income for the farmers. Concerning this conception, others see it as a technique in producing food that is healthy for humans and animals, does not threaten the environment, is humane for workers, respects animals offer good earnings for the farmer and develops rural communities (Altieri, 1995).

Despite the contentious nature in conceptualising sustainable agriculture, it is acknowledged among most authors that it is usually guided by the three key pillars or dimensions of economic, social and the environment (Bockstaller et al., 2015; Deytieuxa et al., 2016;

Eckerberg & Mineur, 2003; Gómez-Limón & Sanchez-Fernandez, 2010; Hameed & Sawicka, 2017) with no agreeable definition among these dimensions (Hayati et al., 2010).

Schaller (1993) observed two separate views of agricultural sustainability. The first being the modification or fine-tuning of conventional farming practices as they are sound. Proponents of this view argue that gains from the production paradigm can only be maintained through this process, as it is not clear if the proposed sustainable agricultural practices will produce sufficient food to feed the global populace. The second view espouses that, fundamental changes in agriculture is needed to achieve sustainability and demands society to change its values to ensure that. The former argues that sustainable agriculture is not profitable and will not be able to feed the world's population while the latter posits that sustainable agriculture is more profitable if we cost the food and other functions it provides.

The profitability of sustainable agriculture and its ability to produce enough food for the global populace are two issues to be addressed in sustainability studies. Proponents of conventional agriculture argue that its methods have been tried and tested to be more profitable and productive than the proposed sustainable approaches. Further, to discard their approach means going back to the hoe, which is associated with hard labour, low yields and low farm incomes for farmers. In response to these claims, proponents of a sustainable farming point to the fact that the use of less to no inputs will reduce cost and make farms more profitable in the long run. Besides, the calculation of profits excludes many of the benefits of sustainable agriculture to farmers and society while also excluding the negative impacts of conventional agriculture like soil erosion and groundwater contamination (Schaller, 1993).

In terms of adequacy of food production, it is argued by conventional proponents that sustainable designs will not yield adequate output to meet our food demand taking into account current and projected global population. This feeds into current arguments that

production gains are insufficient to meet projected food demands thus the need to more than double current crop outputs. They also contend that most of the world's arable land is now in use, thus there is a need to intensify existing farm outputs through conventional approaches rather than through area expansion.

Opponents of the conventional approach contend that sustainable yields can equal or even surpass conventional ones. Sustainable practices will yield stable yields. Additionally, yields of conventional approaches will fall drastically as the global population exceeds the earth carrying capacity. At the same time, sustainable practitioners expect changes in diet, which are different from the current livestock and meat-based diets as these, relatively, use a lot of energy to produce food. Sustainable agriculture is often regarded as an alternative to conventional agriculture. With conventional agriculture riddled with the abuse of chemicals, which pollutes the environment, reduce biodiversity and only benefits the few who have the wherewithal to purchase farm inputs, the poor are left behind not only in their inability to purchase food but to also engage themselves meaningfully. Most of the profits that accrue when the natural way of replenishing the soil is discouraged are to the metropolitan companies that manufacture and control the distribution of these chemicals (Mansour, 1980; Yaro et al., 2016). Sustainable agriculture also means trade-offs between the three pillars with these being interdependent (Kanter et al., 2018)

Quintero-Angel and González-Acevedo (2018) additionally observed two interpretations of the concept of sustainability-weak and strong sustainability. The former incorporates ideas of the use and damaging of nature to attain economic growth while the latter strongly encourages the balance between economic growth and nature. Strong sustainability assumes that some ecological functions and resources cannot be substituted with technological or other man-made replacements, while weak sustainability assumes universal substitution (Mayer et al., 2004; Dietz & Neumayer, 2007).

From these brief conceptualisations, it is clear that sustainable farming revolves around issues of economic profitability, environmental protection, social protection, intergenerational access and equity in the distribution of gains made in the use of a community's assets and capabilities. This means that sustainable farming can be attained collectively but must be pursued individually. It also means sustainable farming is a process and progress towards sustainable farming should start with the individual as it is farmers who apply sustainable farming principles and practices at the farm level. They are also those who decide on how to produce and distribute food within their households and what kinds of infrastructure and structures are needed to support the sustainability of their farm enterprises. These observations draw out attention to the issue of measuring or assessing sustainable farming. Sustainable farming, from a realist view, is a social construction but realist will like to know the people doing the construction as individual construction differ and have different effects, which are both latent and manifest.

2.6.2 Measuring/Assessing sustainable farming systems

The plurality of views concerning the conceptualisation and definitions of sustainable farming has yielded the development of diverse methods in its measurement (Beland Lindahl et al., 2016; Deytieuxa et al., 2016; Pannell & Glenn, 2000; Schaller, 1993; Tao & Wall, 2009). Most studies have relied on the indicator framework in an attempt to assess the sustainability of agricultural systems (Mayer, 2008; Vilei, 2011). Indicator based frameworks are noted to suggest a linear cause between agricultural practices and resulting consequences. It is however suggested that there is a causal network than a chain of causes (Bockstaller et al., 2015). Additionally, the use of these frameworks in indicator selection has been noted to be good at the aggregate level but not suitable to individual farmers or for assessing sustainability at the farm level (Hayati et al., 2010).

The indicators are premised on the idea that sustainable farming cannot be compressed into a single definition. It is multifaceted. The use of indicators to measure sustainable farming is also justified by the seeming inability to measure complex systems or concepts (Bockstaller et al., 2015). When many indicators are used, they are either presented in a framework of categories or aggregated into an index. An index thus becomes a quantitative aggregation of many indicators. Indicators measure the stages or success of sectors, organisation, and regions in moving towards a sustainable future (O'Toole et al., 2014).

The use of indicators to measure sustainable farming has gained momentum, but are often criticised to be technocratic in outlook and overly skewed towards measuring the ecological and economic dimension of sustainable farming (Binder et al., 2010; Mayer, 2008; Pannell & Glenn, 2000). It is, therefore, argued that indicators are only valuable when they can inform the decision-making process. Even if indicators are recommended to farmers, their applicability is based on the farmer's choice. Their choice is influenced by their perceptions of which indicator(s) account for sustainable farming. It is, therefore, necessary to consider the understandings of those who are the implementers of sustainable farming in our studies. Farmers' view of a sustainable farm is also necessary for guiding indicator selection and policy formulation to farm sustainability. The acceptance and use of sustainable agricultural practices are influenced by the number of years of work in agriculture (Hameed & Sawicka, 2017) a positive attitude of farmers towards sustainable agriculture and knowledge (Azman (Azman et al., 2013).

However, there are observed challenges in developing a set of suitable indicators for measuring sustainable farming systems in developing countries due to the heterogeneous nature of these systems. This situation is further confounded by the absence of or inadequacy of data (Vilei, 2011). There is also the lack of consensus on a given set of indicators to be included among experts within the sustainability field (Olde et al., 2016). Indicators and

indices often give a static view of a system, but when calculated over time it can give a view of whether a system is sustainable or not and can offer a sense of which factors to promote to enhance the sustainability of a system. Frameworks for measuring sustainable agriculture are developed through literature review, consultations with scientific experts and local people (van Asselt et al., 2014) This approach does not address the conflicting qualitative goals farming systems are envisaged to perform (Bachev, 2016). For instance, should farm systems pursue high productivity and income at the expense of biodiversity loss and workers health or preserve ecosystem services at the expense of food security?

Beyond the use of indicators, sustainability can be measured by observing some farm practices. Farm practices that are deemed harmful to the environment like leading to increasing erosion, deforestation, longer working hours, harm to human health are not sustainable. Crop yields can also be measured as to whether they are decreasing or increasing. Cropping systems are sustainable when an appreciable level of harvestable yields are produced from a cropping cycle to cropping cycle without a decline in yield (Izac & Swift, 1994). Yields allow us to evaluate both the biological and economic sustainability of farming activities. The yield gaps approach is, however, deterministic and not suited for developing countries as most smallholder farmers have no records. The use of this approach is also time-consuming and laborious as it entails harvesting and weighing farm produce for some number of years to be able to establish yield gaps (Ruiz-Rosado, 2009; Zinck et al., 2004). A sustainable farming system can additionally be assessed concerning the use of pesticides, inorganic fertilizers, and the presence or otherwise of crop diversity (Hayati et al., 2010).

The sustainability of an agricultural system can be measured at different levels and scales (Fresco & Westphal, 1988; Izac & Swift, 1994; Ruiz-Rosado, 2009; Zinck et al., 2004). This can be at the field or plot scale and cropping system scale. However, there are observed

issues at the scale of the cropping system but provides a useful starting point for any rigorous analysis (Izac & Swift, 1994). Zinck et al. (2004) further identified four levels at which sustainable farming can be measured. These levels relate to the ones developed by Fresco and Westphal (1988) that conceives agriculture as a set of hierarchical systems that interrelate both internally and externally as shown in Table 2.1.

Table 2.1: Hierarchical level, indicators, and techniques for measuring sustainable farming

| HIERARCHICAL LEVEL | UNIT | INDICATOR | APPROACH/TECHNIQUE |
|----------------------------|-------------------------|---|---------------------------------------|
| Land management system | Soil unit | Soil property | Quality Control Charting (SQC) |
| Cropping system | Land parcel or field | Crop yield | Yield gap analysis (YGA) |
| Farming system | Production unit or farm | Input/output ratio | Energy balance analysis (EBA) |
| Agricultural sector system | Region or nation | Partial indexes Agro diversity System efficiency Land resource base Food security | Aggregated sustainability index (ASI) |

Adopted from Zinck et al. (2004)

From Table 2.1, the land management system is used in the individual soil unit. Sustainability within these systems are measured through Quality Control Charting (SQC). This is often done to determine the fertility and other biophysical characteristics of the soil. The cropping system level uses yield as a measure of farm sustainability. The yield gap approach is used to evaluate sustainable crop productivity at this level. This approach cannot tell which yield level is sustainable but sets a benchmark higher than the farmer production level. This level could be achieved with external inputs and tailored management practices (Zinck et al., 2004). If farmers can raise productivity to such levels, their activities will become profitable and economically sustainable. At the farming systems level, which corresponds to the production unit level, the concept of energy balance is used. This concept uses the input/output ratio to compare the sustainability of farming systems. Even though this study is aligned to this level of the agricultural hierarchy, it is difficult to effectively

execute an energy balance due to difficulties in attaining all energy input and output data of farming systems in the Builsa area.

Beyond these techniques deployed at each hierarchy to assess farm sustainability, some practical measures of sustainable farming at the farm level start with teams of natural and social science researchers each assigning weights base on system contribution to sustainability. This process is saddled with the inability to reach a consensus by the different stakeholders on which attributes contribute more to sustainability than the other. It is also limited by the tendency for some stakeholders to influence others.

To overcome this, a method was proposed that elicit weights representing perceptions of major stakeholders (Gowda & Jayaramaiah, 1998; Van Calker, Berentsen, Giesen, & Huirne, 2005). A sample of judges is used, consisting of scientist and representatives of various stakeholder groups. Relative weights are attained by attribute ordinal ranking and scale rating. In the ordinal ranking, important information could be lost, and in rating too, respondents might not rate attributes relative to each other. Krajnc and Glavič (2005) used an analytical hierarchy procedure (AHP), to assess the relative impacts of individual sustainability attributes. This is superior to ordinal ranking and scale rating. This is however difficult in cases where the number of sustainability attribute and pair-wise comparisons is very large.

Another strategy is to apply the Cost-Benefit Analysis procedure. This method relies on the use of market prices. A disadvantage is how to calculate the value of non-market goods, which cannot be easily quantified into monetary units. Additionally, the seasonality of prices, the lack of standards and the inability to quantify productivity in rural areas will make this tool difficult to be applied in this study. Conjoint Analysis (CA) a method used to draw connections between consumer decision-making and the traits or attributes of a good or service is based on the assumption that people are the best judges of their well-being and

consciously make decisions to improve this well-being (Sydorovych & Wossink, 2008). CA relies on utility maximization in a multi-attribute setting. CA, however, failed to draw a contrast in opinion on gender or any other strata at the local level.

This calls for the use of both indicator frameworks and explanations for measuring sustainable farming at the local level. With the combination of qualitative and quantitative techniques and data, insight can be gained into what farmers perceive to be sustainable to them and at the same time production gains can be measured to ascertain the contribution of local farming systems towards household food availability. We can also identify the farming systems that contribute more to food security and are sustainable in practice in the long run.

2.7 Theory and conceptual framework

Despite the challenges with the theorisation of Malthus (1798) on the relationship between population growth and the ability of environmental resources to support it, this position marks an interesting entry point into the population environment debate. Thinking along the lines of limits to environmental resources, Malthus and Neo-Malthusians envisaged an end to environmental resources under conditions of continuous population pressure. This reasoning resulted in the use of theories and methods that sought to measure the carrying capacities of places and spaces to ascertain their ability to support given human populations. In line with this, shifting cultivation, a dominant farming strategy in the tropics is estimated to be able to survive under a given population density beyond which environmental degradation, poverty and food insecurity sets in. Even though there still exist relics of these strands of thinking within academia, the Malthusian school has seriously been challenged.

An alternative theoretical argument to the end of shifting cultivation is the emergence of permanent cultivation under population pressure. In a Boserupian style, farms will evolve in stages with the aid of innovations and technology (Fresco & Westphal, 1988). It has,

however, been observed that while evolution theories always involve long term changes in farming systems, most agricultural research involves improvement within a given farm system (Fresco & Westphal, 1988). Farmers do not only innovate and adopt technology as a result of population pressure since there exists market or demand-driven innovation adaptation even in less populated areas. Beyond these two views is emerging evidence that humans have agency and are not just passive observers who will wait to perish under stressors on their production systems. However, these innovations have not benefited humanity equally or have at best resulted in the impoverishment of marginalised people. This calls for new theorisations to cater for agricultural productions that ensure food for all. This should take the forms of the sustainability of the environment and the population it supports and new ways of assessing how resources of places can be sustainably used. A holistic approach is, thus, needed. This can be done by considering farms as systems with interrelated parts working towards common goals.

Beyond the conventional theories, a theory that underpins farming systems studies is systems theory, which attempts to understand how components of systems are interrelated with their internal and external interactions. Every agricultural activity is made up of a hierarchy of interrelated systems (Ruiz-Rosado, 2009; Zinck et al., 2004). A system is defined as an arrangement of components or parts that interact according to some process and transform inputs into outputs (Odum, 1983) or as “a recognizable assemblage of agricultural procedures and activities that can be distinguished as a functionally integrated pattern characterized by genetic and generic cohesion of elements, traits, technologies, procedures, and activities” (Spencer & Stewart, 1973, p. 532). Systems theory seeks to outline the hierarchical levels within a system and thus helps to identify the geographical and temporal scales in the analysis of any agricultural activity (Ruiz-Rosado, 2009). In using system theory, efforts are made at understanding the behaviour of the entire system rather than that of its components. Systems theory tries to understand not just the summation of

components making up a system but how they are arranged and influence each other (Kaine & Cowan, 2011).

An open system of which farms are a part interacts with their environment and assume some characteristics of this environment over time (Kaine & Cowan, 2011). Systems theory is noted to be the overarching theory in studying the sustainability of farming systems, following the shortfalls in the use of the indicator-based models and frameworks (Hayati et al., 2010). With systems theory, research is mandated to define systems boundaries and the level of study. Hayati et al. (2010) identify four (4) levels or hierarchies in studying farming systems. These are the cropping systems (plot-level), the farming systems (farm level), village level and the landscape level (regional level). This concurs with the work of earlier scholars using farming systems as an approach to studying farms (Fresco & Westphal, 1988; Hart & Pinchinat, 1982; Zinck et al., 2004).

Even though systems approach to the study of agriculture has been advocated by many scholars, it has been arbitrarily applied resulting in several models of it. The first scholars to apply an ecological systems approach to small farmer agriculture were Hart and Pinchinat (1982). By analogy with ecology, agriculture can be viewed as a hierarchy. Starting from the cell to the plant or animal organs to crop or herd, the field or pasture, the farm, to the complex ecosystem such as a village, culminating in the agricultural sector and beyond. Each of the units constitutes a system as it involves an arrangement that transforms inputs into outputs (Fresco & Westphal, 1988). Agricultural research planning requires that we understand the trends in the evolution of farming systems. While it is accepted that farm systems change over time and at different rates, attempts at documenting these changes are scarce (Fresco & Westphal, 1988). There are suggestions that we can only build on current successes in the agricultural systems in Africa, encourage new and innovative thinking

about future pathways and opportunities by adopting farming systems approaches in studying agricultural development in developing countries (Garrity et al., 2012).

2.7.1 The farming systems approach to agricultural research in developing countries

Farming system change and the changes in yields, prices and farming methods across and between countries make up the temporal and spatial evolution of farming systems (Schiere et al., 1999). Thus, farming systems research is a result of the evolution in the thinking and practice regarding the development of farm systems. It has its theoretical root in ecology and systems theory (Schiere et al., 2012; Schiere et al., 1999). This approach has, however, been applied broadly to understand how rural livelihood can be shaped in ways that better their wellbeing and environments.

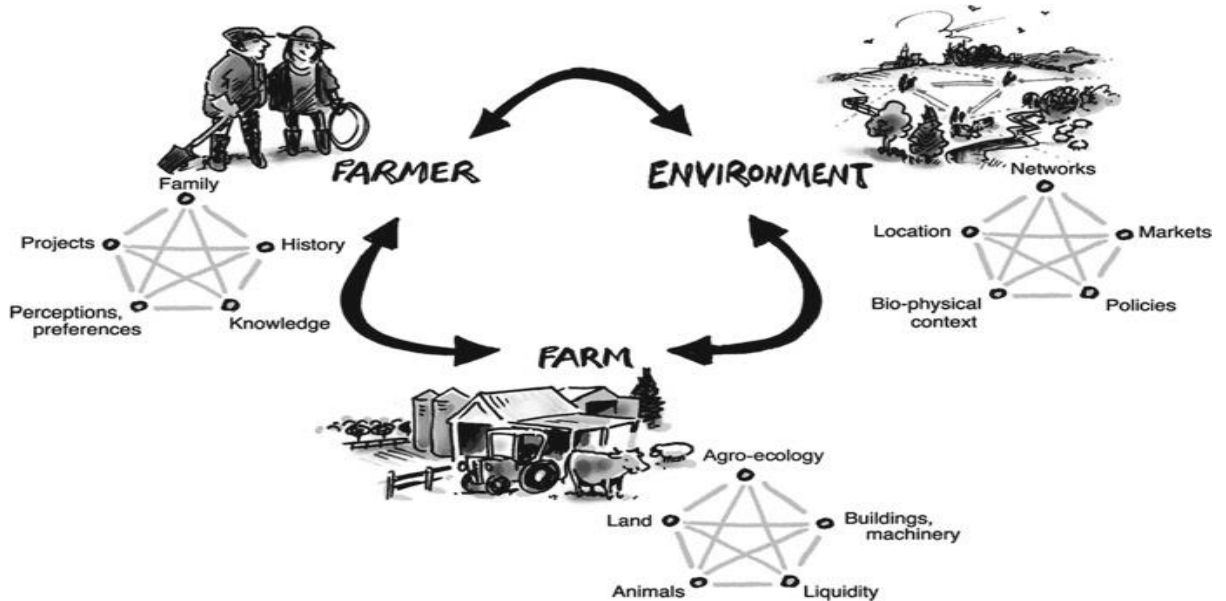
Farming systems research (FSR) approach is described as a world view, a conception of the nature of reality and how it should be investigated (Schiere et al., 2012). Viewed this way, there are many types of farming systems researches, making it difficult to have a single approach to farming systems research. The farming systems approach emerged as a result of the failure of proposed methods and technologies in solving livelihood problems in developing countries by conventional approaches (Norman, 1978, 2002; Schiere et al., 2012). Farming systems research since its emergence in the later parts of the 1970s has been used broadly to mean a variety of activities (Byerlee, Harrington, & Winkelmann, 1982). But specifically, concerns itself with research that views the farm holistically and is interested in interactions in the system (Byerlee et al., 1982; Norman, 2002). In contrast to traditional science, which is held by reductionism and organised along disciplinary or commodity lines, farming system perspectives incorporate the views of social scientists and the beneficiaries in the research process (Byerlee et al., 1982). As tradition agricultural research is often restricted to agricultural stations, it failed to develop technologies that mimic farmers' fields or farming systems in developing countries. It also failed to

incorporate the views of farmers and to address the heterogeneous nature of their farm enterprises. The farming systems approaches advocate a bottom up approach to understanding and improving rural livelihoods (Byerlee et al., 1982; Norman, 1978, 2002). The initial focus of farming systems research was to improve the performance of farming systems in developing countries either by prescribing new systems or injecting technology into existing ones through on-farm experiments (Collinson, 1987; Meyz, 1980). This perspective, with a centre stage that acknowledges interactions within a farming system was used to overcome adoption of technology barriers associated with reductionist approaches through on-farm experiments and participatory approaches. This has, however, been widened to include infrastructure, processes and the functionality of farming (Whitfield et al., 2015). Interest in interactions in farming systems are not only within components of a farming system but goes beyond to include processes that are outside the system and yet influence how it operates. It is noted for instance that international financial development institutions continue to play a pivotal role in shaping and reshaping development policies of nation-states and their rural areas and in transforming these areas (Borras, 2009; Luabe, 2015). A gap exists between research findings and farmer adaption of technology. Gaps also exist between expert conceptions of sustainable farming and local conceptions. Most technologies that are developed through conventional research often fail to address the needs of small farmers. Thus, the need to include their views in identifying technologies relevant to their context.

To address these failures, it is recognised that farms do not exist in isolation. There is the need to consider the environment and socio-economic context within which farming systems operate. It is, additionally noted that in doing this, there is a need to integrate knowledge and skills from different disciplines, backgrounds and involve the views of farmers (Collinson, 1987). These are what is described as the initial foundations of the

farming system approach to research, which involve system thinking, interdisciplinary and participatory. This implied a systemic approach is required, which allows for insights into the interactions of parts. A framework for doing this and necessary for this study is that suggested by Darnhofer, Gibbon, and Dedieu (2012) in Fig. 2.5.

Figure 2.5: Components of a farming system



Adopted from Darnhofer et al. (2012, p. 6)

The components are made of material objects such as the soil, plants, animals and buildings, subjective perceptions, values, and preferences. A farm does not exist alone, and to understand a farm, we should consider the locale, territory or region within which it is located with its associated agro-ecological specificity, economic opportunities, and cultural values. With this conceptual framework, you have to consider the farm, farmer and the environment in which he/she operates in analysing a farming system. There are, however, observed, practical impossibilities to implementing all the three foundations of the farming systems research in a single study, thus the need to reflexively choose those that suit one's context. The choices of farmers are not based on objective facts but influenced by perceptions, values, and activities of other members of the community. Farmer's choice in

farming system research is understood to be influenced by social constructions with values playing a role in the construction of facts.

Darnhofer et al. (2012) view a farming systems approach as accepting the social constructions involved and the complexity of the farmer's position in the system. The farming system is part of larger systems- the local community system and can be divided into subsystems – cropping systems and animal systems. Farming systems research is holistic and location-specific (Whitfield et al., 2015). In farming system research one must identify the dependent variables to be measured e.g. varieties, production techniques, labour usage, pesticide use, etc. The farming systems approach is noted to be capable of recognising the diversity of livelihoods of people in rural areas and provides a framework for exploring the various pathways to the growth and development of rural areas (FAO, 2001).

2.8 My philosophical stand

Conceptually, this study is guided by the critical realist ontological and epistemological view of reality and ways of knowing. Critical realism, especially that espoused by Sayer (2006) admits the existence of a real world out there, which is independent of our knowledge of it. Our ideas about the world are, however, constructed in terms of our various ways of seeing- perceptual schemata, concepts, and discourses. It is not possible to step outside these to see the world as they are needed to see and think. Critical realism thus recognises both objective and subjective reality (Peter & Park, 2018). Critical realism is in contrast to constructivism. The former belief the existence of a reality independent of our knowledge and can be attained through objective experiments while the latter denies the existence of an objective reality out there but that which is gained through human knowledge and discourses. This critical realist sees this stand of constructivists as reducing ontology to epistemology (Peter & Park, 2018).

Contrary to positivist who mistakes discourses of the world as reality or idealist who claim that the world is the product of our knowledge, critical realists make a distinction between the world and our knowledge of it. Positivism and idealism do not subscribe to the fallibility of knowledge but realism does. The fallibility of knowledge to realists is critical to uncovering that the world is whatever it is regardless of our knowledge of it and not just what we see and think about it (Sayer, 2006). To realists, social ideas are social constructions, which are construed differently. They see social constructions to have some independence after they have been constructed. In this regard, realists are not just interested in social constructions but fundamentally concerned about the people doing these constructions. They also acknowledge social constructions as processes over time and space and that attempts at this construction involve the use of ideational (peoples beliefs and habits) and material resources. Success and failure depend on how some properties of ideas and material are used. Realists admit the power of discourse in influencing action but are, however, cautious to note just like sociologists that every discourse has both manifest (intended) and latent (unintended) effects and are thus fallible (Sayer, 2006). This assertion is in contrast to the poststructuralist position of the power of discourse, which posits that anything can be constructed based on discourse as this lapses into a form of idealism.

Again to the realist, all things (people, discourses and institutions) have causal powers and susceptibilities. Cause to realists is that which produces or blocks change. Ideas, discourses or ways of thinking are extremely important in shaping societies and their geographies. Discourses on how agriculture should be pursued have influenced the evolution of farming systems over the years in developing countries, with both intended and unintended consequences. Culture plays an important role in studying the geographies of people since they are the highest form of life, capable of taking on cultural characteristics. Realist recognises the dynamic nature of culture and accepts that there is a time element to people and structures, with their corresponding powers and susceptibilities. Relating this to the

study, sustainable farming is not an end process and farmers will continue to appraise and apply farm practices and strategies according to their powers and susceptibilities within a given context. The powers and susceptibilities of people are acquired through socialisation. While some of these have to be frequently exercised for survival, others can be dormant and may not be exercised at all. The activation or not of these powers or susceptibilities are context-dependent. In summary, some basic realist's ideas necessary for this study are:

- Human behaviour is context-dependent.
- Research can establish regularities but more interest should be in what these mean and stand for.
- Things (discourses, people and structures) have causal powers and susceptibilities that are reproduced over time.
- The structure has elements that come together to reproduce it.
- There are material and immaterial elements in social constructions of our social world
- Social constructions of the world differ among people and are construed differently.

Realism, just like any social philosophy that lay claims to reality and espouses ways of understanding it cannot escape the cannon of dissenting views. It has thus been criticised for not aligning itself with any methodology of the social sciences and difficult to be translated into any research methodology. Yet, it has been used with qualitative research and can be combined with pragmatism (Peter & Park, 2018). Critical realists conceptualise their objects of study as that is necessary for identifying the causal powers and susceptibility of these objects (Sayer, 2004). Contrary to other philosophical beliefs, critical realist sees causation and meaning to be the same. If a cause is that which can produce change, then meaning has casual powers because meaning is shared to effect change. Discourses are casual or can produce change. Critical realist belief in strong objectivity. This posits that we

are more likely to get closer to objective knowledge if we reflect more on our different standpoints.

2.9 Proposing a perceptual framework for studying sustainable farming in Builsa

Several frameworks have been used in measuring or assessing the sustainability of environmental systems. These include the popular livelihood framework, indicator-based frameworks, resilience frameworks, vulnerability framework, and others that describe system attributes like stability and desirability. The livelihood framework is broad and has a wide range of applicability. Central to this framework in analysing sustainable livelihoods is its emphasis on structures, especially policies within a vulnerability context that limit the agency of people in attaining a sustainable livelihood. Livelihood approaches are noted to be good at identifying problems but not solutions to these problems and focuses less on distributional issues.

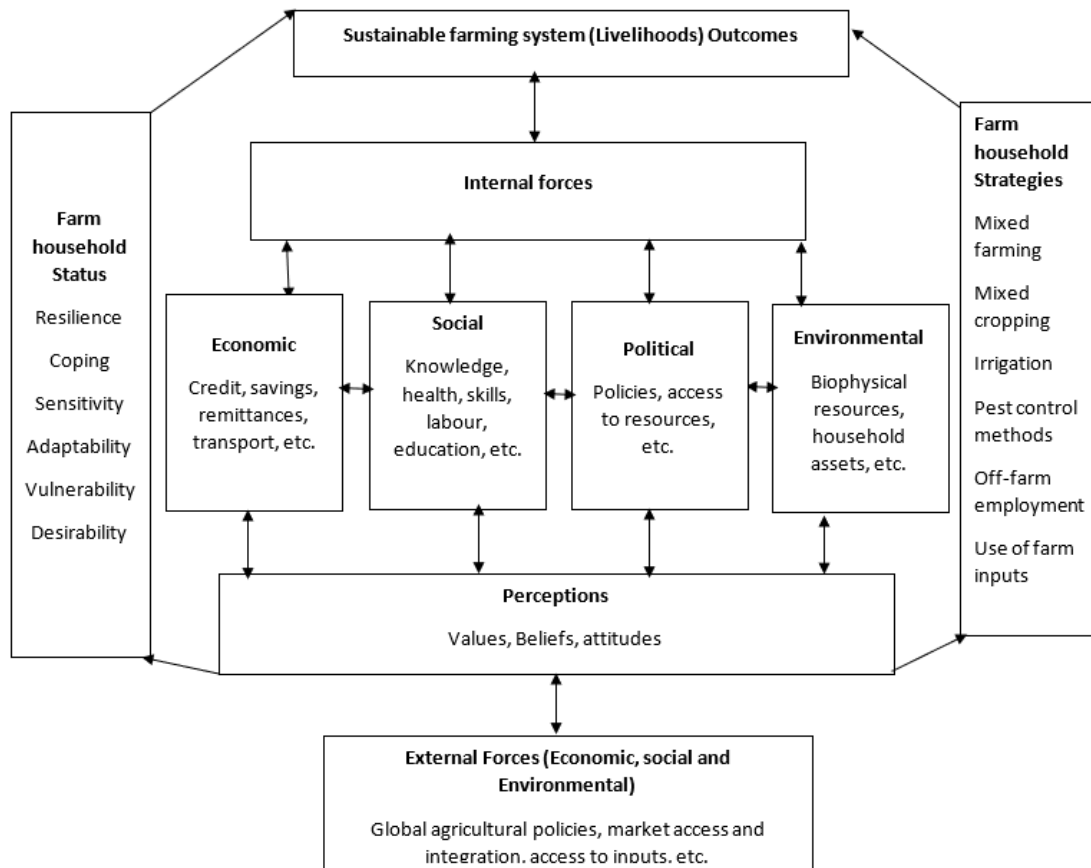
The concept of resilience was developed following dynamic systems theory and catastrophe theory in ecology. It implies the ability of a system to bounce back or recover after a stress or perturbation (Sala et al., 2012). Resilience frameworks have been applied to the dynamics of farming systems. Resilience is defined as the ability of a system to persist despite changes in its environment (Mayer, 2008; Schiere et al., 2012). It reflects characteristics of continuity and discontinuity, chaos and order and an ability to maintain system function and structure under intense pressure (Davidson, 2010). A shortfall in resilience means a system will adapt or transform. With resilience thinking, there are no end states in the vitality of a system but evolutionary stages. When systems are not resilient, they adapt or adjust to their contingent condition. Adaptability represents the ability of a system to adjust to stressors. Resilience is strengthened by experience and knowledge and also by diversity.

The term vulnerability is conceived as the extent to which farm households are susceptible to and respond to stressors (Antwi-Agyei et al., 2012). Even within the same ecological

zone, households are noted to experience different degrees of climatic vulnerability (Antwi-Agyei et al., 2012). Socioeconomic characteristics such as wealth, gender and access to capital explain this situation. Much as there are vulnerable households within resilient communities so are there resilient households within vulnerable communities. Outlier households are found to possess certain characteristics, such as having alternative livelihood options, well connected socially, which help them to take up opportunities related to environmental and economic changes.

Stability within open systems talks about the ability of the system to operate within acceptable limits. This notion of stability is in line with that of steady states. Stability describes the capacity of a system to accommodate changes in the environmental state. So farm systems are stable when they can produce the same outcomes under stressors or shocks without any changes to their structure (Kaine & Cowan, 2011). Adaptation occurs when the structure of the farm system needs to be changed for it to continue to produce the desired outcomes. If structural changes result in the inability of the farm systems to continue to produce its outcomes, then adjustment sets in. Adjustment is in line with diversification, value addition, off-farm employment opportunities, (Kaine & Cowan, 2011). Farming systems to be sustainable should also incorporate issues of desirability, which should use more solar energy and biological processes in the production process. It should do these in conformity with social order, which is governed by values that hold sustainability to be a priority (Moles, 1989). Bringing these concepts together, Fig. 2.6 proposes a framework for assessing the sustainability of farming systems in the Builsa area.

Figure 2.6: A perceptual framework for assessing sustainable farming systems



Source: Author's construct.

The framework is referred to as a perceptual framework that put at its centre the role of human agency in interpreting, producing and reproducing structures. Farms are considered as structures made up of components that are interrelated and works toward attaining set goals. Humans perceive differently and socially construct differently as espoused by realists. How we construct is a combination of both our material and immaterial world. At the centre of the perceptual framework is how farmers use their immaterial resources. How their beliefs, values, attitudes, and preferences allow them to interpret and respond to opportunities and constraints.

These opportunities and constraints have both internal and external dimensions, which farmers need to overcome if they will succeed in their farm enterprises. The status of a farm household is based on its ability to deal with these opportunities and constraints at any material time. It could be resilient, coping, adapting, vulnerable, desirable, sensitive or

stable. This brings to our attention that sustainability is not an end process and is context depended. Farm households depending on their appraisal of their opportunities and constraint have a variety of options to pursue. It is when the combination of the resources at the farm household's disposal, contingent on its perceptual schemata yields a strategy and a status that is acceptable to the local community and helps in uplifting the well-being of the farmer that sustainability is achieved. Farm households have a variety of strategies to pursue in achieving their given outcomes. These strategies are determined by both structure and agency as farmers have no control over external factors impinging on their farm systems but can mobilise resources at their disposal in selecting a response strategy to these stressors. Farming systems then become sustainable if they individually and collectively demonstrate acceptable statuses such as resilience and desirability.

CHAPTER 3

THE METHODOLOGY OF STUDY

3.0 Introduction

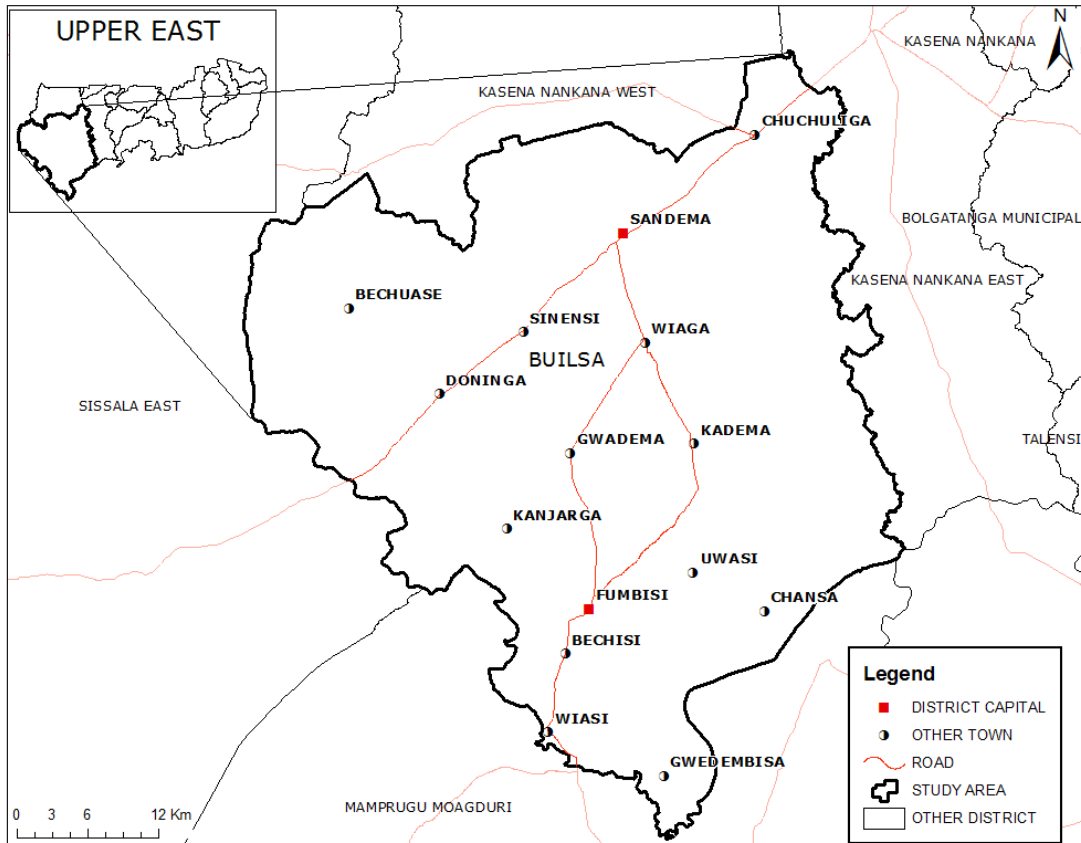
The main data types are secondary and primary data. The secondary data is drawn from official records at the national and local level while the primary data is generated from both qualitative and quantitative techniques. The entire Builsa area, comprising the Builsa North and Builsa South Districts formed the spatial coverage for this study. The unit of analysis is, however, the household. Both towns and villages with different micro-social, economic and ecological endowments in the study area were selected for the study. Most communities selected in the Builsa North area have a higher population density relative to those in Builsa South.

3.1 The study area

The study is conducted in the Builsa area of the Upper East region of Ghana. Builsa is traditionally occupied by the Builsa people with their main language being Buili. Administratively, it is made up of two districts, which are the Builsa North and Builsa South Districts. The traditional occupation of the people of Buluk (Builsa land) is farming – crop and livestock. These major activities are often supplemented by off-farm (gathering of shea nuts, dawadawa, and other wide fruits) and non-farm activities (basket weaving, pottery, hunting, fishing, charcoal and firewood harvesting, etc.).

Buluk is located within the savannah ecological zone of Ghana (Fig. 1) and thus has a monomodal rainfall regime between 3 to 5 months of rains (April and October) and between 900 to 1000 mm of annual rainfall (Callo-Concha et al., 2012). Climate variability has been established to be a limiting factor to farming in this parts of Ghana as it “provoke stunting, drying up and destruction of plantations” (Callo-Concha et al. (2012, p. 6). Groundwater availability is also limited to develop an irrigation-based system.

Figure 3.1: Map of study area showing selected communities



Source: Extracted from district shapefiles of Ghana (2018).

Temperatures are relatively high and these have implications on the success of the farming systems in the area as crop and livestock productivity can be limited by this variable. Soils developed in this part of the world are known to have kaolinite clay, less water holding capacities and little organic matter depending on the history of cultivation. They are also low in the supply of nitrogen (N) and phosphor (P) and sometimes phosphate (K), sulphur (S) and zinc (Zn) (Callo-Concha et al., 2012). Soil nutrients are known to be additionally mined due to a combination of factors – slash and burn systems, burning of crop biomass, the high temperature that encourages decomposition and the non-replacement of organic input. These factors have implications on the farming systems and food security as the population is largely rural with a non-farm sector that is not well developed to absorb excess labour forced out of farming.

3.1.1 Conceptualising the peasant household

The people assessing the sustainability of the farming systems in Builsa and being assessed are farm households, led by their heads. The farm household thus forms the basic unit of analysis. According to Yaro (2004a), the peasant household is conceptualised in spatial, structural and functional terms. It is a separate dwelling with its production mapped out from the rest of the community. Households in the Builsa area are organised in compounds with heads. A compound is a group of interrelated households, who sometimes trace their relationship to a common ancestor. This notwithstanding, households have their adjoining dwellings and enjoy a semi-autonomous economic, social and political space. In terms of structure, the household is a production unit and addresses issues relating to the division of labour as well as intra-household exchanges and patterns of authority and power. Functionally, the household is the place or space for reproduction, production, distribution, transmission, and co-residence.

There is stratification at the household level as they are differentially endowed in resources and capabilities. The household is the production and consumption unit, thus making both management decisions and taking responsibility for the production and consumption of goods and services at the local level. Households are therefore the best assessors of the sustainability of their farming systems and the contribution of these to food security.

3.2 Research design

The study uses a mixed-method approach as the researcher is interested in analysing farmers' understanding of sustainable farming and in generating numeric records based on farmers' input, output and consumption data to assess the contribution of the major farming systems to food security. A qualitative approach, with an inductive design, is relevant when dealing with the descriptive and interpretative aspects of sustainable farming, especially in a

situation where there are challenges in terms of data availability and accuracy (Atanga, 2016). Quantitative data will generate numeric records on some variables of the farming systems and was used to validate the qualitative data. Mixed methods approach follow works of scholars who view complex and multidimensional issues as best explored using diverse approaches (Brookfield, 2001; Creswell, 2009, 2011; Gómez-Limón & Sanchez-Fernandez, 2010; Ivankova, Creswell, & Stick, 2016; Teye, 2012; Veisi et al., 2013). Such an approach helps in better explaining or understanding complex issues as it allows for convergence, triangulation or integration in a study. This has an advantage over using one method in investigating such issues (Botha, 2011). Additionally, this approach will enable the researcher to understand sustainable farming at both the group and individual levels (Morse, 2016).

A mixed-method approach to research involves the use of both qualitative and quantitative approaches in data collection, analysis, and presentation (Botha, 2011; Creswell, 2011; Greene, Caracelli, & Graham, 1989; Robinson, 2013). However, some scholars are of the view that the concept of a mixed-method approach goes beyond combining quantitative and qualitative approaches in a single study to include the use of multiple qualitative or quantitative methods in a single study (Johnson, Onwuegbuzie, & Turner, 2007; Morse, 2010). Others also view mixed methods as a synthesis that includes ideas from qualitative and quantitative research (Johnson et al., 2007; Onwuegbuzie & Leech, 2007).

This study, following Bryman, Becker, and Sempik (2008) and the views of Creswell (2011), conceived of a mixed-method research as the use of both quantitative and qualitative approaches in selecting the dominant farming systems, describing their transitions, assessing their sustainability and contributions to food security in the Builsa area. This is because, using both approaches provide a more detailed understanding of the topic than a single approach (Creswell, 2011; Morse, 2016). Also, detailed data on the farming systems

and their perceived sustainability and contribution to food security have been obtained by the use of qualitative techniques like focus groups, in-depth interviews and informal conversations as they are most appropriate for explaining behaviour and perceptions (Teye, 2012). Production data, however, is needed in combination with other variables to ascertain the food security status of farm households thus necessitating the use of the survey.

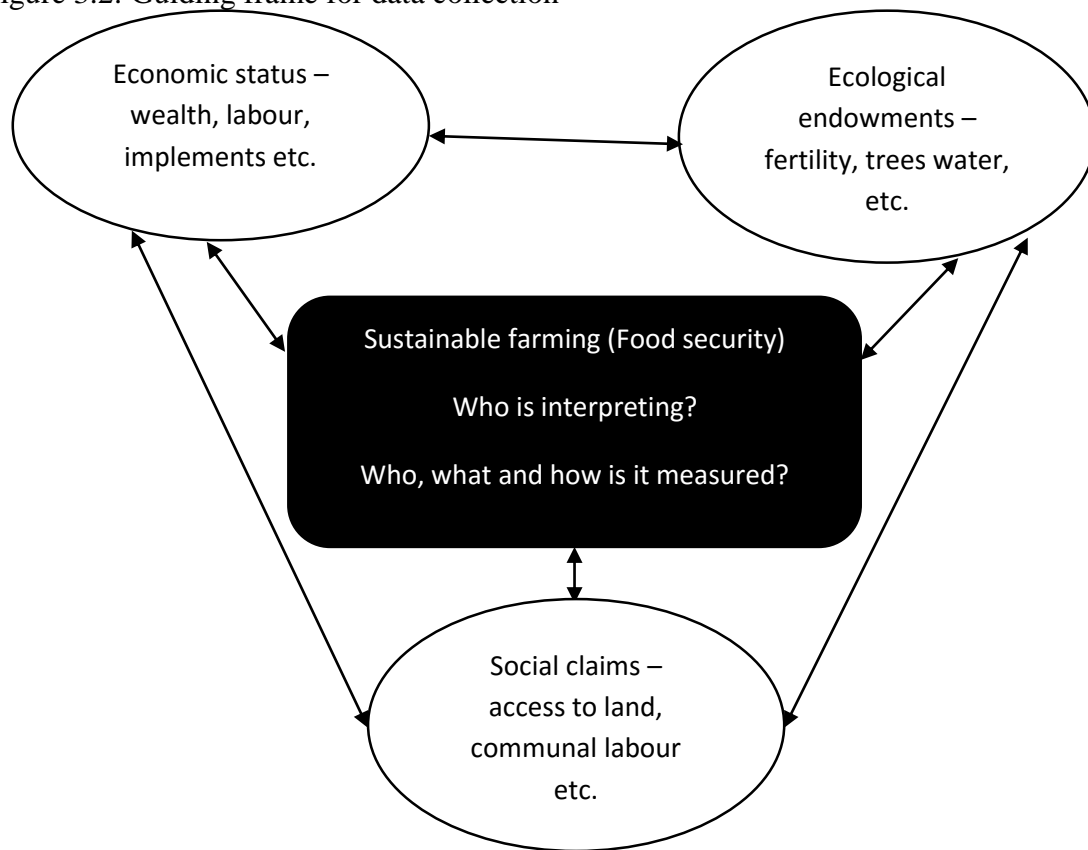
Johnson et al. (2007) noted that mixed-method research falls within a continuum of qualitative and quantitative research but, identified the two most important variant designs for this research. These are the QUAL + quan and QUAN + qual designs. Relatedly, Morse (2016) identified eight designs used in mixed-method studies based on the theoretical drive and pacing. A study depending on the research question could be inductively or deductively driven. When the research question seeks for description and a people's understanding of a problem then the research is inductively driven with a QUAL core component and a supplementary quan component. Pacing describes how the core and complementary components of a mixed-methods study are synchronised. We can use both methods concurrently, which is indicated with a + (plus) sign or the study could be paced sequentially, indicated with a → (arrow). This study follows a QUAL → quan mixed methods design (Morse, 2016; Onwuegbuzie & Leech, 2007). Thus, focus group discussions, expert and in-depth interviews and informal conversations were followed by a household survey. This design is supported by Hay (2008) who opines that a survey can be administered after a focus group discussion to test the generalisability of ideas emerging from the focus group. Also, to increase the representativeness and legitimacy of the study, triangulation of the approaches is important.

The choice of this approach is underpinned by a critical realist worldview. Critical realists are interested in applying pragmatism in finding solutions to a problem, but not necessarily adopting a specific approach to research (Brannen, 2005; Creswell, 2011; Sayer, 2006,

2010). They are opened to practicable options. This worldview does not restrict itself to any method but uses all available methods capable of better explaining a problem in doing so. The focus is on the research problem with pluralistic approaches used to derive knowledge about the problem (Creswell, 2011). A major assumption of this worldview and relevant to my work is its non-alignment to any one particular philosophy of reality. It also assumes that every researcher has a freedom of choice. In this case, the purpose and needs of the research problems define the methods and techniques to be used rather than specific approaches. Critical realists see the world, not as an absolute unity. This makes them ascribe to many approaches for collecting and analysing data. It sees multiple truths as time-specific and making mixed methods researchers use multiple approaches in understanding a problem, which is supported by its belief in an external world independent of the mind as well as that lodged in the mind (Kettles, Creswell, & Zhang, 2011; Sayer, 2004, 2006).

From a critical realist ontological perspective, farmers are conscious agents and capable of interpreting both their physical and social environment but differently with diversified outcomes. These interpretations allow them to combine resources at their disposal in enterprises that help them make a living. To sustenance, farmers are aware of the need to sustain the resource base of their enterprises. The sustainability is mediated to a large extent by a mix of macro and micro stressors with successes or failures dependent on a household status.

Figure 3.2: Guiding frame for data collection



Source: Author's construct

It is accepted here that households are not homogenous in their resource endowments and thus occupy or assume different statuses, which are strengths and vulnerabilities relative to each other. Households have economic, ecological and social resources as captured in Fig. 3.1. It is a frame on how the data collection proceeded. It revolved around the three dimensions of sustainable farming, economic, ecological and social. Within these are both macro and micro stressors and how a household interprets these, inform to some extent the interpretation of sustainable farming and its contribution to food security. It is, therefore, important to consider people's specific circumstances, their resource entitlements and ability to appreciate the operation of both the macro and micro stressors on their livelihoods in assessing sustainable farming. The qualitative techniques elicited informing on the economic, social and environmental dimensions of their resource base with farmer explanation on how macro and micro-level structures affect their understandings and practices of sustainable farming. The survey generated production and consumption data, in

addition to assessing perceptions of sustainability concerning key variables of the three dimensions of sustainable farming. In assessing sustainable farming, it is important to ask questions about whose understanding of sustainability we are measuring, who is doing the measurement, what is used in the process and how it is being done.

3.3 Relevance of mixed methods to my study

Mixed methods have had issues of acceptance within the social sciences over how to resolve the problem of combining methods with different ontological and epistemological underpinnings (Creswell & Miller, 2000; Feilzer, 2010; Fielding, 2010; Morse, 2010, 2016). This challenge to some extent has been addressed by Morse (2010) whose views concur with Onwuegbuzie and Leech (2007) that a mixed-method design uses one major approach in a study, which is supplemented by another approach with the supplementary component explaining or giving insight to the core and cannot by itself provide a satisfactory explanation to a problem. Relating this to my study, focus group discussions, in-depth interviews, expert interviews, and informal conversations were supplemented with survey data. The focus groups addressed issues relating to the shared conceptions of sustainable farming and if the farming systems are sustainable in the selected communities. They also addressed the shared views of policies that can help contribute to sustainable farming and food security among farm households. These views are contested and validated by group members, which enhances the validity of the study. However, it is difficult to constitute a representative group, especially during the farming season. In organising a group of such nature in local communities, care should be taken not to recruit participants from a single community. The entire areas earmarked for the study should be properly zoned with competent members recruited over the area to attain valid and representative data. This process is laborious, expensive and time-consuming in the context of rural areas as one has to overcome some courtesies in organising such groups.

While both qualitative and quantitative approaches to research are interested in the depth of the phenomena being studied, the former is particularly interested in the understandings and interpretations people give to phenomena (Botha, 2011; Teye, 2012) whereas the latter is concerned with the depth of relationships or differences between variables. The rationale for using a mixed-method design is my conviction that the strengths of these two approaches will provide a better explanation of the concept of sustainable farming and its relation to food security at the local level. If households agree that their farming systems are producing enough to meet their food needs with the qualitative techniques, this can be validated using household production and consuming data. Some aspects of the research such as mapping changes of crops grown and animals kept over the years were difficult to be captured with the survey. The focus groups and interviews were able to capture that aspect of the study. Additionally, just like any other complex issue that has a biophysical and human side interacting to yield given outcomes for rural populations, both approaches have provided a more complete answer to the set research questions (Bryman, 2016). It is necessary to assess how farmers perceive, understand and interpret changes in their agricultural systems, which comprises both their biophysical and social worlds, their sustainability and contribution to food security in the Builsa area. It is additionally important to measure observed changes in the biophysical characteristics of farming systems and to elicit farmer's views on the concept of sustainable farming. To guide policy, there is a need to measure how the different perceptions, understanding, and interpretations of sustainable agriculture yield different food security outcomes for different farm households. Such an exercise will demand the use of a design that enables the researcher to combine methods.

Additionally, some agricultural geographers, including Dalsgaard and Oficial (1991), are of the view that agriculture needs to be qualitatively described and quantitatively measured to help understand the productive performance of the agricultural systems and their ecological impacts. With this view, I strongly believe that the sustainability of the farming systems in

the Builsa area can better be explained by allowing farmers to assign values to some key indicators and offering them an opportunity to express their understandings, experiences, and interpretations of such indicators. Also, the mixed-method design is important to my study as the quantitative measures produce trends in terms of changes observed in the biophysical elements of the farming systems with the qualitative aspects providing explanations to these trends and the factors that influenced the decisions that produced such trends. Once quantitative research helps us to make a generally quick observation of phenomena, we can have a general idea about how farms in the Builsa area are evolving and how farmers feel about the sustainability of these evolutions. I also wanted to know the different perspectives of the concept of sustainable agriculture, which can be triangulated by the use of the two approaches to research.

To further justify the choice of the mixed-method approach, it is argued that sustainable farming is a subjective concept with a contested meaning thus generating different approaches to its empirical study (Beland Lindahl et al., 2016; Mayer, 2008; Rigby, Woodhouse, Young, & Burton, 2001; Schaller, 1993). Also, some scholars agree that in addition to its subjective interpretations, there is a need for sustainable agriculture to be measured to guide policy and to help in its evaluation (Andreoli & Tellarini, 2000; Gómez-Limón & Sanchez-Fernandez, 2010; Pannell & Glenn, 2000). Relatedly, the concept of sustainable agriculture involves the management of both physical and human resources (Sajjad et al., 2014), which necessitates the use of both qualitative and quantitative techniques to unravel how the two can be mutually explored and enhanced. Following the ideas of Morse (2010), that mixed methods projects are driven by both inductive and deductive reasoning, they are used to complement each other (Teye, 2012). It has also been observed that quantitative methods can assist qualitative ones in the research design, data collection and data analysis stages (Johnson et al., 2007). For instance, at the design stage, representative samples and outliers can be identified by the use of both methods.

The qualitative research approach has been criticised for being too subjective and inappropriate for generalisations (Teye, 2012). This limitation was solved in this study by the use of multiple qualitative methods. The mixed-method helped to broaden the dimensions of the study and to ensure validity by involving several participants. As observed by Teye (2012), using a single qualitative method could lead to an unrepresented conclusion since the view of one person cannot represent views of all within a community. With the focus groups, a view expressed by one individual is either affirmed or contested by other group members thereby boosting the validity of the answers.

3.4 Data sources

The study combined both secondary and primary data in answering the research objections and questions. These sources are discussed under data sources. Secondary data consists of reviews from earlier studies and records on the farming systems in the study area. Primary data is that which is generated by the use of the mixed-method techniques of interviews and a survey. These are used to complement each other in giving understanding to the nature of the farming system and their contribution to food security.

3.4.1 Primary data sources

The main sources of primary data for this study are focus group discussions, personal interviews, expert interviews, informal conversations, and a survey. Data collection took place between June and October 2018. **Table 3.1** summarises the phases of data collection.

Table 3.1: Phases of data collection

| | |
|--|---|
| <p>PHASE ONE Focus group discussions and pre-testing of the questionnaire: concept definition, generate indicators for measuring concepts, nature, constraints, and enablers of farming systems. Purpose: to have a general understanding of the concept of sustainable farming and to test the validity of the questionnaire and main ideas (3 weeks in the Builsa area)</p> | <p>PHASE TWO In-depth interviews: Purpose: to have personal understandings of the concept of sustainable farming, transitions in farming systems, and contributions of new forms of farming to food security (2 weeks)</p> |
| <p>PHASE THREE Expert interviews: explain the concept of sustainable farming and linkages between farming systems and food security. Purpose: to elicit expert view on the sustainability of the farming systems in the Builsa area and their contribution to food security (2 weeks)</p> | <p>FINAL PHASE Survey: 453 households in the in seven (7) villages in the Builsa area Purpose: to generate quantifiable data on the farming systems and household consumption, measure perceptions of sustainable agriculture (6 weeks for the survey)</p> |

Source: Author, 2019

The study started with focus group discussions. These groups comprise a small number of people discussing a topic defined by a researcher (Hay, 2008). It has been suggested that conducting between 3 and 6 focus groups can make a study acceptable as more than 90% of one’s themes in a study could be exhausted (Guest, Namey, & McKenna, 2016). This study used between eight (8) and ten (10) participants in the focus group discussions. Because of patriarchal tradition, the study separated women groups from men groups as suggested by Teye (2012). The focus groups did not only compensate for the weakness of corroboration using in-depth interviews, as views of the member are contested, but also “allowed for an exploration of how experiences and meanings are negotiated and contested between participants” (Teye, 2012, p. 384).

This method is selected as part of my study because far more information is generated on the farming system than using only in-depth and expert interviews. The focus groups additionally allow for method triangulation as they provided a context for the household survey (Antwi-Agyei et al., 2015). They also helped in bringing out not only a consensual but a multiple understanding of the concept of sustainable agriculture. Focus groups

discussions were concurrently held with the pre-testing of the questionnaire. This allowed for the modification of questions.

In selecting venues and participants for the focus groups discussions, the Builsa area was divided into two administrative areas – Builsa North and Builsa South districts. Based on these political divisions the study targeted eight (8) focus group discussions. Two (2) communities each were purposively selected from each district where focus group members were drawn. From each district, a town that is around the district capital and a village that is remote from the district capital were selected. Two focus groups comprising male and female groups were held in each selected community. This selection enriched the discussion on the extent to which off-farm job opportunities contribute to sustainable farming and food security. The initial focus group discussions allowed the researcher to gather information on people who have some extensive knowledge of the farming system in the area. The selection was based on gender, age, and experience. Participants were male and female farmers who had the requisite knowledge and experience on the farming systems in the study area. There were variations in age and experience among members of the focus groups. The focus group discussions considered issues relating to changes in cropping systems, livestock systems, farm implements used, ways of maintaining soil fertility, economic, social, and ecological profitability of farm systems, their sustainability and contribution to food security among farm households as shown in Table 3.2.

Table 3.2: Qualitative method of data collection, themes, and variables (Focus groups).

| Method | Themes | Themes/Variables |
|---|---|--|
| Focus group discussions | Nature of farming systems | Livelihood activities Description of farming systems Constraints and enablers of farming systems |
| Eight (8) focus group discussions. One with men and the other with females in Gbedembilisi, Fumbisi, Kadema, and Sandema. | Transitions in farming systems | Changes in: farm size, labour, crops grown, inputs used, integration with livestock, |
| | | Drivers of changes: Media, Self-experimentation, Climate-related, Markets, Dietary changes, institutional induced, Technology induced, NGO initiatives, others |
| | Concept of sustainable farming | Intercropping with trees, management of crop residue, cropping sequences, ways of conserving soil fertility, etc. |
| | Measuring sustainable farming | Economic: |
| | | Profitability, income generation, viability, self-sustenance in food production. |
| | | Social: Land tenure system, access to labour, continuity of farming activities |
| | Environmental: Soil erosion, nature of crop yields, use of chemical inputs, weed and pest management strategies, use of irrigation water and crop diversity. | |

Source: Author's 2019.

Separate group discussions were held for the sexes to avoid intimidation and to allow the females to freely express their views. That was done for two reasons. The first was to allow females to express their views on issues of ownership and the use of farm produce and the second to overcome some cultural challenges of engaging females in the absence of their husbands. The group discussions were well moderated to avoid dominance or loss of self-esteem by some members.

3.4.2 Expert and In-depth interviews

An expert is anyone with relevant or in-depth knowledge about a topic of interest (Krueger, Page, Hubacek, Smith, & Hiscock, 2012). This category of research participants was selected based on their knowledge of the farming system and agriculturally related issues in the Builsa area. Purposive sampling technique was used in selecting participants. This technique is used when cases or units are selected based on a specific purpose rather than randomness (Teddlie & Yu, 2007). In this regard, six (6) agriculture extension officers, four (4) representatives of farmer groups, two (2) representatives of agriculture-based NGOs and two (2) nutrition officers from the Builsa north and south districts were selected for interview using an interview guide. The themes and variable explored with this technique are shown in Table 3.3.

Table 3.3: Qualitative method of data collection (Expert interviews)

| Participants | Themes | variables |
|-------------------------|--|---|
| Expert interviews | Livelihoods | Listing of livelihood activities in communities |
| Retired Agric. officers | Nature of farming in the past three (3) decades | Crop and livestock mix, inputs and implements use, yields, etc. |
| Extension officers | Transitions in farming systems | Cultivable area, new varieties of crops with reasons and sources, contribution to yields, new implements used, drivers of the transitions |
| Renowned farmers | The concept of sustainable farming | Definition of sustainable farming Markers of a sustainable farm Sustainable farming practices in the Builsa area |
| Extension officers | Forces influencing sustainable farming | External and internal forces (ecological, economic and social) |
| Retired Agric. officers | Linkages between farming systems and food security | Modernisation of the farming system have increased food availability |
| Mofa director | Policy contribution | The existence of policies that promote sustainable farming Do farmers adhere to these policies Role of stakeholders in ensuring sustainable farming |

Source: Authors' construction

Further, 20 in-depth interviews were held with farmers across the Builsa area. The purposive sampling technique was used in selecting participants. Table 3.4 contains the themes and variables used to collect data with an in-depth interview.

Table 3.4: Qualitative methods of data collection (in-depth interviews)

| Method | Themes | variables |
|---------------------------------|---|---|
| Qualitative interviews | Livelihood activities | Crop farming, livestock keeping, petty trading, agro-processing, etc. |
| 20 interviews in the study area | Nature of farming systems over the past three (3) decades | Farm types, number of fields, size of each field, types of crops grown, inputs used and yields |
| | Transitions in farming systems | Changes in crops grown and livestock kept (reasons, sources, and effects of new crop and livestock varieties on farmers) |
| | The concept of sustainable farming in terms of : | |
| | Environmental protection | Farm practices that: improve soil fertility and yields, combine tree crops, reduce soil erosion |
| | Improve output | increase livestock numbers brings food all year round |
| | Self-fulfilling | provide enough income, allow access to labour, allow crop-livestock integration and support, allows the eating of preferred, food from farming systems, provide food that protects and strengthens the cultural identity provided support to extended family members in need allows the farming systems to continue |
| | Linkages between farming systems and food security | Eating preferred foods Food produced by farming systems |
| Policy contribution | The expected and actual contribution of farmers towards sustainable farming Expectations of a farmer of the role of external sources e.g. government towards the sustainability of their farm systems. | |

Source: Authors' construction

This technique was used to generate information on yields, income and the control of household produce. Besides this, people are sensitive if it comes to discussing issues on personal experiences and perceptions including household welfare necessitating the use of personal interviews.

3.4.3 Informal conversational interviews

These are interviews held with local people without the use of interview guides (Teye, 2012). The discussion was held with groups such as processors of shea butter, dawadawa, basket weavers, fishers and farmers. Although such a method has been identified to have issues with bias, it nevertheless has been observed to be able to cover areas that cannot be captured by other more organised techniques (Teye, 2012). These conversations revolved around issues of changes in the farming systems, the concept of sustainable farming, the profitability of farms and factors that inhibit or enhance sustainable farming. This technique allowed for the exploration of some aspects of the farming systems that were not covered by the other instruments. Fouls are in high demand during the first three months after harvest as that time is used to appease the ancestors in the Builsa land. These and other details about the farming systems were captured through informal conversations making it a rich source of primary data as participants expressed themselves freely. One other advantage was the ability for other participants to confirm or disagree with earlier views helping to build a common understanding of given themes and variables.

3.4.4 The survey

Sampling describes the process of selecting units or cases of a study using both probability and purposive strategies. The sampling approaches used in this study were both purposive and random. The purposive approach is used in selecting study sites and participants for the qualitative aspect of the study. A detailed discussion of how participants were selected is under the various sources of data used for this study. The survey, which used a random approach, is discussed here.

3.4.4.1 Sampling of survey respondents

The importance of selecting sites and participants in every study is well acknowledged (Francis et al., 2010; Fugard & Potts, 2015). Broadly defined, a mixed-method sampling

design is regarded as the framework within which the sampling occurs and comprises the number and types of sampling schemes and the sample size (Collins, Onwuegbuzie, & Jiao, 2007). The two most important components of a mixed-method sampling design are the sampling scheme and sample size. The former describes the explicit strategies used in selecting units while the latter deals with the number of units selected (Collins et al., 2007). In a mixed-method study, the researcher is to make considerations regarding sample schemes and sizes for the quantitative and qualitative aspects. Regarding sample size, it is suggested that power analysis is done for both the quantitative and qualitative aspects of the research as it provides researchers with information regarding appropriate sampling size for the study.

The study used a multi-stage sampling strategy and blended purposive, simple random and stratified random sampling techniques to select towns, compounds, and households for the survey. With multistage sampling designs, frames were needed at each stage (Lavrakas, 2008). The frame for the first stage was the listing of the towns and villages in the two districts of Builsa. Towns and villages were purposively selected after they were listed. This was guided by the need to assess variation in agricultural systems between settlements of varying sizes and locations. The criteria were thus to select town and village settlements for the study. The second stage was a frame containing the list of the sub-areas under each selected town or village. These were selected using the simple random strategy. At the third stage, compounds within the selected towns and villages were selected. With the aid of the listing of compounds, each selected town was divided into zones using certain landmarks from which the simple random technique was used to select compounds.

At the final stage, household heads were selected, and stratified random technique was used to ensure gender balance. At the compound level, households are listed and stratified based on gender and participants selected from both strata. This allowed for proportionate

representation and to help assess the gender differences in views on sustainable farming and its contribution to food security in the Builsa area (Lavrakas, 2008).

3.4.4.2 Sample size determination

The study area has a total of nineteen thousand four hundred (19400) households and more than 90% of these are farm households (GSS, 2014a). Out of these, the study targeted a confidence level of 95% (0.05) and a confidence interval of three (3). Using the Yamane (1967) formula below, a sample of four hundred and fifty-one (451) farm households were selected for the entire study.

$$n = \frac{N}{(1+Ne^2)}$$

Where

n= corrected sample size, N = population size, and e = Margin of error (MoE), e = 0.05 based on the research condition (Yamane, 1967).

Sample size determination is important for every study as an undersized sample will waste time and resources because of its lack of generalizability, while an oversized sample will use more resources than needed (Francis et al., 2010; Lenth, 2001). Sample size and power estimation are necessary to justify any study and its findings (Onwuegbuzie & Collins, 2007; Prajapati, Dunne, & Armstrong, 2009). To maintain the power of the sample, the 451 households attained based on the Yamane (1967) formula were distributed proportionally among the selected towns and villages. This was done base on the number of household in the selected communities.

The survey conducted in the study area involved 451 farm households selected from seven communities. The themes and variables used for the survey are shown in Table 3.5.

Table 3.5: Quantitative method of data collection

| Method | Themes | variables |
|---|--------------------------------------|--|
| Questionnaire | Demography | Name, sex, age, marital status, education, occupation, and employment |
| Closed-ended questionnaire (451 households in seven selected villages in the study areas) | Nature of the cropping system | Type of cropping system, types of crops grown, size of the plot, quantity harvested, quantity consumed, quantity sold and the unit price |
| | Cost of production for crop farming | Types of chemical fertilisers applied, the quantity applied, cost of chemical fertiliser, cost of organic fertiliser, pesticides applied, cost of pesticides, cost of labour and cost of own labour. |
| | Cost of production for livestock | Type of livestock, number of livestock, number of newly born in a year, number consumed, and number sold, the price per livestock, cost of feed, cost of vet services and cost of labour. |
| | Channels of the spread of innovation | Radio, televisions, friends, extension officers, NGOs, mobile phones. |
| | Soil fertility management | Organ and inorganic means |
| | Sustainability of farming systems | Ecological, economic and social dimensions |
| | | Ecological: |
| | | Soil fertility status Yields per unit area Vegetative cover Erosion control |
| | | Economic: |
| | | Profitability, income generation, sufficient outputs, efficient markets, and storage facilities. |
| | | Social: |
| | | Continuity, food self-sufficiency, eating preferred foods, access to labour, job satisfaction, maintenance of culture, on-farm employment activities. |
| | Hunger scale | The frequency of food intakes Number of months without food |
| Dietary diversity | Variety of food intake per household | |

Source: Authors' 2019.

3.5 Secondary data sources

The study relied on secondary data sources as that was necessary for explaining the influence of external forces and the accounts of other studies on the sustainability of farming systems in the Builsa area. Macro data or national trends of transitions in farming systems are noted to have the effect of explaining micro or empirical trends (Lobao & Meyer, 2001; Yaro, 2004a). These sources are equally important in providing a general picture of the farming systems in the study area in terms of their nature, productivity and constraints. These data sources are triangulated with primary data as there hardly exists solid documentation and reliable databases in developing countries (Kumekpor, 2002). Bryman (2016) identified two sources of secondary data useful to researchers in their studies. These are personal and official records. Official records are subdivided into state and private data sources. Some of the data for this study was derived from official sources. These include agriculture production data from the analytical reports of both Districts Assemblies produced by the Ghana Statistical Service, Ghana Living Standard Reports, the Ministry of Food and Agriculture. National and regional policy documents on agriculture were also reviewed. It also relied on crop and livestock production data from the District Departments of Agriculture. Official documents are important sources of secondary data for describing changes in the biophysical characteristics of an agricultural system. Data on fertilizer use, pesticides, farm outputs, extension services, and the introduction of new crop varieties were obtained from the District Departments of Agriculture in Builsa and the Ghana Living Standard Surveys. The study has also relied on the planning departments of both districts for data on the towns, villages, and compounds with their corresponding population densities. Secondary data on the number of communities and their corresponding populations formed the basis for the survey sampling.

3.6 Data analysis

The qualitative data was manually transcribed and analysed based on themes (Silverman, 2009; Creswell, 2015). The thematic or content analysis technique was deployed to identify emerging themes from the transcribed data and used to answer the research questions. It was also used to enrich findings from the household survey by the use of voice (Francis et al., 2010; Fugard & Potts, 2015). Data were transcribed and imported into NVivo Pro. Transcripts were coded into themes and were analysed thematically.

Objective one, which is to analyse changes in the farming systems over the past three (3) decades is answered by the use of tables and chart generated from the household survey. These are complemented with data from the focus group discussions and interviews. The focus groups and interviews generated descriptive data on changes in farming systems, while data on farm size, yields, access to extension services and the use of external inputs come from the survey. Cross tabulations are used to show the spatial distribution of the demographic characteristics of the respondents and other variables like farm size, crops grown and yields within the different farming systems.

Objective two seeks to measure farmer perceptions on sustainable farming and the sustainability of their farming systems. This is answered by the use of descriptive statistics generated from the survey data using IBM SPSS Statistics software. Specifically, descriptive statistics include the use of means and standard deviations. These are employed to describe the economic, social and environmental variables that are important in addressing the study's objective two. These dimensions of sustainable agriculture, which are measured with a Likert scale, were complemented with views from the focus groups and interview data. The qualitative data is analysed through the process of uncovering themes within the data to complement the survey data (Bryman, 2016; Fugard & Potts, 2015).

Further, objective three is analysed using multiple regression analysis. The regression analysis is used to assess the strength and significance of the relationship between food security status and type of farming systems practised. Objective four, which seeks to measure and discuss the contribution of the local farming systems to food security of all categories of households, is addressed using descriptive statistics. The extent of contribution is addressed using the means and percentages of economic, social and environmental variables used in assessing the sustainability of the farming systems. The findings of the survey are compared with a standard measure of sustainable agriculture drawn from the literature on measuring sustainable agriculture.

3.7 Validity and reliability of the study

Validity describes how accurate participant's realities represent the social phenomena accounted for and is credible to them (Creswell & Miller, 2000). Over the years, there have been some difficulties with the acceptance of the findings of qualitative research because of issues with validity and reliability. Collins et al. (2007), for example, identified a crisis of representation, legitimation, integration, and politics in qualitative research. To this end, Creswell and Miller (2000) recognized a consensus has been reached that qualitative researchers need to demonstrate that their work is reliable. Qualitative researchers, therefore, employ several techniques to achieve reliability. Creswell and Miller (2000) identified member checking, triangulation, thick description, peer review, and external audits as some of the techniques employed.

In this study, the validity of the qualitative methods is ensured based on the views of participants. This is through descriptions of concepts or what they perceived to be sustainable farming. This is informed by the view that knowledge of reality is constructed, with reality becoming what participants see to be real (Creswell & Miller, 2000; Sayer, 2000, 2004, 2010). Data saturation was used to attain content validity. This was achieved

by using shared beliefs, a method noted to overcome the challenges of how to determine data saturation. This occurs when more participants in a study share the same ideas about a concept (Francis et al., 2010).

Triangulation occurs, when multiple methods are used as part of a validation process, such that observed variance is accepted as a result of the phenomena or trait being studied but not the method used (Johnson et al., 2007). Between-methods triangulation, which involves the use of different approaches to the study of a phenomenon will allow for weaknesses of one approach to be compensated for by the strengths of the other (Johnson et al., 2007). In this regard, focus group discussions and the survey complement each other to ensure the validity of the study. The reliability of the questionnaire for the household survey is ensured through pre-testing with twenty households. After the pre-test, there were modifications of some key concept such as sustainable farming and how it can be measured at the local level.

3.8 Research ethics and access to data

Ethics are crucial in social research. The basic ethical concerns are research participants' safety, informed consent, and research participants' anonymity as there is a need to protect participants from danger or unnecessarily exposing them to threats when they agree to assist in co-creating of knowledge. How to treat research participants and how to proceed on conducting research have been observed to be critical in conducting any study (Bryman, 2007). Participants in the focus groups and interviews volunteered without coercing. Convenient venues were selected to allow for ease of access. Another ethical issue that was addressed in this study is the option of respondents to pull out of the study at any stage. This is informed by views that knowledge creation is voluntary and those who participate do that on free will. Consents of the participants were sought before they are selected for the study. Data handling is also important so that it does not expose research participants.

The purpose of the study was explained to the participants. It explains how the intended study is purely for academic purposes. Participants were made aware that pseudo names will be used for the presentation and discussion of results from the focus group discussions, expert interviews, in-depth interviews, and informal conversations. This is done to ensure that the identities of participants are concealed to protect their privacy. In the data collection process, permission was sought to record the voices of participants. They were assured that tape recordings will not be given to third parties and feedbacks in the form of transcripts will be given to participants to authenticate their views. On the issue of incentives, no money was given out to participants since almost all the primary data was collected at the doorstep of participants who did not travel over longer distances except the focus group discussions. This was done to ensure unbiased responses from participants (Robinson, 2013). However, at the end of the group discussion, a token was given to a leader to buy water for the participants to compensate for their time.

An ethical dilemma that the study was confronted with was dealing with the sacrifice farmers made during the farming season in a research situation. The survey questions were bulky and farmers were time-pressed as they needed to control weeds on their farms or undertake other farm activities. A way out would have been to conduct the study during the dry season. Yet still, how do researchers use farmers' time, which would have been used for productive gains without compensating for that time? I had to explain to them the importance of documenting their work for posterity. To ensure smooth data collection, I negotiated with farmers based on a convenient time. In this case, the participants had more power than me and dictated the time a meeting could be held.

3.9 Delimitations and limitations of the study

The spatial coverage of this study is the Builsa area, which comprises the Builsa North and Builsa South Districts. It analyses farmer understandings of the concept of sustainable farming and how that contributes to household food security. This was achieved by using a perceptual framework to assess the economic, social and environmental sustainability of the farming systems.

The study does not entail rigorous biophysical measures of sustainability. The study did not assess the sustainability of all livelihood activities in the Builsa area but only dominant farming systems as farmers do not practice the same systems under seemingly homogeneous biophysical conditions.

CHAPTER 4

TYPES AND TRANSITIONS IN THE FARMING SYSTEMS

4.0 Introduction

This chapter describes the farming systems in the Builsa area with an emphasis on transitions in farm practices in recent decades (1990 - present). Most farm households in Builsa grow crops and keep livestock for sustenance and commercial purposes. Households operate multiple farming systems, which are spatial units and classified differently. Those organised around dwellings are called compound farming systems; those farther away from the dwellings are bush farming systems; in the valleys and marshy areas were valley farming systems; and recently, those along tributaries of the White Volta are described as riverine farming systems. This conceptualisation of farming is in line with that of Benneh (1973) and Yaro (2004a). The chapter outlines and analyses transitions in these systems over time and space. The analysis relied on both a survey and interviews to interrogate the transitions in the various farming systems.

4.1 Socio-demographic conditions in the Builsa traditional area.

A total of 451 farm household heads participated in the survey drawn from seven (7) communities, consisting of towns and villages as shown in Table 4.1.

Table 4.1: Selected towns and villages in Builsa

| Town communities | | | Village communities | | | |
|--------------------|--------------------|------------------|---------------------|------------------|------------------|----------------------|
| Sandema (N-130) | Fumbisi (N-115) | Wiaga (N-122) | Doninga (N-32) | Chansa (N-29) | Kadema (N-18) | Gedembilisi (N-5) |

Source: Field data 2018

Towns are communities with a minimum of 5000 or more inhabitants and inhabitants less than 5000 are classified as villages (GSS, 2014b). Sandema and Fumbisi are district capitals but Wiaga is a bigger town in terms of population and functionality. Kadema, Gbedembilisi, Doninga, and Chansa are located relatively farther from the two district capitals and are considered as village communities as their populations are less than the 5000 thresholds.

The major livelihood activity in Builsa is farming with most households practising multiple farming systems. Almost all farm households own a compound farm with more than half practising bush farming and less than half engaged in valley farming with very few households practising riverine and irrigation farm systems (Table 4.2.). The household is the basic unit for the organisation of farming in Builsa. Households in Builsa comprise a head and members who cooperate economically, socially and politically to pursue not just a living but their general wellbeing as well. Table 4.2 shows that compound farming is the dominant system in the study area with the riverine system accessible to only communities drained by major rivers such as Gbedemilisi and Doninga, which are located very close to River Sisili. The results also show that participants of bush farming systems increase with distance from the major towns in the Builsa area except for Fumbisi. Fumbisi, though a district capital has a higher number (58%) of participants in the bush systems compared to Sandema and Wiaga. This is due to the availability of new frontiers around Fumbisi and the dominant role of Sandeam and Wiaga in attracting educational and other infrastructure making these communities urbaner than Fumbisi. Kadema, Gedembilisi, Doninga and Chansa, which are villages have more than half of farm households participating in the bush systems compared to Sandema and Wiaga, which are towns. This is explained by urbanisation as growth in towns are associated with the competitive use of land with agricultural activities noted to be negatively affected in peri-urban areas in Ghana (Kuusaana & Eledi, 2015).

Table 4.2: Farming systems by community

| Farming System | N | Sandema | Fumbisi | Wiaga | Kadema | Gbedembilisi | Doninga | Chansa | % |
|--------------------|-----|---------|---------|-------|--------|--------------|---------|--------|------|
| Bush farming | 228 | 36.9 | 58.3 | 37.5 | 61.1 | 71.4 | 84.4 | 86.2 | 50.6 |
| Compound farming | 430 | 96.2 | 93.9 | 95.8 | 100.0 | 100.0 | 96.9 | 89.7 | 95.3 |
| Irrigation farming | 15 | 0.8 | 0.9 | 10.8 | 0.0 | 0.0 | 0.0 | 0.0 | 3.3 |
| Valley farming | 183 | 46.2 | 24.4 | 40.0 | 27.8 | 85.7 | 81.3 | 34.5 | 40.6 |
| Riverine farming | 5 | 0.0 | 0.0 | 0.8 | 0.0 | 57.1 | 0.0 | 0.0 | 1.1 |

Source: Field data 2018

Although households are headed by both males and females in the study area, more than two-thirds (78.3%) of heads of farm households are males (Table 4.3a). The entire riverine system is dominated by males (100%) and this is explained by cost as it is an intensive system that excludes females who have relatively inadequate resources to finance its operations as females are not expected to control land and other important resources in Builsa.

This highlights the dominant role of patriarchy (GSS, 2014d) where males are expected to lead in all spheres of life in Builsa with the inheritance system depriving most females of access to land and other properties such as livestock bequeath to them from parents and grandparents. This has an implication on household food security by female-headed households as they are deprived of accessing vital resources needed to support farming activities. This confirms the findings of Babatunde and Qaim (2010) that African males often control productive resources making them relatively food secured than their female counterparts. Tibesigwa and Visser (2016) additionally found that the food security gap between male and female-headed households is wider in rural than in urban areas with this linked to the control of resources. However, in Asia where there are no restrictions in access to productive resources no differences were observed in the food security status of both male and female-headed households (Mallick & Rafi, 2010) emphasising the need to reduce gender inequalities in access to resources if food security is to be attained by all at the household level.

Table 4.3a: Sex distribution of household heads by farming systems

| Farming system | N | Female (%) | Male (%) | Total (%) |
|--------------------|-----|------------|----------|-----------|
| Bush farming | 228 | 11.4 | 88.6 | 100.0 |
| Compound farming | 430 | 22.1 | 77.9 | 100.0 |
| Irrigation farming | 15 | 6.7 | 93.3 | 100.0 |
| Valley farming | 183 | 20.2 | 79.8 | 100.0 |
| Riverine farming | 5 | 0.0 | 100.0 | 100.0 |
| Total | 451 | 21.7 | 78.3 | 100.0 |

Source: Field data 2018

Farming systems in which female participation is relatively higher are compound and valley systems. The former is explained by proximity to homestead as females can conveniently attend to household chores while tending to their farms with the latter related to the need to buffer millet and sorghum from the compound farms with rice which is planted in the valley systems. This strategy spreads risk as the valley systems are capable of holding water relatively longer making the rice less likely to fail in terms of drought.

Female participation in farming is not evenly distributed. Town communities (Sandema 36%, Wiaga 15% and Fumbisi 20%), have more female participation than village communities. A community which is a village but has high female participation is Kadema (28%). This is attributed to locally specific cultural practices that encourage female participation in farming in this community. Generally, the patterns of female participation in farming are not even and thus suggest that patriarchy varies in space with women having more control of their lives and a fair share of resources in areas where there are fewer restrictions to access of resources by females as shown in Table 4.3b.

Table 4.3b: Sex distribution of household heads by community

| Community | N | Female (%) | Male (%) | Total (%) |
|--------------|-----|------------|----------|-----------|
| Sandema | 130 | 36.2 | 63.9 | 100.0 |
| Kadema | 18 | 27.8 | 72.2 | 100.0 |
| Wiaga | 120 | 15.8 | 84.2 | 100.0 |
| Gbedembilisa | 7 | 0.0 | 100.0 | 100.0 |
| Fumbisi | 115 | 20.0 | 80.0 | 100.0 |
| Doninga | 32 | 3.1 | 96.9 | 100.0 |
| Chansa | 29 | 10.3 | 89.7 | 100.0 |
| Total | 451 | 21.7 | 78.3 | 100.0 |

Source: Field data 2018

Household membership in Builsa extends beyond children to grand and great-grandchildren, grandparents, sons and daughters-in-law and other relatives. Household heads mobilise the rest of the members for efficient functioning as they oversee the day-to-day allocation of labour and other critical resources necessary for their survival. Households are autonomous entities but under the leadership and direction of the compound head who is most often the elderly male member of the compound and control the allocation of communal property.

Such property could be inherited cattle, commonly held fields for crop cultivation and livestock grazing.

Although formal education is critical to household participation in both the informal and formal economy, more than half (59.2%) of heads of farm households have had no form of formal education as shown in Table 4.4a.

Table 4.4a: Educational level of household heads in the farming systems

| Farming system | N | None (%) | Primary (%) | JSS/JHS/Middle (%) | Secondary (%) | Total (%) |
|--------------------|-----|----------|-------------|--------------------|---------------|-----------|
| Bush farming | 228 | 59.2 | 15.8 | 10.1 | 14.9 | 100.0 |
| Compound farming | 430 | 59.5 | 16.5 | 8.1 | 15.8 | 100.0 |
| Irrigation farming | 15 | 40.0 | 13.3 | 6.7 | 40.0 | 100.0 |
| Valley farming | 183 | 57.4 | 18.6 | 10.9 | 13.1 | 100.0 |
| Riverine farming | 5 | 80.0 | 20.0 | 0.0 | 0.0 | 100.0 |
| Total | 451 | 59.2 | 16.0 | 8.9 | 16.0 | 100.0 |

Source: Field data 2018

This observation concurs with official records reported by the 2012 census where most residents in the Builsa area are noted to be less educated GSS (2014d). The highest level of formal education attained by most heads of farm households is a primary and secondary school with less than a quarter (16%) having attained that level of education on the average as shown in Table 4.4a. This is followed by Senior High School and Middle school, respectively, which are less than a quarter. As expected, few heads of households have had any form of vocational training with very few heads being trained at the tertiary level. More than a quarter (40%) of farmers who practised irrigation farming had secondary education with equally (40%) who are non-educated. Generally, irrigation farming has the lowest proportion of non-educated farmers and this is explained by the need to keep records and the ability to keep track of some cultural practices that are necessary for a good yield within the irrigation system.

Spatially, communities in rural spaces have the highest number of households with no formal education with Gbedembilisi (0%) having had no respondent attaining secondary education as shown in Table 4.4b.

Table 4.4b: Educational levels in farming communities

| Community | N | None (%) | Primary | JSS/JHS/Middle (%) | Secondary (%) | Total (%) |
|--------------|-----|----------|---------|--------------------|---------------|-----------|
| Sandema | 130 | 56.2 | 19.2 | 6.2 | 18.5 | 100.0 |
| Kadema | 18 | 72.2 | 11.1 | 5.6 | 11.1 | 100.0 |
| Wiaga | 120 | 56.7 | 17.5 | 6.7 | 19.2 | 100.0 |
| Gbedembilisa | 7 | 42.9 | 42.9 | 14.3 | 0.0 | 100.0 |
| Fumbisi | 115 | 62.6 | 11.3 | 11.3 | 14.8 | 100.0 |
| Doninga | 32 | 53.1 | 15.6 | 21.9 | 9.4 | 100.0 |
| Chansa | 29 | 72.4 | 10.3 | 6.9 | 10.3 | 100.0 |
| Total | 451 | 59.2 | 16.0 | 8.9 | 16.0 | 100.0 |

Source: Field data 2018

This is due to location as towns are exposure to higher-order educational and other facilities. Sandema has long served as a district capital for the Builsa area since 1993 (GSS, 2014a). Because of its size, it has attracted higher investments in educational facilities such as secondary schools, vocational training centres and other infrastructural development relative to its surrounding villages. This can be explained by the urban bias theory (Lipton, 1984) that outlines how resources are often concentrated in urban areas with the neglect of the countryside. This leads to a concentration of resource in Sandema with the neglect of surrounding villages. Wiaga, a secondary town closer to Sandema has a missionary station that influenced the establishment of educational units in the area thus benefiting from formal education. The locations of Sandema and Wiaga have exposed these communities to social progress at the regional level as they are more accessible to educational facilities compared to Doninga and other remote communities, which have no strong links with places of a higher order. Educational attainment of heads of farm households thus decreases with distance from towns with villages having the highest number of households without any formal education like Chansa and Kadema, which have more than two-thirds (72.4% and 72.2%) of heads of farm households having no form of formal education. This has implications on the misuse of agrochemicals in the absence of effective agricultural extension services and education. As a focus group member argued that: *“weedicides are incapable of killing any living organism, which has blood in it. It is only capable of killing insects, I can even drink it and nothing will happen to me”*. (Male member, focus group, Chansa, July 2018). This observation confirms that of Laary (2012) who found that in the

Upper East area more than two-thirds (74%) of dry season vegetable farmers were illiterate and misapplied agrochemicals. Thus, farm household educational attainment is linked to the level of urbanisation in their specific locations. This explains why Sandema and Wiaga have a high number of farm household heads attaining higher education relative to the rest of the study communities.

4.2 Non-farm activities

Some farm households do engage in the non-farming sector to augment their livelihoods as they combine it with farm work as shown in Table 4.5a.

Table 4.5a: Farm household participation in the non-farm work by farming systems

| Farming system | N | Non-participant (%) | Participant (%) | Total (%) |
|--------------------|-----|---------------------|-----------------|-----------|
| Bush farming | 228 | 73.7 | 26.3 | 100.0 |
| Compound farming | 430 | 71.9 | 28.1 | 100.0 |
| Irrigation farming | 15 | 73.3 | 26.7 | 100.0 |
| Valley farming | 183 | 80.3 | 19.7 | 100.0 |
| Riverine farming | 5 | 80.0 | 20.0 | 100.0 |
| Total | 451 | 71.8 | 28.2 | 100.0 |

Source: Field data 2018

The non-farm sector includes all income-generating activities outside the main farm work. These include trading in daily consumables, basketry, fishing, hunting, and pottery, which are location specific. Table 4.5a suggests that participation in the non-farm sector is not much as more than two-thirds (71.8%) of heads of farm household do not participate. More farm households who participate in the non-farm sector combined with it with compound farming (28.1%). This shows that the compound system, which is the most practised, is easily combined with the non-farm sector. Results from focus groups and in-depth interviews support a link between the farm and non-farm sectors as proceeds from the non-farm sectors are used to finance farming activities directly and to purchase food to boost household food security, which indirectly enhances own labour availability for farm work.

Although this sector is known to have a positive influence on household food security (Owusu, Abdulai, & Abdul-Rahman, 2011), it is however not viable in Builsa as more than

two-thirds of farm households did to participate in the non-farm sector. This concurs with that of Callo-Concha et al. (2012) that the non-farm sector alone cannot provide work for rural inhabitants. It also means that the depeasantization or deagrarianization theories (Yaro, 2006) cannot be applied in all rural situations especially in areas where the non-farm sectors are not well developed to absorb peasants who will move away from farming. Some reasons assigned for this are inadequate resources especially cash to begin a non-farm income activity by farm households, and the fear of failure by most heads of farm households.

Table 4.5b: Community participation in non-farm work

| Farming system | N | Non-participant (%) | Participant (%) | Total (%) |
|------------------------|-----|---------------------|-----------------|-----------|
| Sandema (Town) | 130 | 66.2 | 33.9 | 100.0 |
| Kadema (Village) | 18 | 77.8 | 22.2 | 100.0 |
| Wiaga (Town) | 120 | 80.0 | 20.0 | 100.0 |
| Gbedembilisi (Village) | 7 | 57.1 | 42.9 | 100.0 |
| Fumbisi (Town) | 115 | 66.1 | 33.9 | 100.0 |
| Doninga (Village) | 32 | 71.9 | 28.1 | 100.0 |
| Chansa (Village) | 29 | 86.2 | 13.8 | 100.0 |
| Total | 451 | 71.8 | 28.2 | 100.0 |

Source: Field data 2018

There are variations in community participation in the non-farm sector and these are shown in Table 4.5b. The community with the highest participation in the non-farm sector is Gbedembilisi as more than a quarter (42.9%) of households in this community are involved. Generally, participation in the non-farm sector increases with urbanisation as town communities have higher participation in the non-farm sector compared to village communities such as Chansa. Urban areas provide a market for non-farming activities because of population density and demand for perishable agricultural goods like fresh vegetables.

The results additionally show that more males than females participated in the non-farm sector as shown in Table 4.5c.

Table 4.5c: Participants in the non-farm sector by the farming system and sex

| Farming system | N | Female | Male | Total | P-value |
|--------------------|-----|--------|-------|-------|---------|
| Bush farming | 228 | 19.23 | 27.23 | 26.32 | 0.383 |
| Compound farming | 430 | 27.37 | 28.36 | 28.14 | 0.850 |
| Irrigation farming | 15 | 0 | 28.57 | 26.67 | 0.533 |
| Valley farming | 183 | 13.51 | 21.23 | 19.67 | 0.291 |
| Riverine farming | 5 | 0.0 | 20 | 20 | . |

Source: Field data 2018

This is due to patriarchy as most heads of farm households in the study area are male.

Farm households who participated in non-farm sector work did not benefit much in terms of income earned as shown in Table 4.6. Again, results from Table 4.6 show that income earned from the non-farm sector decreases with distance from towns as the higher earners are in Sandema, followed by Wiaga and Fumbisi with villages surrounding these towns having little income from the non-farm sector. This is explained by the nature of activities undertaken as towns are relatively more capital endowed than villages. The observation is support by Dary and Kuunibe (2012) that the income earned from the non-farm sector in rural areas is not much. However, those who participate were better-off than non-participants as there is a synergistic relationship between income available to households and the use of modern technologies that will enhance both crop and livestock output.

Table 4.6: Community earnings from the non-farm sector

| Farming system | Sandema | Fumbisi | Wiaga | Kadema | Gbedembilisi | Doninga | Chansa | Total |
|--------------------|----------|----------|----------|----------|--------------|---------|----------|----------|
| Bush farming | 2,871.88 | 1,257.00 | 1,516.67 | 625.00 | 1,466.67 | 500.00 | 1,433.33 | 1,636.13 |
| Compound farming | 2,800.23 | 1,371.57 | 1,962.09 | 1,137.50 | 1,466.67 | 666.67 | 1,400.00 | 1,934.18 |
| Irrigation farming | 500.00 | - | 700.00 | - | - | - | - | 650.00 |
| Valley farming | 1,228.82 | 3,100.00 | 2,362.50 | . | 1,466.67 | 460.00 | 1,300.00 | 1,499.72 |
| Other farming | - | - | - | - | 1,500.00 | - | - | 1,500.00 |
| Average Total | 1,850.23 | 1,432.14 | 1,635.31 | 587.50 | 1,180.00 | 406.67 | 1,033.33 | 1,430.01 |

Source: Field data 2018

Most of the non-farm income is earned from trading and remittances. Besides these, little income is generated from other activities like masonry, catering, welding, fishing, and sand-weaning. This observation is supported by other studies demonstrating the non-viability of non-farm income opportunities in rural areas of developing countries (Andersson, 2011; Djurfeldt, 2015). Generally, more than half of farm households received no income from

non-farm employment opportunities. This also raises questions about the non-diversification of livelihood systems away from the farm sector, as most farm households heavily rely on farming.

4.3 Types of farming systems

Farming is a major livelihood activity of the people in Builsa. Farms are organised on small scale with the primary aim of feeding households and surpluses sold to cater for both food and non-food needs. This notwithstanding, there exist some pockets of commercial crop farmers who are noted for rice cultivation in the Gbedembilisi valley. The Builsas', traditionally grew grains like early and late millets (*Pennisetum typhoides*, *Pennisetum spicatum*), sorghum (*Sorghum bicolour*, *Sorghum Vulgare*), rice (*Oryza sativa*), groundnuts (*Arachis hypogaea*), Bambara groundnuts (*Vigna subterranean*), pulses, little or no maize, a variety of leafy vegetables and kept livestock. The crops are spread over the land, with different ecological characteristics and management practices influencing their cultivation. Farm households practised more than a single farming system. In terms of gender, females are comfortable cultivating compound system compared to the other systems. Due to proximity to dwellings and the non-availability of resources to acquire motorcycles and bicycles to transport them to the bush systems. Absence of females in the riverine system is additionally explained by the capital demands of the valley and riverine systems. Irrigation farming is not well developed in Builsa compared to some parts of Ghana, with only households closer to the tributaries of the White Volta practising what is described in this thesis as the riverine system. The subsequent sections in this chapter detail how each farming system is organised in Builsa.

4.3.1 The compound farming system

A compound (*yire*) in Builsa is a spatial unit made of adjoining households as shown in Plate 4.1. Results from focus groups and in-depth interview show that households often

trace themselves to common ancestry. They own lands and other properties that are handed over to them and often under the control of a compound head (*yirenuna*). These findings confirm those of Lambrecht and Asare (2015) and Callo-Concha et al. (2012) that communal resources are controlled by heads of compounds in the Upper East area.

Plate 4.1: An extraordinary compound house in Builsa



Source: Field Work, June 2018

Compounds are dispersed from each other as this is deliberately done to ensure enough space between them for crop cultivation and livestock raising. Compound systems are organised around the immediate dwellings of farm households. Spatially, they are organised in rings with the intensity of cultivation decreasing with distance from the homestead according to von Thünian's conceptualisation of agricultural land use. The crops grown on compound farms are millets (early and late millets) and sorghum, which are often mixed with cowpea and other leafy vegetables and now maize. Maize was not a local staple and was sown in patches and used to supplement early millet for breaking the hunger season. Generally, farm sizes vary by farming systems and communities with sizes of compound farms dependent on the number of households in the compound. The average sizes of compound farms in Builsa are two (2) acres as shown in Table 4.6.

Table 4.7: Average farm sizes by the farming system and community in acres

| Farming System | Sandem a | Kadema | Wiaga | Gbedembilisi | Fumbisi | Doninga | Chansa | Average Total |
|--------------------|-------------|--------|-------|--------------|---------|---------|--------|------------------|
| Bush farming | 2.9 | 1.9 | 2.4 | 4.0 | 2.3 | 3.1 | 2.0 | 2.5 |
| Compound farming | 2.1 | 2.1 | 1.7 | 3.6 | 1.9 | 3.0 | 1.9 | 2.0 |
| Irrigation farming | 3.0 | | 1.4 | | 2.0 | | | 1.5 |
| Valley farming | 2.3 | 1.6 | 1.8 | 3.8 | 2.3 | 3.1 | 2.3 | 2.3 |
| Riverine farming | . | . | 1.0 | 4.0 | . | . | . | 5.0 |

Source: Field data 2018

Often, the fewer the number of households forming a compound the larger the sizes of compound farms and vice versa. Farm sizes are not evenly distributed in Builsa as shown in Table 4.7. However, some villages turn to have relatively larger farm sizes than the towns. The small farm sizes in towns are due to urbanisation, which leads to the use of agricultural space in towns for housing units and other socio-economic enterprises. It is thus supported by the theory that agricultural land area tends to reduce in peri-urban areas with urbanisation as land will rather be used for residential and more profiting purposes than agriculture (Cobbinah, Gaisie, & Owusu-Amponsah, 2015). The organisation of compound farms is woven around practices such as land preparation, planting, weed control, harvesting and storage, which is discussed under farm practices in the Builsa area.

4.3.2 The bush farming systems

This farming system is organised farther away from the compound. Due to distance, households need alternative modes of transport instead of walking to these farms. Bush farms are thus accessed by either bicycles or motorcycles by wealthy households. These are additionally needed for the movement of inputs to and outputs from the farm to homesteads after harvesting. The average landholding for bush systems in this study is 2.6 acres as shown in Table 4.7. Again, some villages have relatively larger farm holdings than towns in the bush systems. The bush systems are noted for the cultivation of a mix of early and late millets, sorghum, and beans. But this is now gradually changing as noted by an interviewee that: *“Maize is a crop that was not grown on the bush farms but now it finds a*

place there. Maize has now overtaken late millet in terms of crop area on the bush farms” (Excerpt, extension officer, June 2018). Some households do not grow the traditional crops on bush farms due to climate change and market demands for new crops in these spaces. Rather, groundnuts and cowpea are grown with little fertiliser application as soil fertility within these systems is managed by land rotation. The number of plots a farm household operates in the bush system depends on the financial resources available as access to land is not a barrier to most farm households in Builsa.

4.3.3 The valley and riverine farming systems

Valley farms are used here to describe farms located in depressions or areas with waterlogging conditions. There are two categories of valley farms in the study area. The commercialised valleys of Gbedembilisi, Weisi and Doninga; and valleys cultivated by households for subsistence. The focus of the study is on the latter, which are smallholder valley farms that are part of the systems operated by farm households. These farms are noted for the cultivation of rice, which is sometimes intercropped with sorghum and okra or other leafy vegetables used as border crops. The use of fertiliser on these systems was not common, however, there are changes in these systems as fertiliser usage is increasing with planting new varieties of rice. Villages like Gbedembilisi (3.8 acres) and Doninga (3.1 acres) have relatively larger holdings in the valley systems as shown in Table 4.6 and this is due to the communities located by River Sisili. Beyond the natural valley that support rice cultivation in this system, the river brings alluvial deposits and moisture which help these systems to flourish.

Households living close to the tributaries of the White Volta and other rivers farm along the banks and these are referred to as riverine systems. The importance of these systems was not recognised some decades ago. Crops grown here include maize and beans. Previously, households adventurously cultivated these systems due to fears that floods would destroy

their crops. Recently, riverine systems seem to be the most vibrant for some farm households as they are cultivated twice a year in a water-scarce environment. The first cultivation is with maize and the second is beans mainly for commercial purposes. Although this is beneficial to farm households, it could have implications on downstream activities of the Volta River. Thus, the farming systems in Builsa are compound, bush, valley, and riverine farms. There also exists the cultivation of exotic vegetables like carrots and tomatoes, but these are restricted to areas where there is irrigation infrastructure like Kadema, some parts of Wiaga and Sandema. Besides, these are areas with a relatively higher population density and an elite population who demand the cultivation exotic vegetables. There is low growing and consumption of green dark vegetables especially during the dry season as most farm households lack irrigation facilities. This has implications on food security especially micronutrients that are needed for normal living and is supported by Chagomoka et al. (2015) who found low vegetable consumption among farm households in the northern parts of Ghana.

4.4. Farm practices within the farming systems

4.4.1 Land preparation

Land preparation is an activity within the crop sector, which precedes the rest of cropping activities. It unintentionally starts on compound farms immediately after harvest. Straws of millet and sorghum are harvested and used to set fire to warm households in the mornings during the harmattan. During this period, the residue of compound farms closer to the dwelling is gathered and burnt. Actual land preparation of compound farms starts in March, which is done with bare hands and axes while the months preceding March are used for other activities like raising smaller chicken for sale on the local market. Other activities before the start of land preparation on compound farms include organising funerals and

trading. Recently, some farm households prepared compound farms with agrochemicals following the modernisation of agricultural practices in rural areas.

The land is prepared on bush farms in two ways. One is to start land preparation towards the end of a farming cycle. This activity is often done with an axe and the hand hoe. The axe is used to cut down trees and shrubs while the hand hoe is used to loosen the topsoil or to cover the weeds. This is done while there is moisture in the soil. When the weeds are covered, it serves as compost to crops and supports their growth. Another reason for the need to loosen the soil while they are moist is to avoid the arduous task of performing these activities during the dry season under high temperatures. The other way of land preparation on bush farms starts in March with farmers gathering and burning straws and removing shrubs with the axe and machetes. Agrochemicals are also applied here depending on the financial status of the farm household.

4.4.2 Tillage

Tillage is done before planting and is often a male-dominated activity, although women do help their husbands in times of need. If the presence of weeds on the farms are not dense, planting can be done directly after the straw are burned, with weeding following immediately after germination. Traditionally, tillage is often done with simple implements using farm household labour as communal labour is not expected at this stage of the farming cycle. There are, however, instances where farm households can be assisted to till their plots, especially in cases of ill health. Tillage in the farming systems is mostly done with the hand hoe or bullock plough depending on the wealth status of farm households. Beyond wealth, accessibility to bush farms also serves as a barrier to tractors with tree stumps hampering the smooth ridging and ploughing of these spaces by bullocks and tractors respectively making the hand hoe the most preferable method of tillage on the bush farming systems as shown in Plate 4.2.

Plate 4.2: Tilling a bush field with a hand hoe



Source: Fieldwork, 2018

There are however observed transitions in the tillage systems as the use of the hand hoe in this process is gradually waning giving rise to the use of bullock ploughs and most recently the reliance on tractor services as observed by an interviewee:

Before then, farmers did not use mechanical means of tillage. They used the hand hoe, and bulls, which were few, and thus slowed down the farming processes. Now they are encouraged to use tractors” (Except, extension officer, Sandema, June 2018).

This quote highlights that land preparation, an activity that precedes the entire activity cycle of the cropping sub-sector is transitioning over the years based on the introduction and adoption of new technologies by some farm households. There are shifts in the use of the hand hoe to the use of animal power and tractors in the farming systems. These shifts are not linear and thus contrast evolution theories, as they are not backed by population pressure and land scarcity espoused by these theorists (Fischer-Kowalski et al., 2011). Farm households do not also abandon the old methods completely as the hand hoe is used for weed control within crops. The transitioning modes of tillage are shown in Plate. 4.3

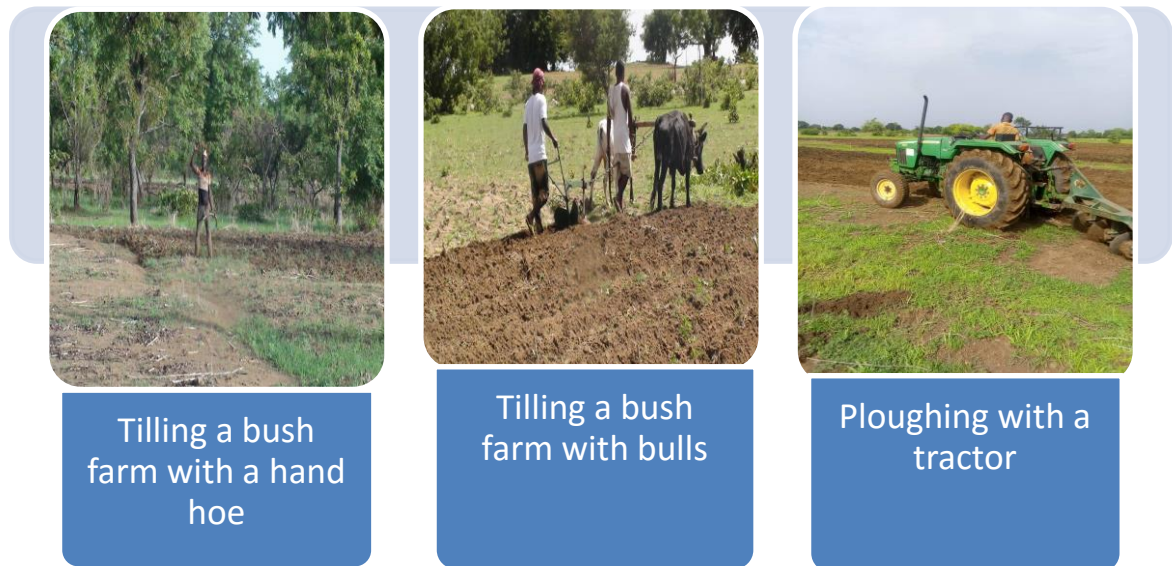


Plate 4.3: Transitioning tillage practices in Builsa

These changes are associated with access to technology based on the wealth of farmers. From the qualitative data (focus group, informal conversations and in-depth interviews), villages that are not well-resourced tend to avoid the use of modern technology to till their lands. Those closer to towns benefit from tractor services more than those farther away. This is an issue of lack of tractors so urban centres are privileged to get tractors than the villages. Additionally, the data suggests that more resource-endowed areas are likely to have access to and use of new technologies compared to less natural resource-endowed areas. Gbedembilisi is one of the remotest areas in Builsa and smaller as well in terms of population density, but following the opening up of its valleys to non-indigenous commercial farmers, it has benefited from a tractor and other mechanised services from commercial farmers compared to other communities without valleys for commercial farming.

A new development in the tillage system is the increasing use of donkeys. Donkeys were not prevalent in the Builsa area about four decades ago. However, there is a conscious effort by households to keep donkeys for farming purposes. This is to avoid theft as it is traditionally believed that donkeys are not stolen in place of bulls, which are of commercial value and are often stolen. Some households have also shifted to donkeys because of carting

of farm produce. They, however, observed that people have started stealing donkeys too. In addition to the increasing use of donkeys in the farming systems, there exist the practice of minimum tillage where some household are using weedicides to control weeds before and after sowing.

4.4.3 Sowing and the growing of crops within the farming systems

There is mixed cropping in all the farming systems and this is shown in Table 4.8a. The table shows the distribution of crops grown across the various farming systems in Builsa. Early millet is a crop that was part of the bush systems but has now disappeared as no household sow early millet on these systems. This is due to inadequate labour to handle birds and the long distance to the farms.

Table 4.8a: Crops grown in the farming system (%)

| Farming system | N | Early Millet | Late Millet | Sorghum | Rice | Groundnut | Beans | Maize | Total |
|--------------------|-----|--------------|-------------|---------|------|-----------|-------|-------|-------|
| Bush farming | 228 | 0.0 | 25.4 | 15.8 | 0.4 | 29.4 | 5.7 | 23.3 | 100.0 |
| Compound farming | 430 | 21.6 | 22.6 | 11.2 | 0.5 | 18.1 | 3.3 | 22.8 | 100.0 |
| Irrigation farming | 15 | 26.7 | 13.3 | 0.0 | 6.7 | 20.0 | 0.0 | 33.3 | 100.0 |
| Valley farming | 183 | 20.2 | 20.8 | 11.5 | 2.7 | 21.9 | 3.3 | 19.7 | 100.0 |
| Riverine farming | 5 | 0.0 | 0.0 | 0.0 | 0.0 | 60.0 | 0.0 | 40.0 | 100.0 |
| Average Total | 451 | 20.6 | 22.4 | 11.1 | 1.6 | 17.7 | 3.1 | 23.5 | 100.0 |

Source: Field data 2018

The study found that fewer farm households now sow early millet with no farm household sowing it on the bush systems. Sowing of early millet is now shifting from its preferred systems-compound and bush to new systems irrigation (26.7%) and valley (20.2%). This is accounted for by climate change/variability as these systems are relatively water sufficient than the upland systems under such conditions. In general, maize has more cropped area (23.5%) than all the crops in the farming systems. This is due to the commercial nature of maize and its ability to substitute for most traditional cereals like millet and sorghum in the preparation of dishes.

Sowing is done when households are certain that the rainy season has begun since farming in Builsa is predominantly rain-fed. Sowing of food crops is sequentially done by first

sowing a mix of late millet and sorghum on the bush systems at the onset of the rainy season. The compound systems are secondly sowed with a mix of early and late millets and sorghum. Then the valleys with rice, and groundnuts on outer rings of compound farms and bush farms. However, this is changing as there is a reduction in the number of growing days coupled with other economic and social factors. The growing of crops varies by the community as shown in Table 4.8b.

Table 4.8b: Dominant crops grown in the communities (%)

| Community | N | Early Millet | Late Millet | Sorghum | Rice | Groundnut | Beans | Maize | Total |
|---------------|-----|--------------|-------------|---------|------|-----------|-------|-------|-------|
| Sandema | 130 | 30.0 | 13.9 | 4.6 | 3.1 | 22.3 | 1.5 | 24.6 | 100.0 |
| Kadema | 18 | 16.7 | 16.7 | 22.2 | 0.0 | 0.0 | 5.6 | 38.9 | 100.0 |
| Wiaga | 120 | 26.7 | 20.8 | 8.3 | 0.8 | 23.3 | 3.3 | 16.7 | 100.0 |
| Gbedembilisi | 7 | 0.0 | 0.0 | 0.0 | 0.0 | 28.6 | 14.3 | 57.1 | 100.0 |
| Fumbisi | 115 | 14.8 | 26.1 | 18.3 | 1.7 | 13.9 | 1.7 | 23.5 | 100.0 |
| Doninga | 32 | 3.1 | 59.4 | 6.3 | 0.0 | 12.5 | 6.3 | 12.5 | 100.0 |
| Chansa | 29 | 3.5 | 20.7 | 24.1 | 0.0 | 3.5 | 6.9 | 41.4 | 100.0 |
| Average Total | 451 | 20.6 | 22.4 | 11.1 | 1.6 | 17.7 | 3.1 | 23.5 | 100.0 |

Source: Field data 2018

Farm households in Gbedembilisi no longer sow millet and sorghum on the compound farming systems and this is represented by the zero values for these crops in Table 4.8b and supported by focus group discussions and in-depth interviews. This is due to the shift to commercial crops like maize, rice and beans. The growing groundnuts, maize and beans in Gbedembilisi is aided by favourable ecological conditions like the valleys and rivers. Sowing has a gender dimension; men use the dibber to create holes while women use the calabash to place the seeds in the hole created and seal them with light soil as shown in Plate 4.4. Women often seal the holes by the hand, but some can close them by the use of the foot after carefully putting in the required number of seeds. On the compound farms and bush systems, seeds are often mixed planted.

The mixing of crops on the farming systems varies across the study area. Some household's plant early millet (*Pennisetum typhoides*) first and interplant with late millet (*Pennisetum spicatum*) and sorghum (*Sorghum bicolor*, *Sorghum Vulgare*). Others mix both early and late millets, sorghum, cowpea (*Vigna unguiculata L.*) and other leafy vegetables in the same

hole used as border plants. Both strategies have their strengths and weaknesses. As the former makes harvesting of early millet easier as they are sown in separate stands, however, this method prolongs sowing time as each crop is planted separately. The latter, however, reduces sowing time as all crops are placed in a single hole at a time, but delays harvesting as early millet need to be carefully selected during harvesting. Additionally, some crops can be cut down or have their growth hampered during harvesting if all crops are planted in a single stand. The onset of sowing used to be March and early April but that has now shifted to May and June due to a changing climate as noted by an interviewee that: *“One reason for changes in farm practices changes in the pattern of the rains. I used to plant in April and harvest in November. But now I plant in June and expect to harvest in October”*. (Excerpt. retired Extension Officer, Sandema, July 2018). This confirms some studies that sowing time in the Upper East region has shifted from late March or April to May or June due to changes in the onset of the rainy season (Dietz, Millar, Dittoh, Obeng, & Ofori-Sarpong, 2004). These shifts are accompanied by the sowing of early maturing crop varieties as supported by the excerpt.

Sowing within compound systems is done in rings. The inner ring consists of a mix of cereal and legume. Cereals grown in the inner ring include early and late millets sorghum with a legume mix and maize (*Zea mays*), a crop introduced to West Africa by the Portuguese in the 16th Century (Callo-Concha et al., 2012). Early millet has a shorter maturity period and is usually ready for use by farm households three (3) months after planting compared to late millet and sorghum. The landraces (traditional varieties) of these crops need a minimum of six (6) months on the field before harvesting. Early millet thus minimizes hunger and provides the energy needed by farm households to complete the rest of the farm activities within a farming cycle.

Plate 4.4: A couple sowing on a compound farm with a dibber



Source: Fieldwork 2018

Planting on the bush systems starts first with a mix of late millet, sorghum and cowpea at the onset of the rainy season. Plots on the bush farm systems are usually not tilled before planting but tillage can be done based on the financial conditions of a household (Plate. 4.2 pg. 114). This is a strategy to prevent birds and rodents from removing the seeds before germination. Crops grow together with the weeds. As late millet is noted to be capable of withstanding weeds, farmers attend to the plots on compound farms and return to control the weeds on their bush systems later. Only households with excess labour for bird control planted early millet on bush systems. This labour is often gotten from women and children as the men are busy weeding their compound and bush farms. Rice is sown in the valley systems and interplanted with either okra or sorghum depending on the nature of the soils and the location of the rice field. Sowing among the farming systems is methodical, with each crop sown at a particular time depending on its maturity period. The maturity periods for early maturing crop varieties is between 90-130 days for maize, rice, sorghum and millet. Late maturing varieties take more than 130 days to mature with cowpea having a maturity period of 55-65 days. Early-maturing crops help to break the hunger season in the late/lean season and enable farm households to meet their food and energy demands to complete the rest of farm activities.

The intercropping of early and late millets is also known as a strategy to make good use of cultivable space and the length of the growing period. These results concur with Callo-Concha et al. (2012) that early maturing crops are planted in the inner ring. While the combination of early millet, late millet and sorghum provide carbohydrates to the local diet, leafy vegetables are necessary to ensure the supply of vitamins to the farm household as different kinds of sauces are prepared with these vegetables.

A common legume that is grown in the Builsa area and part of the cereal-legume mix is cowpea (*Vigna unguiculata L.*). The outer rings are used for legumes like groundnuts (*Arachis hypogea*) and Bambara beans (*Vigna subterranea*) with some spaces left for tethering of small ruminants like goats and sheep or cattle and sheep grazing. Groundnuts are usually planted with Bambara beans a bit farther from the compound plots or as part of the bush systems. Crop cultivation within farming systems of developing countries is noted to be gendered with men growing millet, maize and sorghum while women grow groundnuts and cowpea as noted by Callo-Concha et al. (2012). This is however observed to be changing as women groups reported the cultivation of millet, sorghum, rice and maize in addition to groundnut and cowpea. This observation confirms that of Lambrecht, Schuster, Asare, and Pelleriaux (2018) that there are no men and women crops as crops cultivation is influenced by the same factors as yields, market value, ease of work, and other factors.

There are varied opinions on changes in crop varieties in the study area. It is however generally accepted that there are no changes in the early millet variety but changes do occur in other crop varieties. One interviewee noted that: -

“Traditionally, sorghum, millet, rice, and groundnuts were the dominant crops, now maize, soybeans and cowpeas are cultivated. Cowpea was a crop grown along the banks of river Sisili but now it is grown everywhere. There are also changes in crop

varieties with shifts from farmer to improved varieties” (Excerpt, 65-year male farmer, Fumbisi, June 2018).

Others observed that: -

“Maize is a crop that was not grown on the bush farms but now it finds a place there. It has dominated late millet on the bush farms” (Excerpt, retired Extension Officer, June 2018).

“We were not planting maize on a large scale. But on smaller patches around the house. Maize was a crop that was not planted on the bush farms but now it finds a place there. It has now dominated early millet” (Excerpt, retired extension officer, Senisi, June 2018).

This represents the view of most farm households that maize was not a major crop among the farming systems of Builsa about three decades ago. Commercial growing of maize started in the study area started about three decades ago. This was aided by the works of NGOs and the District Department of Agriculture. The dominant crops grown in these systems were early and late millets, rice, groundnuts, sorghum, cowpea, bambara beans, and sweet potato. This observation is supported by an earlier study that sorghum and millet are the most important crops for people in the Upper East area (Dietz et al. (2004). However, that is changing as maize, beans and groundnuts are gradually taking over the cropped areas that were hitherto dominated by millet and sorghum in Builsa due to the commercial nature of these crops.

These excerpts also show how crops varieties have changed over time within farming systems. There have been additions of new crops and changes in the varieties of existing ones. It also details how there are increases in crop cultivars over space and time. Cowpea was not cultivated on the bush farms as a mono-crop but now farm households do that for

commercial purposes. The improved seeds additionally yield better and have relatively shorter maturity periods compared to the farmer varieties that were planted some decades ago. Furthermore, an interviewee pointed out that: -

“We have stopped planting sorghum and millet because of the weather. At times it will be left with just a single rain for the crops to mature and the rains will stop” (Excerpt, 95-year farmer, Gbedembilisi, June 2018).

Gbedembilisi is a relatively endowed community with vast valleys for commercial rice farming and drained by the Sisili (a tributary of the White Volta). In this community, they have stopped sowing sorghum and millet on compound farms as expressed in the excerpt due to climate variability. Beyond climate variability, there are other challenges. These include birds and pests that destroy the millet. Additionally, there are trade-offs. Farm households are caught between growing commercial and high yielding crops to earn a higher income and food security or traditional and low yielding crops to maintain their culture. There is also conflict between keeping livestock for a long time or for a shorter time as late millet and sorghum have relatively longer maturity periods compared to maize. The implications of tethering livestock for a longer time on the compound systems will reduce the output of work on crops in the other systems. The excerpt also suggests that in well-endowed rural areas where there exists the potential for commercial agriculture, as the case of Gbedembilisi, farm households are more likely to abandon traditional varieties in search of early maturing and more productive varieties with shorter maturity periods and high market values. Additionally, the inner rings of the compound farms are no longer used for sowing a mix of early and late millets with sorghum but a mono-crop of maize. This phenomenon is most widespread in Builsa south compared to the northern parts of Builsa.

4.4.4 Accessing seeds for planting

Households in the study area have multiple ways of accessing seeds for planting. These include own seeds from previous productions, farming in exchange for viable seeds, bartering chicken for viable seeds, buying from the open market, and the supply or purchase of seeds from agricultural extension officers. These sources of seed acquisition are gendered. During focus group discussions, men groups agreed that they could weed on other farmer's plot in exchange for planting seeds. This, however, does not hold for women. They disagreed with this form of acquiring seeds for planting as they described it as improper for a female to do that. Another way is to get seeds in kind by bartering chicken for seeds. The second mode of seed acquisition is also not readily available/accessible to women as most of them do not have fowls that can be used in exchange for seeds. Women plant for men or other women to attain viable seeds for planting as observed during a focus group discussion in some parts of the study area. Farmers can also access seeds from their friends or family members. Households also attain their seeds for planting by buying from the open market or occasionally from agricultural extension officers. Recently, seed access from agricultural extension officers was boosted by the government's 'Planting for Food and Jobs Program' introduced in 2017. Other sources included self-preserved seeds or buying from the open market. Excerpts from focus groups and expert interviews show that farmers are transitioning from the reliance on self-produced seeds to seeds purchased from agricultural extension officers, certified seed companies or the open market.

4.4.5 Weed control and maintenance of soil fertility

The control of weeds within the farming systems is done with the hand hoe or with bare hands depending on the type of farming system involved and the stages of crop and weed growth. Mostly, it is the hand hoe that is used on the compound, bush and riverine systems. The hand hoe is interchangeably used with bare hands on the valley systems especially in

areas with waterlogging conditions. Methods of weed control are now changing as some households rely on the use of weedicides for the control of weeds after planting as shown in Table 4.9a.

Table 4.9a: Herbicides (weedicide) use by farming system

| Farming system | N | No weedicide | Weedicide (%) | Total (%) |
|--------------------|-----|--------------|---------------|-----------|
| Bush farming | 228 | 50.0 | 50.0 | 100.0 |
| Compound farming | 430 | 58.8 | 41.2 | 100.0 |
| Irrigation farming | 15 | 46.7 | 53.3 | 100.0 |
| Valley farming | 183 | 45.4 | 54.6 | 100.0 |
| Riverine farming | 5 | 0.0 | 100.0 | 100.0 |
| Average Total | 451 | 58.1 | 41.9 | 100.0 |

Source: Field data 2018

The results show that on the average more than half (58.1%) of farm households do not use weedicides in their farming systems. However, the use of weedicides varies by farming systems, with all farm households (100%) using weedicides in the riverine farms. This explains the less participation of female-headed households in this system as it is relatively capital intensive. The valley and bush systems also have more than half of farm households using weedicides. The use of weedicides on the compound systems is the lowest (41.2%). This is due to health concerns on livestock safety as explained during focus group discussions and informal conversations.

The finding show that weedicides use, is not generally widespread in these parts of the country compared to other farming communities as more than half of farm households do not use weedicides. Some of the weedicides used by farmers are non-selective (Sunphaate, Land Load, Adumawura, Sarosate, Gonasate, Fire) and selective (Nominee, Bison, Papacate, Nico Plus, Nico King, Agil, Farmer Soja) shown in Table 4.9b.

Table 4.9b: Examples of weedicides use by farm households

| Herbicides (Weedicides use) | | |
|-----------------------------|-------------------------------------|---|
| Non-selective | | |
| Type | Composition | Use |
| Non-Selective | Glyphosate | Total weedkiller (Known locally as condemn) |
| Sunphaate | Glyphosate | Total weed killer |
| Land Load | Glyphosate | Total weed killer |
| Adumawura | Glyphosate | Total weed killer |
| Sarosate | Glyphosate | Total weed killer |
| Gonasate | Glyphosate | Total weed killer |
| Fire | Glyphosate | Total weed killer |
| | | |
| Selective | | |
| Type | Composition | Use |
| Nominee | Bispyribac Sodium | Selective use in a spiral and broad leaves in cereals and legumes |
| Bison | Bromoxynil Octanoate | Selective use in a spiral and broad leaves in cereals and legumes |
| Papacate | Clopyralid, Picloram, And Triclopyr | Selective use in a spiral and broad leaves in cereals and legumes |
| Nico Plus | Atrazine | Selective use in a spiral and broad leaves in cereals and legumes |
| Nico King | | Selective use in a spiral and broad leaves in cereals and legumes |
| Agil | Aryloxyphenoxy Propionates | Selective use in a spiral and broad leaves in cereals and legumes |
| Farmer Soja | | Selective use in a spiral and broad leaves in cereals and legumes |

Source: District Department of Agriculture Builsa South (July 2018)

Both selective (for the control of specific weeds within crops) and non-selective (for the control of all kinds of weeds) weedicides are used by farm households in the study area with the misuse of these having implications on both livestock and human health supported by Fianko, Donkor, Lowor, and Yeboah (2011). The use of weedicides also vary by community and these variations are shown in Table 4.8c.

Table 4.9c. Herbicide (weedicide) use by farming communities

| Community | N | No weedicide | weedicide (%) | Total (%) |
|---------------|-----|--------------|---------------|-----------|
| Sandema | 130 | 56.9 | 43.1 | 100.0 |
| Kadema | 18 | 38.9 | 61.1 | 100.0 |
| Wiaga | 120 | 67.5 | 32.5 | 100.0 |
| Gbedembilisi | 7 | 0.0 | 100.0 | 100.0 |
| Fumbisi | 115 | 68.7 | 31.3 | 100.0 |
| Doninga | 32 | 15.6 | 84.4 | 100.0 |
| Chansa | 29 | 55.2 | 44.8 | 100.0 |
| Average Total | 451 | 58.1 | 41.9 | 100.0 |

Source: Field data 2018

Among communities in Builsa, towns use less of weedicides on farms compared to villages. This is explained by farmers attempt to reduce the potential health risk of agrochemicals to livestock. Although the hand hoe is used in combination with weedicides in weed control, some households with resources and some knowledge are shifting to the use of selective weedicides (Table 4.9b) for maize cultivation. The use of weedicides is noted by some farm households to have the effect of reducing the cost of labour as they do not need to provide drinks and other items needed for communal labour. Weedicide use is additionally observed to be comparatively cheaper than hired labour.

The use of organic and chemical fertilization and land rotation are some of the methods employed by farmers to maintain soil nutrients. Farm households in the study area maintain the fertility of their farms from organic sources, which are made of livestock droppings and household waste. The Builsa area was once littered with cattle and other ruminants like goats and sheep. The droppings of these and poultry served as a good source of manure for the compound plots. The fertility of the compound systems declined with distance as household waste is not conveyed farther afield by children and women. Animal droppings are equally not conveyed far but closer to the homestead due to their bulky nature. It is difficult to cart cow dung with the head from the compound where cattle are kept in kraals to the bush fields. Household heads thus rotate kraals to ensure an even distribution of cow dung in their compound fields to ensure a fair broadcast of their manure in the field to increase crop productivity. The bush fields are rotated to ensure that they regain their

fertility naturally. This strategy is explained by distance and the availability of land in the bush systems. soil fertility is additionally maintained through the burning of crop residue during land preparation where straws are gathered and burnt at given intervals to ensure a fair distribution of ash which serve as a good source of crop nutrients. The perceived state of soil fertility in Builsa is contained in Table 4.10a.

Table 4.10a: Soil fertility status of farming systems

| Farming system | N | Increased (%) | Stable (%) | Decreased (%) | Total (%) |
|--------------------|-----|---------------|------------|---------------|-----------|
| Bush farming | 228 | 7.9 | 28.1 | 64.0 | 100.0 |
| Compound farming | 430 | 8.1 | 30.2 | 61.6 | 100.0 |
| Irrigation farming | 15 | 13.3 | 33.3 | 53.3 | 100.0 |
| Valley farming | 183 | 6.6 | 32.2 | 61.2 | 100.0 |
| Other farming | 5 | 0.0 | 20.0 | 80.0 | 100.0 |
| Average Total | 451 | 7.8 | 29.9 | 62.3 | 100.0 |

Source: Field data 2018

More than half (62.3%) of farm households are of the view that there is a decrease in the soil fertility status of their farming systems over the years with a little over a quarter (29.9%) thinking it had been stable and very few farm households (7.8%) agreeing that there are increases in the soil fertility status of their farming systems. This finding shows that nutrient mining is ongoing in the Builsa area as the farms are continuously cropped with little use of both inorganic and organic manure and confirm earlier studies by Rhodes (1995) and Callo-Concha et al. (2012) of soil nutrient mining in Upper East. This has implications for crop yield and food security in the study area. The perceived soil fertility status of farms is additionally community-specific and the views of farm households within the selected community are shown in Table 4.10b.

Table 4.10b. Views of soil fertility status of farmers

| Community | N | Increased (%) | Stable (%) | Decreased (%) | Total (%) |
|---------------|-----|---------------|------------|---------------|-----------|
| Sandema | 130 | 10.8 | 36.2 | 53.1 | 100.0 |
| Kadema | 18 | 5.6 | 16.7 | 77.8 | 100.0 |
| Wiaga | 120 | 6.7 | 35.8 | 57.5 | 100.0 |
| Gbedembilisi | 7 | 0.0 | 0.0 | 100.0 | 100.0 |
| Fumbisi | 115 | 6.1 | 21.7 | 72.2 | 100.0 |
| Doninga | 32 | 12.5 | 31.3 | 56.3 | 100.0 |
| Chansa | 29 | 3.5 | 24.1 | 72.4 | 100.0 |
| Average Total | 451 | 7.8 | 29.9 | 62.3 | 100.0 |

Source: Field data 2018

Communities that use more chemical fertilisers viewed the soil fertility status of their farming systems to have decreased (Gbedembilisi). Ruminants owned by farm households has declined as a result of increasing enrolment of children into formal education, theft and diseases, hence the continual cropping of compound plots is sustained by chemical fertilisers as shown in Table 4.11a.

Table 4.11a: Chemical fertiliser use by farming system

| Farming system | N | No fertilizer (%) | Fertilizer (%) | Total (%) |
|--------------------|-----|-------------------|----------------|-----------|
| Bush farming | 228 | 59.7 | 40.4 | 100.0 |
| Compound farming | 430 | 65.4 | 34.7 | 100.0 |
| Irrigation farming | 15 | 46.7 | 53.3 | 100.0 |
| Valley farming | 183 | 60.7 | 39.3 | 100.0 |
| Riverine farming | 5 | 20.0 | 80.0 | 100.0 |
| Average Total | 451 | 64.8 | 35.3 | 100.0 |

Source: Field data 2018

More than half (64.8%) of farm households do not use inorganic fertiliser as they can not afford. High usage of this is associated with intensified systems (riverine and irrigation), which results in relatively higher yields in line with a propose Green Revolution theory. This finding shows that less fertiliser is used in rural areas of developing countries, which have adverse effects on crop yield and food security. It is additionally associated with nutrient mining in the Upper East areas as it concurs with studies by Callo-Concha et al. (2012) and Rhodes (1995). Farm households use different types of fertilisers with some examples of these shown in Table 4.11b. The table shows the fertiliser that was available and supplied to the farm household by the District Department of Agriculture at the time of data collection. However, there exist other types on the local market like Urea and Sulphate of ammonia, which is not widely used by farm households.

Table 4.11b: Examples of chemical fertiliser used by farm households

| Fertiliser | | |
|----------------|-------------|---|
| Type | composition | Use |
| Compound/mixed | N. P. K. | The first application to crops for vegetative and root growth |
| 15:20:20 | N. P. K. | The first application to crops for vegetative and root growth |
| 20:10:10 | N. P. K. | The first application to crops for vegetative and root growth |
| 25:10:10 | N. P. K. | The first application to crops for vegetative and root growth |
| 23:10:10 | N. P. K. | The first application to crops for vegetative and root growth |

Source: District Department of Agriculture Builsa South (July 2018)

These fertilisers are applied at the early stages of crop development to enhance vegetative and root growth as shown in Table 4.11b.

At the community level, fertiliser use is high in areas with potential for commercial farming such as Gbedembilisi, which has more than half (57.1%) of farm households using fertiliser in Table 4.11c.

Table 4.11c: Chemical fertiliser use by community

| Community | N | No fertilizer (%) | Fertilizer (%) | Total (%) |
|--------------|-----|-------------------|----------------|-----------|
| Sandema | 130 | 58.5 | 41.5 | 100.0 |
| Kadema | 18 | 61.1 | 38.9 | 100.0 |
| Wiaga | 120 | 65.8 | 34.2 | 100.0 |
| Gbedembilisi | 7 | 42.9 | 57.1 | 100.0 |
| Fumbisi | 115 | 72.2 | 27.8 | 100.0 |
| Doninga | 32 | 65.6 | 34.4 | 100.0 |
| Chansa | 29 | 65.5 | 34.5 | 100.0 |
| Total | 451 | 64.8 | 35.3 | 100.0 |

Source: Field data 2018

Fertiliser (Table 4.11c) is accessed on credit under the ‘Planting for Food and Jobs Program’, purchased from the Department of Agricultural at the district level or the open market.

4.4.6 Labour access

Labour is critical to the efficient functioning of the farming systems. Its sufficiency during the farming season is important to the survival of farms households. Three forms of labour are available for farm work in Builsa. These are own labour, which is provided by household members; communal labour, which is provided by a group of households who have decided to help each other on a rotation basis; and hired labour, which is emerging and most often used by households that are relatively well-resourced. The most dominant form of labour in the study area is own-labour. No household in the Builsa area is labour sufficient as supported by some views on household labour sufficiency in Box 4.1.

Male farmer's view – Kadema Banyansa (Age: 47)

“No. No one can be labour sufficient. I rely on communal labour for farming, as I use the labour of other farmers. There are however instances where they (communal labourers) are late in coming, and in that case, I could sell an animal or if I have money I hire by-day workers. Labour is readily available if you have money”.

Male farmer's view – Sandema Bilinmonsa (Age: 52)

“No. I meet my labour needs through communal help. If that fails, I rely on the livestock sector. I sell my animals to support the cropping sector by paying for the extra labour needed”.

Male farmer's view (Age: 95)

“No, but labour is available both locally and externally. During the farming season one can access labour if you have money. There are linkages between the livestock and crop sectors as we sell livestock to buy seed, pay hired labourers, and kill some to support farm” work.

Box 4.1: Farmer views on household labour sufficiency

This results from a combination of factors among them are increases in farm sizes, migration of household members, and education. It also showcases the linkages between the crop and livestock sectors as animals are sold to finance the cropping sector in times of household labour shortages through hired labour.

Household labour for farm work is not sufficient and is giving way for the emergence of hired labour given that communal labour is already challenged. An interviewee noted that:

“At the initial stages of the farming season, we manage as a household to control weeds. But for the subsequent weed control, one will need help” (Excerpt, 95-year-old male farmer,

Gbedembilisi, June 2018). Apart from the household, extra labour for farm work is gotten through hired labour or reciprocal exchanges. With hired labour, it is not difficult to find farm households who are willing to sell labour during the farming season in the study area.

At the community level, the only exception where labour shortages were established during the focus group discussion and group conversations is with commercial beans farming at Gbedembilisi. This shortage is however compensated for by labour migration from other communities to the beans farms. In villages where all households are involved in the same kind of activities, which are time-bound and demand the labour of all household members, external labour is needed as in the case of dry season beans growing in Gbedembilisi noted by one interviewee that: -

“There is access to labour in this village, but it becomes problematic during the dry season beans farming. However, people migrate from some parts of the district to offer their labour during these times. I especially go to villages that do not farm beans with a tricycle to bring them to help me on my beans farm. They are often paid GhC 10 per day¹ and fed” (Excerpt, 56 year’s old widowed, Gbedembilisi, June 2018).

The cost of labour is however said to be expensive and varies over space and time. Labour cost is not uniform throughout the Builsa area. Labour costs also change per activity and in time. Some farm households pay GhC 8 per day for planting while others pay more for weeding as noted by an interviewee:

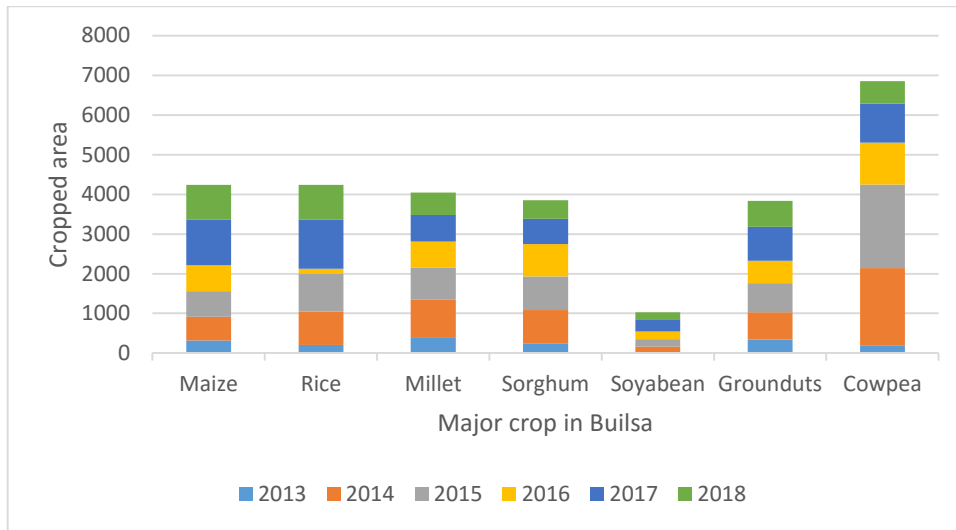
“Weed control is done by hired labourers who are either within this community or migrants. I depend on paid labour. Females also have group farming where they help each other but I rely on the paid labour. I pay 15 Ghana Cedis a day and they can close at either 2:00 pm or if you will cook for them then 4:00 pm (Excerpt, 42-year-old widow, Sandema, June 2018).

4.4.7 Acreage and yields

Over the years, there has been an increase in acreage or area cropped by farm households in Builsa as shown in Figure 4.1.

¹ 1 USD is equivalent to 5.0 Gh at the time of data collection

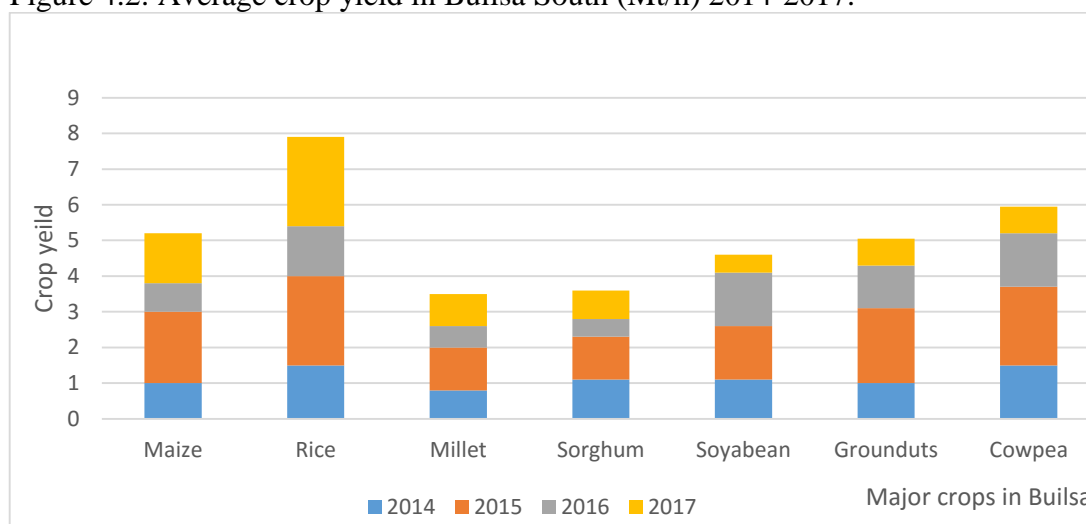
Figure 4.1: Area cropped in Builsa South (ha) 2013-2018.



District Department of Agriculture Builsa South (July 2018)

The data in Fig. 4.1 is confirmed by interviews and focus group discussions where farm households acknowledged that there are increases in the cropped area over time. This is due to the availability of both animal and machine power, combined with agrochemicals and improved crop varieties. The nature of the improved crop varieties motivates farmers to farm more with the expectation of having higher yields. It is additionally motivated by market forces as increases in the area cropped is relatively more in crops such as cowpea, maize, rice and groundnuts, which are commercial crops. Crop yield in Builsa, shown in Fig. 4.2 is less than the national potential yield for all the crops observed (MoFA, 2015).

Figure 4.2: Average crop yield in Builsa South (Mt/h) 2014-2017.



District Department of Agriculture Builsa South (July 2018)

The yield of the major crops shown in Fig. 4.2 are higher for maize, rice, groundnuts and cowpea in 2015 with declines in 2016. Generally, the yield for millet and sorghum have not increased significantly between 2014 and 2017. This is due to the inability of farmers to adopt new cultivars of millet and some claims that these crops do not respond positively to chemical fertilisers.

Crop yields vary by farming systems and the yield of the different crops in Builsa as shown in Table 4.12a.

Table 4.12a: Crop yields by farming systems

| Farming system | N | Early Millet (Kg/Ha) | Late Millet (Kg/Ha) | Sorghum (Kg/Ha) | Rice (Kg/Ha) | Groundnut (Kg/Ha) | Beans (Kg/Ha) | Maize (Kg/Ha) |
|--------------------|-----|----------------------|---------------------|-----------------|--------------|-------------------|---------------|---------------|
| Bush farming | 228 | . | 378.0 | 346.2 | 963.0 | 577.0 | 463.3 | 688.4 |
| Compound farming | 430 | 269.7 | 356.3 | 343.4 | 642.0 | 566.4 | 444.7 | 620.4 |
| Irrigation farming | 15 | 169.8 | 225.3 | . | 963.0 | 679.0 | . | 597.5 |
| Valley farming | 183 | 247.8 | 353.6 | 312.4 | 581.8 | 543.3 | 502.8 | 614.8 |
| Riverine farming | 5 | . | . | . | . | 799.7 | . | 497.9 |
| Average Total | 451 | 269.7 | 352.3 | 345.5 | 601.9 | 563.6 | 444.7 | 628.8 |

Source: Field data 2018

Maize yield (628.8 Kg/Ha) is the highest in all the farming systems and this is followed by rice (601.9 Kg/Ha) and groundnuts (563.6 Kg/Ha). Again, markets and climate variability coupled with the availability of improved varieties and aided by access to external inputs is accounting for the relative importance farm households attach to these crops. This finding

has an implication on which crops and farming systems to improve upon and to concentrate on. Crop yield additionally varies by community and this is shown in Table 4.12b.

Table 4.12b: Crop yields by community

| Community | N | Early Millet (Kg/Ha) | Late Millet (Kg/Ha) | Sorghum (Kg/Ha) | Rice (Kg/Ha) | Groundnut (Kg/Ha) | Beans (Kg/Ha) | Maize (Kg/Ha) |
|---------------|-----|----------------------|---------------------|-----------------|--------------|-------------------|---------------|---------------|
| Sandema | 130 | 296.2 | 289.0 | 250.3 | 321.0 | 581.4 | 441.4 | 887.8 |
| Kadema | 18 | 161.9 | 373.8 | 185.2 | . | . | 543.2 | 616.7 |
| Wiaga | 120 | 245.4 | 229.3 | 449.4 | 963.0 | 517.5 | 344.0 | 528.0 |
| Gbedembilisi | 7 | . | . | . | . | 1018.5 | 776.0 | 520.6 |
| Fumbisi | 115 | 265.2 | 392.7 | 351.1 | 842.6 | 572.9 | 543.2 | 549.6 |
| Doninga | 32 | 108.6 | 501.6 | 432.1 | . | 519.4 | 237.7 | 305.6 |
| Chansa | 29 | 543.2 | 374.5 | 329.2 | . | 452.7 | 543.2 | 441.4 |
| Average Total | 451 | 269.7 | 352.3 | 345.5 | 601.9 | 563.6 | 444.7 | 628.8 |

Source: Field data 2018

The variation in yield show communities that need support to enhance crop yield thereby increasing their food security status. The distribution of crop yield by sex is shown in Table 4.12c. The results show that female heads of households have lower crop yield in maize, rice and sorghum than their male counterparts. However, they dominate their male counterparts in early and late millets and groundnuts. This is explained by the concentration of female-headed households on the compound systems where millets are mostly grown. Additionally, male-headed households allocate relatively more resources to the cultivation of commercial crops (rice, beans, maize and groundnuts) than to traditional crops.

Table 4.12c: Crop yields by sex

| Sex | N | Early Millet (Kg/Ha) | Late Millet (Kg/Ha) | Sorghum (Kg/Ha) | Rice (Kg/Ha) | Groundnut (Kg/Ha) | Beans (Kg/Ha) | Maize (Kg/Ha) |
|---------------|-----|----------------------|---------------------|-----------------|--------------|-------------------|---------------|---------------|
| <i>Female</i> | 98 | 302.2 | 353.6 | 321.0 | 321.0 | 596.6 | . | 525.1 |
| <i>Male</i> | 353 | 254.2 | 352.0 | 351.0 | 882.7 | 553.3 | 444.7 | 646.3 |
| <i>Total</i> | 451 | 269.7 | 352.3 | 345.5 | 601.9 | 563.6 | 444.7 | 628.8 |

Source: Field data 2018

Generally, the output of traditional crops like early and late millets and sorghum is lower than that of maize, rice, groundnuts and beans. The commercial nature of maize, rice, groundnuts and beans backed by the use of modern implements is leading to increases in area cropped for these crops as interviewee notes:

“At first, in the absence of tractors, we used to farm but not as large as it is today. Now with the presence of tractors, we have made some progress. From about 3 to 10 acres” (Excerpt, male farmer, Gbedembilisi, June 2018).

The cropped area has increased compared to the past but that does not commensurate with yields attained on smaller plots previously as established through focus group discussions and in-depth interviews. This is supported by findings that nutrient mining has occurred in the Upper East area as household need to extend area cultivated to meet annual caloric needs (Aniah, Wedamb, Pukunyiemc, & Yinimid, 2013). Although the arable area is increased, crop yields are declining for traditional crops (early and late millets and sorghum). Farm households admitted that because their soils are poor, they have to plough more land to get their desired output. Farm households and some experts observed that yields from the farming systems used to be better than they are today as an interviewee noted:

“An acre could yield ten bags of groundnuts previously but now that same acre can only give you three bags”. (Excerpt, extension officer, Sandema, June 2018).

This is further supported by another interviewee:

“The yield from the farming systems was too good. By then the soils were not badly destroyed as they are today” (Excerpt, retired Agricultural extension officer, Senesi, June 2018).

In support of declined soil fertility and reduced yields, another interviewee noted that:

In the beginning, the outputs from our farms were enough to feed us throughout the year with some left to be used in financing the next farming cycle. Now our farm output cannot even feed us let alone selling the surplus” (Excerpt, Kanbognab (Sub-chief) of Logmisa, June 2018).

4.4.8 Harvesting and storage

Harvesting, the process of collecting matured grains is done at different times of the year as crops have different maturity periods. The number of growing days in the study area is between 180 and 200 days (MoFA, 2015) and all crops are grown and harvested within this time. Early millet and maize, which have a short maturity period and are used to break the hunger season, are harvest 90 days after planting. This is often done around June. Sorghum and late millet are harvested around October and November depending on the time of sowing. Harvesting is an important process as improper harvest time is noted by Hodges and Maritime (2012) to have implications on grain quantity and quality.

Harvesting is done in Builsa using either household or hired labour. There are no improved ways of harvesting in the study area as farm households mostly used human labour with manual tools. The tools include machetes, axes, hand hoes, knives and sickles. Machines are used at the threshing stage for some cereals like maize. This is however limited to areas where maize is cultivated in large quantities. Processors are either hired or invited from villages that have them as most farmers do not own processors. The use of hands coupled with inadequate drying spaces for grains often negatively influence their quality resulting in low market prices both on the local and international market. Local rice and millet are, for instance, noted to be mixed with stones, which affect their market value. This observation confirms that made by CSIR-SARI (2011) on the low-quality nature of grains produced in Sub-Saharan Africa.

There are shifts in the traditional ways of storage as bags and living rooms are now involved. The harvest, which is mostly cereal, used to be stored in bans made of bricks or earth (Plate 4.5).



Plate 4.5: A ban (*Naab bui*) – traditional storage system
Source: Fieldwork, 2018

Legumes such as groundnuts and beans are not kept in bans but structures made with woven straws known as silos and called locally as '*Yikori*'. These are often plastered with cow dung to prevent weevils and other insects from attacking the grains. There is a shift from the use of these structures to the use of bags. For commercial purposes, farm produce is mostly kept in fifty-kilogram (50kg) bags. This is done to ease measurement when farm produce is sent to the market for sale.

4.5 Livestock keeping

There are thus transitions in the farming systems and these are not only within the cropping sub-sectors as transitions exist in the livestock sub-sectors. These transitions are captured by an interviewee in Box 4.2 who has been observing the farming systems over the years.

On predominant crops grown: The farming systems were good, even the yield was too good. By then the soils were not badly destroyed as they are now. Thirty (30) years back, the orders of chiefs were obeyed, who regulated burning and other environmentally-related issues. In those days, sowing was in April, then, May for weeding and June early millet will start tasselling. In June, drought will set in bringing the Landlords and the 'Tin-nyana' to come together and call upon the gods for the rains to come. June ending is the time for harvesting early millet. Early millet, late millet, sorghum, and early groundnuts were planted in April, then May, they will continue with groundnuts, rice, bambara nuts and other crops. Sorghum was dominating late millet on the bush farms but now late millet has dominated sorghum because it can do better in poor soils. We were not sowing maize in large quantities. But on smaller patches around the house. Maize was a crop that was not sown on the bush farms but now it finds a place there. It has overtaken early millet.

On changes in the farming systems and yield levels. Yes, there are changes in the farming systems. Now we cultivate more land but get fewer yields. Even though new varieties of existing crops have been introduced, the soil are very poor, thus, resulting in the reduced yields. The yields of maize per acre is about 8 bags while that of sorghum is about 1.5 bags leading people to shift to the planting of maize. New varieties of sorghum like kapala, Buakwa Red and Buakwa White are now dominating. In terms of sorghum, very few people now have the landrace as these have been replaced by the enhanced varieties. The reasons for these changes can be found in changes in the season. We used to sow in April and harvest in November. But now we sow in June and are expected to harvest in October as the farms are dried up from that time onwards.

Box 4.2: David's views on the nature of the farming systems before the 1990s

Livestock is often integrated with crops on the compound farm but there exist instances where farm households kept livestock, especially birds and small ruminants on their bush farms. This is done at the time they have finished attending to the compound farms and have moved to the bush farms. Fishing and hunting practices are restricted to people living closer to the source of water bodies and in the interior parts of the study area, respectively. Beekeeping is also practised in some areas but this is not common and done with the use of traditional knowledge where earthen pots are hanged on trees to attract the bees. Table 4.13 shows livestock keeping in the two districts in Builsa. It shows that there is a difference in livestock kept by farm households combining bush and valley farming with livestock in the two districts. It also shows that most farm households in Builsa combine livestock keeping with crop farming as more than a two-thirds of farm kept livestock.

Table 4.13: Livestock-keeping by the farming system and district

| Farming System | N | Builsa North (% keeping) | Builsa South (% keeping) | Total (% keeping) | Chi2 (P-value) |
|--------------------|-----|-----------------------------|-----------------------------|----------------------|----------------|
| Bush farming | 228 | 93.3 | 79.0 | 85.5 | 0.002 |
| Compound farming | 430 | 84.9 | 77.9 | 82.1 | 0.065 |
| Irrigation farming | 15 | 100.0 | 100.0 | 100.0 | . |
| Valley farming | 183 | 90.3 | 95.7 | 92.4 | 0.178 |
| Riverine farming | 5 | 100.0 | 100.0 | 100.0 | . |

Source: Field data 2018

The dominant traditional livestock raised by farmers includes cattle, poultry (chicken, guinea fowl, ducks, turkeys, and pigeons), goats, sheep, and now the increasing presence of donkeys and pigs. The increasing presence of pigs and donkeys is due to their commercial purposes as pigs are sold for their meat and donkeys for farm work. Poultry like ducks and turkeys are not widely raised due to inadequate skills in the instance of the former and low patronage in the instance of the latter. Poultry is kept in structures made locally with mud or thatch and built in a conical form. Production within this sub-sector is rudimentary with little or no use of modern technology as it is largely dependent on local knowledge. Poultry is produced on a free-range system where birds are allowed to roam and fend for themselves. They only return at dusk to the structures prepared for them. The feed may be provided for birds depending on their age. Chicks are often fed on termites or cereals depending on what is available to a farm household, while older birds fend for themselves.

The production of ruminants also relies on local knowledge. Ruminants are kept separately. Smaller ruminants (goats, sheep and pigs) are kept in pens built with mud and a thatch roof adjoining the homestead or just by it. Larger ruminants (cattle and donkeys) are kept in kraals built in two styles. The first is with logs just by the compound house. This is because a Kraal is a collective property for keeping all the larger ruminants of the compound house. A second way is the circular building of compound houses with spaces created in the centre. An entrance is then created to allow passage for larger ruminants. Maintenance of spaces for larger ruminants is a collective responsibility while those for smaller ones is the

responsibility of the household. The confinement of livestock is important as their dropping provide inorganic fertiliser for crop use.

Different strategies are used in caring for ruminants. Smaller ruminants, which are under the control of households, are left to fend for themselves during the dry season but are tethered during the farming season. Tethering is done in two ways. The first form of tethering is done in the outer rings of the compound systems and within spaces that are not cultivated at the beginning of the farming season. This is done to avoid conflict between ruminants and crops. Tethering grounds are also rotated to ensure that there is enough grass for ruminants to graze. Water is provided to animals at the grazing grounds during this period. The ruminants are often tethered in the morning before households attend to other farm activities and are often the responsibility of children. Their positions may be rotated at the tethering grounds depending on the availability of water and grass for grazing. They are brought back to the hats to sleep at dusk. The second strategy is used when early millet have been harvested with late millet and sorghum tasselling. During this time, the grasses in open spaces within the second rings of the compound systems become overgrown. Coupled with the early morning dew, which is a source of resistance to the goats, children, whose main task is tethering of smaller ruminants, find it difficult to perform their duties. Thus, a hut is constructed for the ruminants to be tethered at the backyard. The leaves of the late millet and sorghum are harvested and fed to them. This period also coincides with the harvesting of groundnuts and the leaves are additionally used as feed.

Larger ruminants fend for themselves during the dry season but shepherded during the farming season. Shepherding is done by younger members of households mostly male children. Female children do participate in instances where a household own cattle but have no male child capable of shepherding. Shepherding is done in rotation depending on ownership of cattle. Larger ruminants can be taken farther to the bush farming systems that

are not under cultivation for grazing or just around open spaces within the compound systems. They are often returned to the kraals in the evening to rest. The water sources of large ruminants are dugouts that collect water during the rainy seasons and dams in the dry season.

Livestock keeping in the Upper East area is noted to be limited to indigenous breeds due to the presence of the tsetse fly and its associated trypanosomiasis disease. The local breed is noted to be resistant to this disease but relatively less productive in terms of milk and meat output. This is now changing in some parts of the Builsa area as farmers are interested in and are combining the local breed with exotic ones, especially in the cattle sub-sector. Farm households are mixing the indigenous breed with the Fulani breed such as the Sakoto Red, Sanga, Sokoto Gudaali, and Ndama, which have a higher market value due to their size; however, they are less resistant to diseases. There is likewise the introduction of new categories of birds like the turkey, although farm households who are interested in keeping them have not mastered the skills involved in raising them.

Beyond the introduction of new breeds of ruminants in the livestock sector and new birds in the poultry sectors, changes exist in livestock keeping practices. In terms of pens and kraals, most farm households now keep birds and small ruminants in structures erected with bricks or blocks and roofed with iron sheets. This is influenced by the important role the livestock sector play in supplementing household income. It is also due to material and educational support provided by some agricultural NGOs operating in the Builsa area. Large ruminants like cattle and donkeys are now tethered too, a practise alien to the Builsa area. This may be due to the non-availability of children to shepherd them as they are schooling. There is also a reduction in the presence of large ruminants as most households have sublet their care to the Fulani herdsmen due to the increasing enrolment of children and theft. It

is, however, important to note that some farm households are not happy leaving their cattle with the Fulani as noted by an interviewee noted that: -

“I am not happy that my cattle are with the Fulani herdsmen as they maltreat them and do not take good care of them. The number of cattle I have with the Fulani is not increasing as calves are deprived of milk and vaccines, which result in deaths. Additionally, manure is not getting to my farms as the Fulani keep the cattle farther away from the homestead” (Excerpt, farmer, Gbedembilisi, June 2018).

Previously, farm households were not interested in veterinary services and this is explained by the little importance placed by farm households in this sector. Most farm households kept landrace breeds, which were resistant to diseases. This is now changing as farm households adopt crossbreeds and have seen the complementary role of the livestock sector in supporting the crop sector and enhancing household food security. A positive development in the livestock sector is the increasing patronage of veterinary services as most households vaccinate livestock in anticipation of disease outbreak as supported by an interviewee that:

“People are now concerned about their animals. They are vaccinated three times yearly. Beyond that, farm households appreciate the services I render to them. Apart from paying for my services in cash, they also pay me in kind by giving me animals” (Excerpt, retired veterinary officer, Fumbisi, June 2018).

Another interviewee asserts that: -

“I improve the livestock sector by working closely with the agricultural department in the district and its personnel. I also have to adopt new maintenance strategies to enhance livestock productivity”. (Excerpt, 35-year male farmer, Sandema, June 2018).

The excerpts above confirm the increasing interest in the livestock sector by farm households. They now patronise vaccines from the veterinary officers and call on them to treat large ruminants. They additionally advise them on best practices to livestock keeping. Livestock is raised with crops because of the synergistic relationship between them. This is managed with a semi-intensive system where small ruminants like goats and sheep are tethered during the farming season. Cattle and donkeys are shepherded by children. Livestock is left to roam in the dry season. As crops provide them with feed especially during the farming season and early harvest, they in turn supply manure for crop production. Interview data additionally support the use of livestock in supporting crop farming either through direct sale and proceeds used for hired labour on farms or as food for communal labour. Livestock is also used as a buffer against crop failure, a finding that concurs with that of Quaye (2008) that income from livestock sale serves as a buffer to crop production. This is, however, changing as the number of cattle per household is decreasing. Also, most households with cattle have given them to the Fulani herdsmen. This, they explain is to allow their children to have access to education, a development that they are not happy with. Changes in livestock are not prevalent in Builsa North as they have issues with the Fulani settlers but much more in Builsa South where the Fulani settlers are accepted by the chiefs. While most households in the north kept landrace livestock, a majority of farm households in the south have a hybrid or only the exotic breed of livestock. There are known challenges to keeping the exotic breed as farmers are aware of their inability to withstand diseases and stress and need for constant care by the veterinary officers. Because of proximity to dwellings, compound farms are the most favoured for this activity as it helps to check thieves and other predators. Livestock can easily be attended to by the older members and children while younger and energetic members work further afield on the bush or valley farms. There are changes in the livestock kept over the year with the introduction of exotic breeds mostly by the activities of the Fulani herdsmen.

4.6 Conclusions

Farm households in Builsa engage in multiple farming systems with transitional practises within these systems. Findings from this study are supported by Benneh (1973) and Yaro (2004a) who observed compound, bush and valley farming systems in the study area, however, some farm households now practise what is described by this study as the riverine system. This system is practised by communities located along the tributaries of the White Volta such as Gbedembilisi and Doninga. It is an intensive system, which allows for two cropping cycles within a year. These are often short duration crop varieties (maize and cowpea). This is aided by the alluvial deposits and the relatively high moisture content along the banks of the rivers where it is practised. Participation in this farming system is gendered with less female-headed household involved as it is capital intensive.

Educational attainment of farm households is low and tends to decrease with distance from the main towns. It is associated with the misuse of agrochemicals as farmers with low literacy levels are likely to misuse agrochemicals. Educational attainment of heads of farm households is additionally linked to participation in the non-farm sector. Diversification of livelihood activities reduces with distance from towns as farm households located in towns are more likely to participate in non-farm work than rural households. Despite some findings in the northern areas by Owusu et al. (2011) that non-farm work contributes positively to household income and food security, most farm households in the Builsa area have not diversified to the non-farm sector. It shows that in rural areas with abundant land, farm households are more interested in growing commercial crops (crop diversification) to increase their participation in the global market economy rather than diversify to non-farm income activities as it is the case in Gbedembilisi. It also implies that, in small towns with less favourable ecological conditions for the growth of commercial crops, farm households pay more attention to the non-farm sectors. Farm household participation in the non-farm

sector is influenced by poverty as farm households cited (focus groups and in-depth interviews) inadequate capital as the most reason for not participating in this sector. This is confirmed by findings of Marchetta (2013) who linked poverty to limited participation in non-farm work. Educational attainment and proximity to markets have been noted as key determinants of participation in non-work in northern Ghana Marchetta (2013) and this explains why town communities, which have high literacy rates and are closer to markets, participate relatively more than village communities in Builsa.

There are gradual shifts in land preparation from the use of the bare hands, hand hoes and local implements to the use of agrochemicals. This is the result of agricultural modernisation, however with negative implications on the local ecology and farmer health. The improper use and handling of agrochemicals are known to have negative health implications on farmers, consumers and the ecology and confirmed by Laary (2012) and Fianko et al. (2011). Transitions exist in the tillage systems from the use of the hand hoe to bullocks, and now tractors. This is however not linear as espoused by evolutionary theorists Boserup (2017) with the hand hoe still significant in the tillage systems. This development follows an attempt at agricultural modernisation in post-independence Ghana especially with the introduction of the Structural Adjustment Programs (SAPs) in the 1980s as confirmed by Yaro et al. (2017). As farm households are not homogenous, there is inequality in wealth, which excludes poorer households from access to the new forms of tillage with negative implications for crop yields and food security among these categories of farm households. Additionally, the use of tractors is restricted in the bush systems due to challenges with accessibility and the presence of tree stumps. This has implications for cropped area expansion in these systems.

Crop varieties have changed in response to climate change and variability coupled with other drivers such as markets, the taste of farm households and the availability of improved

varieties of crops. Most of the landrace varieties of maize, rice, groundnuts and cowpea have been replaced by improved varieties. There is little change in millet and sorghum varieties. This shows that beyond climate, socio-economic factors influence transitions in farming systems. There is the emergence of mono-cropping systems, which were not common in the study area. Groundnut was sowed with Bambara groundnuts but now sown alone. Additionally, spaces in the inner rings of compound farms that were used for a mix of early and late millet and sorghum is now mono-cropped with maize. Cropped area of maize has increased in all the farming systems as its cultivation is influenced by relatively higher yields. Maize responds very well to external inputs and can be used as a substitute in preparing traditional meals like *Tou Zaafi* (TZ).

Different types of weedicides are now used to complement the hand hoe in weed control before, during and after sowing. This has implications for communal labour. From focus groups and in-depth interviews, weedicide is observed to be relatively cheaper compared to communal labour and this affects the social organisation of farming in the Builsa area. It shows how agricultural modernisation is altering social organisation at the local level. Labour use is shifting from the communal based arrangement to hired labour in line with the neo-liberal agenda observed by Yaro (2013a).

There are changes in fertiliser use and the maintenance of soil fertility. Soils are poor in quality and this is supported by some studies in the Upper East area. Soil nutrient balance is negative as nutrient uptake through harvest and use of straws is more than replenishment as supported by Callo-Concha et al. (2012) of the low level of adoption of inorganic fertilisers by farmers in these areas. With more food produced globally using inorganic fertilisers, improved seeds and irrigation, a yield gap exists in these farming systems with actual yields below expected yields. However, there is a gradual adoption of fertiliser use in

all the farming systems with relatively higher application in the compound systems as they are continuously cropped.

There are also changes in livestock care practices as shepherding has given way to tethering of larger ruminants, which were not previously tethered. This is as a result of the increasing participation of children in formal education. Another strategy for farm households who own cattle was to sublet the care to the Fulani herdsmen. This has however been observed to have negative implications on the livestock health and have deprived the compound farming systems of organic fertiliser.

CHAPTER 5

HOW SUSTAINABLE ARE FARMING SYSTEMS IN THE BUILSA AREA?

5.0 Introduction

Assessing sustainability with farmer-lenses is the focus of this chapter. Farmer perceptions of sustainable farming are important because they act based on what they think and experience rather than merely what experts tell them. This chapter examines first, the concept of sustainable farming from farmer perspectives, then assesses the ecological, economic and social sustainability of the farming systems in Builsa. It finally provides a discussion on recommendations to sustainable farming in Builsa.

5.1 Defining sustainable farming from farmers' perspectives

The conventional definitions of sustainable farming are complex (Hayati et al., 2010) and often conceptualised around the three pillars of sustainability – economic, social and environmental (Bachev, 2016), although there are extensions of these to include political and cultural sustainability. What is missing and is addressed by this chapter is how farmers, at the local level, conceptualise and operationalise the concept of sustainable farming. This concept varies among farm households as well as local experts as supported by findings of Vilei (2011). Farmers have varied opinions on what constitutes sustainable farming. Although at a glance, farm households may not be able to define sustainable farming as conceptualised by the scientific literature or the academy, as most have not heard of that term, some attempts at defining sustainable farming are made.

Some farm households defined sustainable farming as the ability of the farming systems to generate enough yields at the end of the farming cycle. This conception of sustainable farming is common in Builsa with farmers thinking of sustainability in terms of the sufficiency of farm yields as noted by an interviewee that:

“Sometimes we can farm and the yield is so good, that is sustainable farming and sometime the yield could be bad and that is unsustainable farming”

(Excerpt, farmer, Sandema, June 2018).

Another relates that:

“Sustainable farming is about the ability of the farmer to carry out all planned activities with regards to crops and livestock during the farming cycles to yield desirable outcomes” (Excerpt, female member, Logmisa, June 2018).

Still another interviewee sees sustainable farming as:

“When you take good care of your crops and animals and keep your soils in a way that they do not become infertile for both crops and livestock to become productive” (Excerpt, farmer, June 2018).

These excerpts emphasize a definition of sustainable farming about productivity. For this category of farm households, sustainability is equivalent to productivity such that the more productive their farming systems are the more sustainable they become. There also exist elements of the conception of continuity as notions of infertility of soils are in the definitions. This observation concurs with that of Hansen (1996) that sustainable farming is conceptualised as a process and as a product.

Other farm households define sustainable farming to exist when there is timely availability of farm inputs to execute a successful farm cycle as noted by an interviewee that:

“My farming systems are sustainable when I can get farm inputs at the right time. But as I lack resources to execute my farm activities at the right time then the farming systems become unsustainable” (Excerpts, female member, Logmisa, June 2018).

This excerpt shows that as farm households delay at the beginning of the farming cycle, then everything delays leading to failure in that farming cycle. For such households, the timely availability of farm inputs is critical to securing a sustainable farm. This conception does not contain notions of continuity and maintenance of the biophysical resources to secure a farm livelihood today and into the future. In defining sustainable farming, a typical view in the study area is capture in Box 5.1.

I have not heard of the term sustainable farming. But I engage in farm practices that involves replenishing soil fertility through both organic and inorganic means. However, having given my cattle to the Fulani, I can no longer have access to the large quantities of the organic fertilisers. I apply organic matter from the dropping of poultry and other smaller ruminants. Inorganic fertilisers are the new sustainable form of farming. We get the fertilisers from the Department of Agriculture. I do not deliberately plant trees but allow shea, dawadawa and other economic trees to grow on my farms. In terms of soil erosion, I have no immediate means of preventing it. I have no ways of enhancing productivity of the livestock sector. Farming is profitable and products can feed my family throughout the year if the weather is good. The farming systems are profitable as we additionally sell livestock for cash.

Box 5.1: Apaalen, a male farmer's views on the sustainability of the farming systems in Builsa

This view touches on several aspects of sustainable farming. It begins with a confirmation that most farm households are not able to give an academic definition of sustainable farming yet are involved in sustainable farming practices. It moves on to confirm the changes that have occurred in farm practices with a gradual transitioning to the use of inorganic fertilisers and their sources. It concludes by suggesting the critical role of climate to the productivity and profitability of the farming systems. Sustainable farming can be defined from these conceptualisations by identifying sustainable and unsustainable farm practices at the local level. It additionally shows conceptualisations of sustainable farming as products in terms of yields and as a process in terms of carefully planned activities to be executed by farm households. The rest of the chapter will assess the sustainability of the local farming systems under the ecological, economic and social domains as perceived by farm households.

5.2. Assessing the ecological sustainability of the farming systems

Beyond the conventional ecological measures of sustainable farming that test for soil ph., organic matter content, cation exchange capacity and other biophysical properties of soils, which forms the medium for the production and reproduction of farm households and their farming systems, farmers have their criteria of assessing the ecological sustainability of their farming systems. Even at the local level, conceptualisations of biophysical measures of sustainable farming is non-consensual among farm households and between farm household and local experts. Local Experts used markers such as successes in project implementation, the practice of crop rotation, the physical health of crops on the field, the production of higher yields continuously, organic matter content of the soil, use of external inputs, taking farming as a business, the seriousness of the farmer and timely harvest as measures of sustainable farming. There are however some similarities in the measures of sustainability used by local experts and farmers.

Farmer criteria of measuring ecological sustainability include rainfall reliability, the incidence of soil erosion, usability of open water in the locality, crop output per unit area, extent of forest cover, loss of landrace crop varieties and livestock breed, increasing reliance on chemical fertilisers, and livestock poisoning due to chemical pollution. Farmer's perceptions of the ecological sustainability of their farming systems are tested on these criteria and the mean of their responses is shown in Table 5.1.

Table 5.1: Ecological markers of sustainable farming

| Ecological markers | Min. | Max. | Mean | Std. Deviation |
|---|------|------|------|----------------|
| Rainfall is not reliable | 1 | 5 | 4.18 | 1.117 |
| Soil erosion is on the rise | 1 | 5 | 4.42 | 0.776 |
| Cannot drink from open water sources due to pesticides | 1 | 5 | 3.97 | 1.088 |
| Crop outputs are declining per land area over the years | 1 | 5 | 4.12 | 0.927 |
| There is a reduction in forest cover | 1 | 5 | 4.25 | 0.815 |
| We have lost most of our traditional crops | 1 | 5 | 4.1 | 0.938 |
| There are increases in chemical fertilizer use | 1 | 5 | 4.01 | 0.96 |
| Our animals die due to agrochemical contamination | 1 | 5 | 4.04 | 0.964 |

Source: Fieldwork, 2018. NB: 1=strongly disagree, 5=strongly agree.

The results show that most farm households in Builsa view their farming systems as ecologically unsustainable. With a mean around four (4), it means that they strongly agree to all the markers identified within the ecological pillar of sustainable farming. This is additionally supported by a low Standard Deviation indicating that the responses are clustered around the mean. As the farming systems are rain-fed, the reliability of rain is critical to the sustainability of these systems.

The mean responses of the communities show variations in farmer assessment of the ecological sustainability of their farming systems and the difference in the responses are shown in Table 5.2. Less than a quarter of farm households do not perceive their farming systems as ecologically unsustainable. The compound systems are perceived as most ecologically sustainable as shown by the results in Table 5.2. This is explained by the high proportion of farmers who practice this system and its proximity to the homestead. These perceptions vary by communities with no clear difference in views between town and village communities. Generally, communities that use a higher level of external inputs do not see their farming systems as sustainable as is the case of Gbedembilisi supported by (Table 4.10) on fertiliser use.

Table 5.2: Ecological sustainability of farming systems

| Farming system | N | Ecologically Sustainable (%) | Not Ecologically Sustainable (%) | Total (%) |
|--------------------|-----|------------------------------|----------------------------------|-----------|
| Bush farming | 228 | 13.6 | 86.4 | 100.0 |
| Compound farming | 430 | 16.5 | 83.5 | 100.0 |
| Irrigation farming | 15 | 13.3 | 86.7 | 100.0 |
| Valley farming | 183 | 11.5 | 88.5 | 100.0 |
| Other farming | 5 | 0.0 | 100.0 | 100.0 |
| Total | 451 | 16.9 | 83.2 | 100.0 |
| Community | | | | |
| Sandema | 130 | 15.4 | 84.6 | 100.0 |
| Kadema | 18 | 22.2 | 77.8 | 100.0 |
| Wiaga | 120 | 21.7 | 78.3 | 100.0 |
| Gbedembilisi | 7 | 0.0 | 100.0 | 100.0 |
| Fumbisi | 115 | 13.0 | 87.0 | 100.0 |
| Doninga | 32 | 0.0 | 100.0 | 100.0 |
| Chansa | 29 | 37.9 | 62.1 | 100.0 |
| Total | 451 | 16.9 | 83.2 | 100.0 |

Source: Field data 2018

Most farm households do not deliberately plant trees on their farms but protect and maintain economic trees that grow on their own. Some farmers claim that trees competed with their crops for sunlight and nutrients so there is no need to keep them on their farms. Others noted the importance of trees and can identify some species of trees that improve the yields of crops but are of the view that such trees are not deliberately planted because of cultural reasons. In some instances, household plant mangoes and cashews on the compound farms explaining why it is the system that farm households perceived to have the highest tree presence. These are used as shades during the dry season and supply the household with fruits for household use and sale. Table 5.3 shows tree presence by farming systems and community in Builsa.

Table 5.3: Tree presence by farming systems and communities

| Farming system | N | No trees on-farm (%) | Trees on the farm (%) | Total (%) |
|--------------------|-----|----------------------|-----------------------|-----------|
| Bush farming | 228 | 51.3 | 48.7 | 100.0 |
| Compound farming | 430 | 61.2 | 38.8 | 100.0 |
| Irrigation farming | 15 | 46.7 | 53.3 | 100.0 |
| Valley farming | 183 | 50.8 | 49.2 | 100.0 |
| Riverine farming | 5 | 0.0 | 100.0 | 100.0 |
| Total | 451 | 62.5 | 37.5 | 100.0 |
| Community | | | | |
| Sandema | 130 | 68.5 | 31.5 | 100.0 |
| Kadema | 18 | 77.8 | 22.2 | 100.0 |
| Wiaga | 120 | 60.8 | 39.2 | 100.0 |
| Gbedembilisi | 7 | 14.3 | 85.7 | 100.0 |
| Fumbisi | 115 | 68.7 | 31.3 | 100.0 |
| Doninga | 32 | 25.0 | 75.0 | 100.0 |
| Chansa | 29 | 62.1 | 37.9 | 100.0 |
| Total | 451 | 62.5 | 37.5 | 100.0 |

Source: Field data 2018

More than half of farm households do not have trees on their farms with Gbedembilisi being the community with the highest tree presence. This could be explained by its location and drainage. It is located in a low-lying area and drained by a tributary of the White Volta thus making trees around this village relatively water sufficient than upland communities. On compound farms, some trees are deliberately planted (Plate 5.1) as against other systems where farm households only maintain economic trees as noted by an interviewee that:

“Yes, on the compound farms I plant mangoes and other economic trees but with the bush farm, I maintain the economic trees that grow out of space but do not deliberately plant them”. (Excerpt, 42-year male farmer, Kadema, June 2018).

Another ecological measure of sustainable farming is the fertility of soils and how they are maintained. Soil fertility is maintained on compound systems through a blend of strategies. These include the use of both organic and inorganic fertilisers. Household waste and dropping of livestock like poultry, sheep, goats and cattle form the organic strategy of maintaining soil fertility within the compound systems. Inorganic fertilisers are also used following their introduction by state institutions like the Department of Agriculture and some agricultural NGOs.

Plate 5.1: Tree presence on compound systems



Source: Fieldwork, 2018

As compounds are organised in rings, the inner ring is the most fertilised with deposits of household waste and droppings of farm animals deposited as observed on page 113. Farm households without livestock had innovative ways of maintaining soil fertility on their

compound farms as expressed by a male farmer that: *“I gather cow dung during the dry season from people’s cattle as they graze on the compound farms. I also ridge the late millet and sorghum at the tasselling stage, which re-fertilisers the soil in the next cropping seasons”* (Excerpt, 46-year male farmer, Sandema, June 2018). Soil fertility is maintained on bush systems by the use of rotation strategies where plots and crops are rotated. Most farmers in the study area are of the view that the soil fertility of their farming systems is declining as discussed in the previous chapter. Following this, there is a gradual increase in the use of chemical fertilisers in all the farming systems. This is a measure of sustainable farming as yields of crops are affected by these processes that invariably lead to a decline in the food security statutes of farm households. The shifts to the use of inorganic fertilisers contrast some views that associate the use of conservation agricultural practices with poor households in rural areas (Lalani, Dorward, Holloway, & Wauters, 2016).

Soil erosion is a biophysical marker of sustainable farming in the study area. Its presence indicates the washing away of topsoil and nutrients on farms thus reducing their productivity. Most farm households affirmed the presence of erosion on their farms. However, most of them have no immediate means of addressing it. This confirms a study in the Upper East area that shows increasing soil erosion with negative implications for the farming systems (Aniah et al., 2013). Avoiding parts of the fields that are affected by erosion, diversions using logs and the planting of grasses that are water-resistant were some measure adopted by farm households that attempted to control water soil erosion. This suggests that in land-abundant rural areas, little attention is paid to maintaining the soils as farm households can change plots or portions of it affected by erosion.

5.3 Assessing the economic sustainability of the farming systems

Economic criteria developed for assessing the sustainability of the farming systems in Builsa include profitability, income generation, the sufficiency of farm outputs in meeting

household food needs, presence of efficient markets for the sale of farm products, and the presence of rural infrastructure that aid farming. These are assessed using what is described as economic markers of sustainable farming presented in Table 5.4.

Table 5.4: Economic markers of sustainable farming

| Markers (Economic) | Min. | Max. | Mean | Std. Deviation |
|---|------|------|------|----------------|
| The profitability of current farming systems | 1 | 5 | 3.11 | 1.244 |
| Enough income generated from Farming | 1 | 5 | 2.91 | 1.202 |
| Sufficiency of output in meeting household food needs | 1 | 5 | 2.95 | 1.205 |
| Presence of efficient markets for farm produce | 1 | 5 | 2.92 | 1.182 |
| A good infrastructure that aid farming | 1 | 5 | 2.38 | 1.296 |

Source: Fieldwork, June 2018. NB: 1=strongly disagree, 5=strongly agree.

The means of the responses indicate that most farm households expressed negative concerns about the economic sustainability of their farming systems. A Standard Deviation of around 1 additionally supports that most of the responses are clustered around the mean thus indicating farm households are not sure of the economic sustainability of their farm systems. A variable with a higher mean is the profitability of the farming systems indicating that most farm households perceive their farming systems to be sustainable when they are profitable. The responses were additionally analysed by farming systems and community and the results are shown in Table 5.5. There are variations in farm households view on the economic sustainability of their farming systems.

Table 5.5: Economic sustainability of farming systems

| Farming system | N | Not economically Sustainable (%) | Economically Sustainable (%) | Total (%) |
|--------------------|-----|----------------------------------|------------------------------|-----------|
| Bush farming | 228 | 71.5 | 28.5 | 100.0 |
| Compound farming | 430 | 76.3 | 23.7 | 100.0 |
| Irrigation farming | 15 | 86.7 | 13.3 | 100.0 |
| Valley farming | 183 | 70.0 | 30.1 | 100.0 |
| Riverine farming | 5 | 20.0 | 80.0 | 100.0 |
| Total | 451 | 76.3 | 23.7 | 100.0 |
| Community | | | | |
| Sandema | 130 | 66.9 | 33.1 | 100.0 |
| Kadema | 18 | 94.4 | 5.6 | 100.0 |
| Wiaga | 120 | 78.3 | 21.7 | 100.0 |
| Gbedembilisi | 7 | 0.0 | 100.0 | 100.0 |
| Fumbisi | 115 | 93.0 | 7.0 | 100.0 |
| Doninga | 32 | 37.5 | 62.5 | 100.0 |
| Chansa | 29 | 93.1 | 6.9 | 100.0 |
| Total | 451 | 76.3 | 23.7 | 100.0 |

Source: Field data 2018

The results show that more than two-thirds (76.3%) of farm households perceive their farming systems as economically unsustainable. A farming system perceived as economically sustainable (80%) is the riverine system. This system is practised in areas with relatively high moisture as they are located along the banks of the tributaries of the White Volta. These are additionally new frontiers, thus capable of boosting crop yields. Beyond these, all farm households in Gbedembilisi who practised this system use fertiliser in their farming systems suggesting that relatively high access to modern technology through the activities of commercial rice farmers contribute to this outcome.

At the community level, Gbedembilisi and Doninga have high scores for the economic sustainability of their farming systems. This is explained by the ability to grow commercial crops twice a year. Moreover, Doninga is a new frontier that is less explored by farmers as relatively less inorganic fertiliser is used by farm households in this community; but its economic sustainability score is high. This is a result of fertile lands compared to the rest of the communities in the Builsa area. Fumbisi, which used to be a breadbasket, has most of its lands depleted of soil nutrients evidenced by the relatively high use of inorganic fertilisers. It is also due to the opening up of this community following the creation of the Builsa South

District in 2012 with Fumbisi as the district capital. As farm households engage in the non-farm sectors the farm sectors become economically unsustainable to them.

Economically, farm households conceive of sustainable farming as farm systems that can produce an appreciable level of output at the end of a farming cycle to meet household feeding and the sale of the surpluses on the market for cash. This conception is not wholly different from some scholarly conceptions of economic sustainability as when an acceptable level of economic returns on used resources are attained Bachev (2016) and financial stability achieved Lebacqz, Baret, and Stilmant (2012). With this view, issues of continuity of the farming systems do not readily come to mind. What the farmer seeks is output per unit input and if that is attained then the farming systems are sustainable and vice versa. This conceptualisation applies to both livestock and crop sectors where output attained in a year measures the success of the farming system. With the non-farm sector contributing very little to household income, yield is a good measure of economic success in this context.

The need for the farming systems to be profitable in addition to other factors such as climate change and variability are driving shifts from the cultivation of traditional-base crops like millet and sorghum to maize, groundnuts and cowpea, which have a shorter maturity period and are high yielding under the influence of external inputs such as chemical fertilisers, herbicides and pesticides. Another economic marker of sustainable farming is the timely availability of farm inputs to execute farming activities at the onset of the farming season. Most farm households are of the view that if they had timely access to farm inputs like tractors, seeds, and chemicals, they will have a sustainable farming system. This is linked directly to productivity as all things being equal, timely execution of farm activities will lead to higher yields and the reverse will happen if that is not done.

Labour access is one important economic factor that is linked to sustainable farming from the perspective of farm households. Labour is available in the study area during the farming

season but not accessible to all categories of farm households as supported by views from focus group discussion as:

There is access to labour (communal and hired) in this village but it becomes problematic during dry season cowpea farming. As almost all villagers are involved in these activities there are often labour shortages. But this can be overcome if you have money as people migrate from some parts of the district to sell their labour during these times. I especially go to villages that are not endowed with the potential of bean farming with a tricycle to bring them to come and help. They are often paid GHC 10 per day and fed. (Excerpt, 43-year male farmer, Gedembilisi, June 2018).

Labour is relatively more accessible to the economically well-off households making those household attain a sustainable farm system as they can timely perform all the farm practices through hired labour. It is important to note that in rural areas, although communal labour exists, it is not readily accessible during certain times of the farming season. It is, for instance, difficult to access communal labour during planting, early weeding, and harvesting. In these instances, farm households with larger acreages and fewer members will have to rely on hired labour or modern technologies.

Access to credit for farming in the study area is difficult. At the time of data collection, two banks were operating in the study area. These are the GN Bank and the Builsa Community Bank. These banks serve two categories of farmers. These are group farmers and individual farmers. The GN Bank stopped providing credit to farmers in groups at the time of the study due to difficulties in retrieving group loans. Accessing an individual loan is also tedious because of the need for at least two guarantors. The Builsa Community Bank provides group credit to farmers only in collaboration with donor partners with individual loans having to be supported by collateral. Both managers of these banks are of the view that

access to agricultural credit in the area is on the rise. This assertion is not supported by most farm households as they have no access to agricultural loans shown in Table 5.6. Only a few farm households had access to loans over the past three years. This period covers three years before the data was collected. Most of the loans were sourced from the rural bank with only a single person of the sample having sourced a loan from the commercial bank. Those who had higher access to loans were involved in capital intensive systems such as riverine and irrigation. The community with the highest loan access is Gbedembilisi, which seems to suggest a relationship between the incidence of commercial farming and loan access. Several reasons were given for the inability of farm households to access credit. While some were self-sufficient, others had no collateral with some afraid of the risk of inability to pay in cases of crop failure.

Table 5.6: Loan access by farming systems and community

| Farming system | N | No loan (%) | Obtained loan (%) | Total (%) |
|--------------------|-----|-------------|-------------------|-----------|
| Bush farming | 228 | 89.0 | 11.0 | 100.0 |
| Compound farming | 430 | 90.5 | 9.5 | 100.0 |
| Irrigation farming | 15 | 80.0 | 20.0 | 100.0 |
| Valley farming | 183 | 88.0 | 12.0 | 100.0 |
| Riverine farming | 5 | 80.0 | 20.0 | 100.0 |
| Total | 451 | 90.5 | 9.5 | 100.0 |
| Community | | | | |
| Sandema | 130 | 94.6 | 5.4 | 100.0 |
| Kadema | 18 | 94.4 | 5.6 | 100.0 |
| Wiaga | 120 | 86.7 | 13.3 | 100.0 |
| Gbedembilisi | 7 | 85.7 | 14.3 | 100.0 |
| Fumbisi | 115 | 87.8 | 12.2 | 100.0 |
| Doninga | 32 | 90.6 | 9.4 | 100.0 |
| Chansa | 29 | 96.6 | 3.5 | 100.0 |
| Total | 451 | 90.5 | 9.5 | 100.0 |

Source: Field data 201

These results from the survey are corroborated by a focus group discussion where it was observed that access to agricultural loan among women groups is non-existent. Women have access to business loans, however, the terms of repayment, which is every market day, is so demanding for them to use these loans for agricultural purposes as noted by an interviewee that: *“I have no access to agricultural loans, but I have access to trade loans”*. (Excerpt, 43-year female farmer, Logmisa, June 2018). The inability to access agricultural loans to

some extent determines the sustainability or not of local farming systems as it is linked with a household's ability to acquire tractor services and other input for the timely execution of the farm work.

Marketability of farm produce is linked to rural infrastructure like good roads to allow for access to the market. This is influenced by the overall development of rural areas as markets are linked to efficient vehicles and other services that enhance the movement of goods from production centres to markets and farm inputs back to these areas. Market accessibility in Builsa is a function of location and the nature of the road networks. Farm households closer to the major markets (Sandema and Fumbisi) had easier access compared to those who are farther away but had no good linking roads. The problem of physical accessibility had to do with those households far from the market and had bad linking roads. Other issues with market accessibility have to do with patronage and value of farm outputs. The prices of farm produce are seasonal. The prices of crop outputs are often low during harvesting and some farmers sell farm output cheaply in attempts to pay-off debts or attend to some pressing household needs. At certain times like December and Easter, farm households have good prices for livestock while during planting time the market is glutted as all try to sell livestock to reduce the burden during the farming time. Livestock is also sold during this time in support of crop farming. The bad nature of the roads is making it generally difficult to sell livestock and farm produce as shown in Table 5.7.

Table 5.7: Ease with which farm produce is sold

| Farming system | Very difficult (%) | Difficult (%) | Neutral (%) | Easy (%) | Very easy (%) | Total |
|--------------------|--------------------|---------------|-------------|----------|---------------|-------|
| Bush farming | 17.1 | 43.4 | 17.1 | 13.2 | 9.2 | 100.0 |
| Compound farming | 13.3 | 44.4 | 20.0 | 12.1 | 10.2 | 100.0 |
| Irrigation farming | 0.0 | 53.3 | 13.3 | 13.3 | 20.0 | 100.0 |
| Valley farming | 19.1 | 43.2 | 17.5 | 6.0 | 14.2 | 100.0 |
| Riverine farming | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 100.0 |
| Total | 13.8 | 44.1 | 19.7 | 12.0 | 10.4 | 100.0 |
| Community | | | | | | |
| Sandema | 3.1 | 33.9 | 25.4 | 11.5 | 26.2 | 100.0 |
| Kadema | 22.2 | 55.6 | 16.7 | 5.6 | 0.0 | 100.0 |
| Wiaga | 18.3 | 46.7 | 11.7 | 17.5 | 5.8 | 100.0 |
| Gbedembilisi | 0.0 | 85.7 | 0.0 | 14.3 | 0.0 | 100.0 |
| Fumbisi | 6.1 | 48.7 | 28.7 | 12.2 | 4.4 | 100.0 |
| Doninga | 53.1 | 40.6 | 0.0 | 3.1 | 3.1 | 100.0 |
| Chansa | 27.6 | 48.3 | 20.7 | 3.5 | 0.0 | 100.0 |
| Total | 13.8 | 44.1 | 19.7 | 12.0 | 10.4 | 100.0 |

Source: Field data 2018

More than half (13.8% and 44.1%) of farm households have difficulties in selling farm products. Those farm households engaged in irrigation and valley farming find it relatively easy to sell farm products. At the community level, those with the least resistance to overcome are the towns (Sandema, Wiaga and Fumbisi), which are market centres and relatively better connected in terms of road networks. The community with the most difficulty in market access is Gbedembilisi, which is located far from the Fumbisi and Sandema markets thus making it difficult for farm households to cart inputs and outputs from and to the market centres. Additionally, the high cost of movement between this community and the main markets deprive some farm households access to these markets. This is supported by Mori (2013) who observed distance to market as a limiting factor in the sale of dairy products.

5.4 Assessing the social sustainability of the farming systems

Social sustainability is used here to describe the ability of farm households to fulfil their needs and rights and to fully participate in the expected lives of the people in Builsa. These include farm household's ability to: grow and eat preferred foods, be self-sufficient in own food production, be confident in the continuation of farm systems by future generations,

have access to labour, be satisfied with their work, etc. as captured in Table 5.8. Farm household assessment of the social sustainability of their farming systems does not diverge strongly from that of the economic markers as the mean is closer to three (3) and the Standard deviation around one (1). This implies that most responses of farm households are negative on the social sustainability of their farming systems. A marker that had a higher mean and which seems to be accepted by most farm households is that their farm systems can sustain their culture. This is however in contrast with observations in some villages during focus group discussions, in-depth interviews, and personal observations. In Gbedembilisi for instance, farmers have completely stopped the cultivation of millet and sorghum, which are traditional crops. At a broader scale too, there is a general reduction in the growing of millet and sorghum. Traditional crop reduction trajectory is from the northern parts of the study area towards the south with most farm households in southern Builsa moving from millet to maize cultivation. In northern Builsa, the mix of early and late millet with sorghum is practised. This, however, reduces as you travel south with most compound farms planted with maize.

Table 5.8: Social markers of sustainable farming²

| Markers (social) | Min. | Max. | Mean | Std. Deviation |
|---|------|------|------|----------------|
| I eat my preferred foods all year round | 1 | 5 | 2.93 | 1.221 |
| I am self-sufficient in own food production | 1 | 5 | 3 | 1.266 |
| Myself, children and grandchildren will continue to farm forever | 1 | 5 | 2.69 | 1.395 |
| I have access to sufficient own or hired labour during farming activities | 1 | 5 | 2.82 | 1.246 |
| I am satisfied with the farming job | 1 | 5 | 2.99 | 1.252 |
| I earn some income working on the farms of others | 1 | 5 | 2.52 | 1.174 |
| Our traditions and culture are sustained through our farming system | 1 | 5 | 3.64 | 1.24 |
| I get paid jobs from farming-related activities all year round | 1 | 5 | 2.86 | 1.256 |

Source: Fieldwork, 2018.

Socially and culturally, farm households conceived of sustainable farming as growing and eating preferred crops and foods, respectively. The people of Builsa traditionally grow and eat grains. They grow legumes such as cowpea and cereals like; millet, sorghum, rice, groundnuts, Bambara nuts and local leafy vegetables. Millets are important staples and at the same time cultural commodities. Early millet mature in three (3) months and that is used to moderate hunger during the farming season. Late millet matures with sorghum and the landrace cowpea that is usually harvested around late October and November. To be a Builsa without millet on your farm or in your household means you are not a true Builsa. Culturally, they believed that the gods and ancestors of the Builsa land can only respond to them during libation with millet flour or sorghum beer (locally called *pito*). Funerals cannot be performed without millet and sorghum stocks and seeds as these are needed to enhance the smooth transition of the dead into the ancestral realm. The shift in the cropping systems from millet to maize is making the functions that are expected of the people wane. They either buy from the market to meet cultural demands or borrow from households that have grown some millet for such purposes. This highlights cultural changes among some farm households in Builsa, which are influenced by the transitioning farming systems. The sustainability of the farming systems is thus measured by the crops with which the people are identified. It also reflects in their food preferences, as most farm households preferred millet TZ (a paste of millet or sorghum flour) to maize TZ but had to eat maize because that is what is readily available. Table 5.9 shows that farm households are giving priority to the cultivation of maize rather than the traditional crops (millets, sorghum and groundnuts).

Table 5.9: Average cropped area by farming systems

| Farming system | Early millet | Late Millet | Sorghum | Rice | Groundnut | Beans | Maize | Average Total |
|--------------------|--------------|-------------|---------|------|-----------|-------|-------|---------------|
| Bush farming | - | 2.6 | 2.3 | 1.0 | 2.0 | 2.2 | 3.3 | 2.5 |
| Compound farming | 1.4 | 2.3 | 2.2 | 0.8 | 1.9 | 2.2 | 2.5 | 2.0 |
| Irrigation farming | 1.0 | 1.5 | - | 1.0 | 2.0 | - | 1.8 | 1.5 |
| Valley farming | 1.4 | 2.6 | 2.2 | 2.5 | 2.1 | 2.4 | 3.0 | 2.3 |
| Riverine | - | - | - | - | - | 2.0 | 4.5 | 3.0 |

Source: Field data 2018

The social organisation of farming is additionally changing. Group and in-law farming are giving way to hired labour and the use of agrochemicals. This is mostly due to cost as it is less expensive to apply these chemicals compared to food and drinks involved in group and in-law farming arrangements.

A community that thinks their farming systems are socially sustainable is Gbedembilisi. This observation is however in contrast with interview data as farm households in this community did not cultivate traditional crops like millet and sorghum on their compound farms. In-law farming is an arrangement where a son-in-law organises labourers among his kinsmen to weed for his father-in-law. This shows that what is social- and culturally-sustainable is location-specific and based, to some extent, on the priorities of communities. Households in Gbedembilisi do not cultivate crops that meet traditional demands but can satisfy other cultural needs through the markets.

5.5 Conclusions

Sustainable farming is a concept with several conceptualisations among farm households in Builsa. This concurs with observations that sustainable farming means different things to different people by Sydorovych and Wossink (2008) and Bockstaller et al. (2015). Farmers in rural areas may not have an academic definition of sustainable farming as their conceptualisation differs from academics and experts who have had a formal education.

This notwithstanding, farmers are aware and do practice sustainable farming at the individual level. This is shown by the differing conceptualisations of sustainable farming among farm households in Builsa. Some conceptualisations used markers such as good yields at the end of a farming cycle, availability of farms inputs at the right time to execute farm work, ability to organise the other factors necessary for farm work and ensuring that soils are fertile to continuously yield desirable outcomes. Generally, farm households conceive of sustainability in terms of productivity, however, there are differences between households on the different markers of sustainable farming as confirms the study of Vilei (2011). These conceptualisations additionally show two categories of sustainable farming in Builsa. One has to do with farm households relying on the outcome of their farming systems to define sustainability and the others rely on the processes. This concurs with Hansen (1996) conceptualisation of sustainable farming as a product to be delivered and as a process involving a series of activities to be undertaken. Farm households who conceive of sustainable farming as a process argue that if all the ingredients that are needed for farming are present at the right time sustainability will be achieved. It is thus necessary to have a local conceptualisation of sustainable farming before remedial measures are implemented as sustainability even under similar ecological characteristics is conceptualised and operationalised differently.

The difference in conceptualisations plays out in attempts at measuring sustainable farming as different markers are used by farm households. These markers are conceived of in terms of farm practices and are derived from the perceptions of farmers using qualitative data. Based on these markers, farmers view on the sustainability of all the domains (ecological, economic and social) of their farming systems remain negative while they think that their farming systems are more ecologically unsustainable. At the farming systems level, farm households who engage in compound farming perceived their systems as relatively more

ecologically sustainable than other farming systems. Economically, farm households who practised the riverine and valley systems viewed their systems as relatively more sustainable than other systems. Within the social domain, those who practised the riverine and valley systems viewed their systems to be more socially sustainable. This implies that no single farming systems can be highly sustainable in all the domains used in assessing sustainable farming. The strength and weakness in sustainability or not of farming systems at the community level also varies. This demand location-specific solution to defining and addressing issues of sustainable farming systems in Builsa. There must be trade-offs in sustainability as economic sustainability may cause ecological and social sustainability problems. Some farm households are transitioning towards commercial agriculture but that should be blended with the traditional ways of maintaining soil fertility to ensure the sustainability of the farming systems. Tree presence is more associated with compound than with other farming systems. This practice tends to reduce water erosion, provide soil organic matter and supplement household food and income, a conscious effort is thus needed by all stakeholders to address tree planting within the farming systems in Builsa. Sustainable farming is influenced by both external and internal forces and these are the focus of my discussion in the next chapter.

CHAPTER 6

EXTERNAL AND INTERNAL FORCES DEFINING SUSTAINABLE FARMING

6.0 Introduction

This chapter explores the external and internal forces that influence sustainable farming by farm households. It shows how and why farm households are limited in their pursuit of sustainable farming, and also examines factors determining their ability to engage in practices that lead to sustainability. The chapter further examines farmers view on what can be done to overcome the limitation and promote sustainability. External and internal forces to sustainable farming are organised along the three dimensions or domains of sustainability, which are ecological, economic social.

6.1 External forces affecting sustainable farming in Builsa

The development of agriculture is generally limited by both external and internal forces with this section discussing external forces. External forces are used here to describe the factors that are not entirely controlled by farm households yet necessary for the smooth execution of sustainable farming. Externally, climate change, international and local policies on agriculture, globalisation, and trade liberalisation have had an enormous influence on sustainable agriculture. The combination of these factors backed by the attributes of households has different outcomes on sustainable farming and food security at the local level. The sustainability of farming systems is influenced by how the different actors within the systems interpret and apply these external forces in combination with their local and specific context. How they appraise and utilise the resources at their disposal define whether they achieve sustainability or not. Farm households in the study area are differentially endowed with ecological, economic and social resources, which influences their level of constraint and success.

6.1.1 External ecological forces affecting sustainable farming

External ecological forces impinging on the sustainability of the farming system in Builsa include climate change and variability, pest and disease outbreaks and spread, external input access and usage. Farming in Builsa as noted earlier is mostly rain-fed in line with the observation that farming systems in West Africa are determined by rainfall variability Callo-Concha et al. (2012). Results show that water supply to the farming systems was not sufficient in 2017, the year before data collection as shown in Table 6.1.

Table 6.1: Sufficiency of rainfall by farming systems and community

| Farming system | N | Not sufficient (%) | Sufficient water (%) | Total (%) |
|--------------------|-----|--------------------|----------------------|-----------|
| Bush farming | 228 | 75.4 | 24.6 | 100.0 |
| Compound farming | 430 | 74.4 | 25.6 | 100.0 |
| Irrigation farming | 15 | 60.0 | 40.0 | 100.0 |
| Valley farming | 183 | 83.6 | 16.4 | 100.0 |
| Riverine farming | 5 | 100.0 | 0.0 | 100.0 |
| Total | 451 | 75.4 | 24.6 | 100.0 |
| Community | | | | |
| Sandema | 130 | 78.5 | 21.5 | 100.0 |
| Kadema | 18 | 61.1 | 38.9 | 100.0 |
| Wiaga | 120 | 67.5 | 32.5 | 100.0 |
| Gbedembilisi | 7 | 85.7 | 14.3 | 100.0 |
| Fumbisi | 115 | 80.9 | 19.1 | 100.0 |
| Doninga | 32 | 87.5 | 12.5 | 100.0 |
| Chansa | 29 | 65.5 | 34.5 | 100.0 |
| Total | 451 | 75.4 | 24.6 | 100.0 |

Source: Field data 2018

This lends credence to the claim that water availability is a constraint to sustainable farming in Builsa. Ecologically, the study area is located within the Guinea savannah ecological zone, which receives only a single rainfall in a year thus allowing for one growing period in the absence of irrigation water as supported by Ellis-Jones et al. (2012). Those who practised riverine and valley systems were affected more than those who practise other farming systems. This is explained by farmer expectations as crops cultivated in these systems have different water requirements. Climate change and variability is thus a big challenge to sustainable farming in Builsa as expressed by an interviewee that:

“Initially, the onset of the rainy season was predictable, with the rains being consistent once they start. But now, after the initial rains, a gap exists between them and the subsequent ones, which encourage the growth of weeds within this gap. To overcome the weeds quickly for planting, you will need a tractor or bullocks as the hand hoe cannot do much” (Excerpt, farmer, Kadema, June 2018).

This excerpt is backed by secondary data confirm the effects of climate change on the sustainability of the farming systems in the study area (Morton, 2007; Yaro, 2013b; Yiran & Stringer, 2016). Climate variability affects the growth of crops in the early stages of the farming season and could lead to low yields as observed by most farm households. Relatedly, irrigation, which would have ameliorated the effects of climate change, is not developed in the study area. For the past decade, there has not been any development of irrigation infrastructure in the area. Farmers are thus of the view that their livelihoods would have been better with the development of irrigation as that could augment rainfall and serve as an avenue for dry season vegetable farming. To a large extent, it is the compound and bush farming systems that are affected in years of droughts as these are mostly located on drier areas compared to the valley and riverine systems. This implies that crops sown on compound and bush systems are more vulnerable to water scarcity than those on riverine and valley systems as noted by an interviewee that: *“I plant rice on my valley farms with okro as border plants. My valley farm has never failed me. I use weedicides to control weeds on the valley farm when I cannot weed it alone”*. (Excerpt, 34-year female farmer, Sandema). The riverine systems are relatively water sufficient but farmers risk the possibility of their crops being washed away in years of excessive rainfall as happened during the time of data collection. In 2018 while data was being collected, most farm households who farmed along the banks of River Sisili had their farms flooded. It was only

the relatively endowed households who had a harvest of maize as they had canoes that aided harvest in the floodwaters. The role of climate in limiting crop yield of peasant farmers in the Upper East region confirms the work of Luabe (2015) on local adaptation to environmental change. This effect can be reduced if farmers can precisely plant and harvest their crops before the floodwaters.

The livestock sector is also affected by climate change and variability especially the large ruminant sub-sector, which is managed by a semi-intensive strategy. Large ruminants like cattle and donkey are allowed to fend for themselves during the dry season. By this time, most dugouts and low lying areas where water had collected during the rainy season have dried up and livestock have to travel for long distances to access water. It is during this period that some stray, get diseased and die out of neglect by their owners or are stolen. Beyond water, livestock has to additionally travel over longer distances far away from the communities especially to low lying areas to graze as evidenced in Box 6.1.

In Builsa, the long dry season affects the keeping of livestock as some travel over long distances for pasture and water during the dry season. In the course of this, some die and others get stolen. I practice a semi-intensive system of livestock keeping here. The livestock are left to feed on their own during the dry season. So some die of pneumonia, anthrax, and the black leg disease, which are typical with cattle. Other constraints include the cost of drugs, which prevents livestock owners from treating animals, insufficient staff strength, and inadequate access to water. Market is not a problem because there is a vibrant market for livestock in this area.

Box 6.1: Moro's views on forces affecting sustainable livestock production

To overcome the challenges of water scarcity and feed shortages during the dry season some farm household dig wells and draw water for their animals during the dry seasons. Some have started storing the residue of crops like groundnut and beans or purchase them from the market for their livestock. Vaccination or frequent treatment of livestock is proposed as a strategy for sustainable farming as this will improve livestock health and numbers. It additionally encourages the raising of livestock, which has a synergistic relationship with the crop sector as these sectors support each other. Instead of allowing livestock to roam

and fend for themselves, supplementary feeding during the dry season should be proposed. There already exists a market for the sale of supplementary feeds. These come in the form of dry leaves from groundnuts and other legumes, as well as rice hulls, maize husks, and other crops. Farm households observed that if this is done, it will reduce theft and death of livestock.

A profound ecological force, which is external to the sustainability of the farming systems, is the presence and spread of pest and diseases with devastating effects to both the crop and livestock sectors. Some of the most common pests to crops in Builsa include the fall armyworm and birds. These attack crops afield and are noted to have contributed to yield declines in the study area. Pests are crop-specific with the fall armyworm gaining notoriety for the destruction of maize. Other diseases attack dry season vegetable production in the Upper East area as this finding concurs with that by Tanzubil and Boatbil (2014). It is observed that rice is generally not destroyed by pests compared to other crops but birds have started attacking rice fields. This means that the problem with birds destroying cereal crops is not widespread in the valley systems compared to the bush and compound systems. Most farmers have stopped sowing early millet on bush farms because of birds as they need to scare them away at the tasselling stage, which conflicts with other important farm activities like weed control on the compound systems. In Gbedembilisi, for instance, the entire community has stopped the cultivation of millets within the compound systems and bird disturbance is cited as a major challenge to the sowing of millet. The crops most affected by pests are maize and beans. Beyond infield pest attacks on crops, weevils and rodents attack crops within the cereal sub-sector and contribute to post-harvest losses. With the legume sub-sector, there is the presence of bacteria and fungi that destroy groundnut pods. There are additionally insects that drain the seeds after the groundnut have been uprooted and awaiting plucking on the field. Insect and fungal diseases affect beans more frequently

than other legumes making the riverine systems more expensive to operate as noted by an interviewee that:

“The riverine farms contribute more to food security in this village (Gbedembilisi). With the beans plots, I can harvest between 30 to 50 bags (50 kg) of beans, which can easily be converted into cash. However, if not because of theft, the compound farms are better as it cost more to do beans farming”. (Excerpt, 46-year male farmer, Gbedembilisi, June 2018)

Without the wherewithal to purchase chemicals for controlling pest during the farming season, low yields are recorded in the cereals sub-sector as a result of pest and diseases. There are diseases within the livestock sector too, which affect the numbers of livestock in the study area as noted in Box 6.1. Livestock death as a result of disease conditions discourages some households from devoting their time to livestock keeping, thus, making the sector relatively less attractive and sustainable.

Another critical external ecological force to sustainable farming is access to and use of external farm inputs by farm households. Access is conceptualised here in two ways. The first, being economic access, is discussed under internal economic forces and the second, which is discussed here, is physical access. External inputs like fertilisers, weedicides and pesticides are important to the sustainability of the farming systems under current conditions. Physical access is defined here as the ease with which farm households can get farm inputs to farms, with all things being equal. There are disparities in physical access to farm inputs by farm households as some have to travel over long distances to access these inputs. Beyond these, most private input dealers locate their shops in the markets within the district capitals that are far from communities located in distant areas as noted by an interviewee that: *“We have no agrochemical shops here, which affect our activities. The shops are not close enough to us but located in Fumbisi the district capital”.* (Excerpt, 51-

year-old male farmer, Gbedembilisi, June 2018). With markets having specific days that they occur, it is difficult for most farm household to purchase and timely transport some bulky farm inputs like fertilisers to their farms as they have no own means of transport.

A related environmental challenge raised by farm households is the effects of the excessive use of agrochemicals on human and livestock health. These concerns are more associated with the compound and riverine systems compared to the bush and valley systems. Some household heads are linking weedicide and pesticide use to livestock death at the onset of the rains as they observed their livestock die after feeding on fields where the chemical was applied. This observation is supported by empirical work on the abuse of agrochemicals in the Upper East region (Laary, 2012). The use of agrochemicals to boost crop yields have been noted to contaminate food and the environment (Liu, Pan, & Li, 2014). However, agrochemical usage has generated mixed feelings in some communities. While some farmers are concerned of a link between agrochemical usage and livestock deaths as noted that: *“In managing the effects of weedicides on livestock, we tether them before the spraying as they die after eating the sprayed grasses”*. (Excerpt, 45-year-old male, Kadema, June 2018). Others think agrochemicals have come to relieve them of the burden of spending too much resource or money on labour as labour cost is observed to be relatively expensive in the study area as noted by an interviewee that:

“The weedicides are better than the use of communal labour in augmenting own labour because of the cost. As people will demand different kinds of items like alcohol, cigarette, kola nuts, tobacco, and food”. (Excerpt, 35-year male farmer, Gbedembilisi, June 2018).

As a way of overcoming chemical pollution associated with the use of chemical fertilisers, some farm households suggest the use of organic manure from animal droppings. They,

however, noted that organic manure would not yield exponential gains in yields compared to chemical fertilizers but is long-lasting and preserves their soils for posterity.

6.1.2 External economic forces affecting sustainable farming

Some external economic forces affecting sustainable farming in the study area include the ability to pay for inputs, inadequate access to agricultural credit, inadequate agricultural infrastructure and trade liberalisation. A critical input associated with the transitioning farm systems is the availability of external energy for tillage as farmers are moving away from the use of the hand hoe in this process. This is the result of increases in acreage, which results from several reasons such as poor soils, integration of the peasantry into global markets, which demands the production of commercial crops, etc. They are shifting to either animal-drawn power or tractors but the latter is the preferable mode as there is limited availability of bullocks and donkeys for ploughing. This results from a challenge with the large ruminant sub-sector discussed earlier. This observation does not concur with the intensification argument (Campbell, Thornton, Zougmore, van Asten, & Lipper, 2014; Rockström et al., 2017) of producing more on the same piece of land or less land. It rather supports the view that inland abundant rural areas, farm households will expand the cropped area to increase yields rather than invest in intensive technologies. However, access to tractors in the study area is limited. Households do not own tractors but access tractor services in two ways. The first is to rely on the tractor services of migrant or elite farmers who come to plough the valleys of Gbedembilisi, Weisi and Doninga for commercial rice. The second is for some farmers to mobilise their colleagues to go outside the community and find a tractor to come and plough their fields. Although households are willing and prepared to pay for tractor services, they are not always available at the onset of the farming season as noted by an interviewee that:

If I had a tractor my farming systems will be interesting. As it stands now there is just a single tractor working here. So there is a queue for that tractor. I contribute money together with my friends and look for a tractor before the beginning of cropping. I am not a member of any farmer group but anyone who brings a tractor to the village the rest of us will benefit by paying for our farms to be ploughed. (Excerpt, 54-year male farmer, Kadema, June 2018).

Access to tractors is additionally skewed in favour of relatively wealthy farmers and males as observed by another interviewee that:

The late arrival of implements (tractors) is a challenge to our farming systems. Tractors even if they arrive, are hijacked by the relatively wealthy in the village. This affects the crops we grow as we are rice growers. If the tractors come late, they cannot plough the valleys for planting as they get stuck (Excerpt, 42-year-old female farmer, Kadema, June 2018).

The non-availability of tractors is thus a setback to sustainable farming as less land is cultivated in the absence of the tractor with crops, not timely planted leading to reduced output from the farming systems. This, however, contrasts with the views of some farm households who say tractors are destroying their lands and will rather prefer to use animal power. This category of farmers observed that tractors deplete their soils of nutrients and compact them thus reducing their functionality. This makes sustainable farming a contested issue at the local level as households have to trade-off the cropped area with longevity. It is important to note that not all farm households could afford tractors services. Beyond this is the challenge in access to agrochemicals as they are too expensive to the poor.

Although tractors are seen as the most efficient way of overcoming weeds and extending the area under cultivations, their use has been observed by some farm households as detrimental to the sustainability of their farm systems. Such farm households thus proposed

the use of bullocks instead of tractors. They suggested that even if the tractors are used, ploughing should be intermittently done but not every year as they compact the soils and expose them to erosion. They also observed that deep ploughing overturned the topsoils with the little organic matter, thus preventing crops from doing well.

Another economic challenge is inadequate access to agricultural credit. There are two banks in the study area offering group and individual loans. However, farmers are not well organised to access group loans and lack the collateral to go for individual loans as noted by an interviewee that:

“Agriculture financing is a big challenge in this area. We have not been able to organise ourselves into groups to access credit. So I encourage farmers to be in groups to enable us to access both credits from microfinance institutions and out-grower schemes”. (Excerpt, 35-year male farmer, Sandema, June 2018).

The inability to access agricultural credit affects the sustainability of the farming systems as inputs like fertilisers, seeds, weedicides, and pesticides are needed to support farming. It also shows that the farming systems cannot be sustained through conservation agriculture as it has been established that organic farming with crop biomass can only be successful after a considerable amount of crop biomass has been generated. This biomass is often done through the use of fertilisers (Vanlauwe, Wendt, et al., 2014). The cost of agriculture input is also high. Throughout the interviews, household heads observed that the cost of farm inputs like seeds, fertilisers, pesticides, weedicides and implements are high. This situation excludes poorer households from pursuing a sustainable livelihood as they continue to mine the little nutrients available on their farms. Related to this is the non-availability of sufficient funds at certain times of the farming cycle to pay for labour.

Agricultural infrastructure is used here to describe all rural development needs such as the availability of good roads, portable drinking water, health care units and how they are easily accessed, warehouses for storage of agricultural produce, and other physical infrastructure that aids the development of agriculture at the local level. The road networks in Builsa are appalling with most communities cut-off the district capitals and major markets during the rainy season as shown in Plate 6.1.

Plate 6.1: Section of road inundated with water at Kadema



Source: Fieldwork, June 2018

Beyond bad road networks, some communities have no access to portable drinking water with this affecting labour availability for farm work as women spend time drawing water for household use. Additionally, households also suffer labour losses due to water-related illnesses like cholera and other water-borne diseases. Due to efforts by successive government interventions, there are Community-Based Health Planning and Services (CHPS) in almost all communities in Builsa. The main challenge of most of these CHPS compounds is that they do not have well-qualified staff stationed in the communities or inadequate vaccines to address issues like snakebite, which are more pronounced in the farming season. Most farmers suffer post-harvest losses due to inadequate storage or inadequate knowledge in the storage of some farm produce. Thus, farmers are forced to sell their produce cheaply immediately after harvest to avoid damages that could lead to an eventual loss of farm produce. The farming systems that are most vulnerable in this regard are the valley and riverine systems. With the former, harvesting of rice is often poorly

handled leading to the mix with stones resulting in low market value. Linked to this is trade liberalisation; a neo-liberal ideology, which supports free trade and the opening up of markets in developing countries. The neoliberal ideology and its related strategies have resulted in the reluctance of the state in supporting agricultural development in rural areas. The result had been the removal of agricultural subsidies, the importation of cheaper agricultural produce and general neglect of the agricultural sector.

6.1.3 External social forces affecting sustainable farming

These are forces that have to do with interactions and relationships between actors in the rural space and higher-order spaces. The immediate social force at the farmer level is the interaction of farmers with the district departments of agriculture within Builsa. These are the institutions with the mandate to educate farmers on best practices and to advise them on ways of improving outputs within the entire farming systems. These institutions are however located at the district capitals making it difficult for farmers in remote parts of Builsa to easily access them. The distance travelled to access expert advice in the purchase and use of some pesticides to control the fall army-worm invasion was for instance noted as a negative force to sustainable maize production in Builsa as an interviewee noted that:

“I lost my maize crops last year. This was due to my inability to access the district department of agriculture timely to get advice and pesticides to control the fall armyworm on the maize crops”. (Excerpt, 38-year female, Kadema, June 2018).

Besides the difficulty in accessing the Department of Agriculture, there exist inadequate extension staff and logistical challenges at the district departments of agriculture as noted by an interviewee that:

“There is inadequate staff in this department especially extension staff. There are also no logistics and field officers. It is the development officer and me

(Management Information Systems-MIS) *who do everything*” (Excerpt, extension officer, Fumbisi, June 2018).

The departments of agriculture do take directive from higher-order spaces like the regional department of agriculture and the ministry of agriculture. Policies of the ministry of agriculture is in turn influenced by international policies of trade in agricultural commodities and how they should be produced. This is thus reflected in the types of agricultural products that have a market value at the local level and the quantities that need to be produced quickly for uptake through the markets. These processes have implications on the sustainability of the farming systems as embedded in some of these processes is the support of unsustainable farming practices like the excessive use of agrochemicals and ploughing along the slopes by some tractor operators who are in a hurry to make more money at the expense of more ecologically-friendly ploughing techniques.

Another external social force is migration, which is noted to influence the farming systems greatly as observed by an interviewee that: *“The farming systems were subsistence but now, they have become commercial. This is due to the inflow of migrants who have encouraged the local to take farming serious”* (Excerpt, 61-year, Fumbisi, June 2018). Migration – immigration and emigration - has had a tremendous influence on the farming systems as immigrant farmers often have a commercial motive and by that introduce superior farm implements to the indigenes especially in the rice sector. Indigenes who migrate seasonally to farming areas down south also return with new techniques of farming and these together influence sustainable farming. Some have learned how to control weeds with weedicides and to fertilise crops with chemical fertiliser to attain desirable outputs. Migrant Fulani herdsmen have also had a tremendous influence in the livestock sector. Indigenous livestock

keepers are now shifting to hybrids as they are noted to have a superior market value relative to the local breeds as noted by an interviewee that:

The presence of the Fulani herdsmen has helped me in the livestock sector. When they cross my cattle, the hybrids are often bigger than the local breeds and have a higher market value. The hybrid is however difficult to keep as they are not as disease-resistant as the landrace. (Excerpt, 45-year male farmer, Kadema, June 2018).

The excerpt shows a mix reaction to the introduction of different breeds of livestock to farm households. In the first instance, they are happy that the hybrids produced have a higher market value than the landrace. The second is a concern about care as the hybrid is not disease-resistant and resilient as the landrace. Additionally, it cost relatively more to maintain the hybrid than the landraces. Returnees also have taste for some foods that were hitherto alien to the indigenous people leading to shifts in the sustainable cultivation of crops that produce such foodstuff.

6.2 Internal forces affecting sustainable farming

As noted earlier, in addition to the external forces, there are internal forces within the ecological, economic and social domains that influence sustainable farming at the local level. Internal forces are used here to describe factors that are under the control of farm households or which farm households have the capability of altering to achieve a sustainable outcome.

6.2.1 Internal ecological forces affecting sustainable farming

Nutrient mining is a major concern for sustainable farming in the study area. The compound systems, from which most of the food in the study area is derived are continuously cropped

Internal forces influencing sustainable farming in Builsa

There is a reduction in the number of livestock held by households with the introduction of formal education. Children used to tend the cattle but now they are in school so households have to keep lower numbers so that they can be tethered. With the small ruminant like sheep and goats it is still the same. Beyond these are outbreaks of diseases but the outbreaks are not the major problems. Other issue have to do with the expansion in farm sizes. Previously people used not to extend their farms beyond the immediate compounds but now they do leaving no space to support large numbers of livestock. People expand their plots because of diversity but that is not the main reason, in that previously, the smaller area cultivated yielded enough to take care of the household but now the soils have been mined due to continuous cropping without replacement of soil fertility.

Box 6.2: Azaayam's views on forces influencing sustainable farming

without a commensurate replacement of soil nutrients. Continuous cropping is leading to soil nutrient mining as observed by most respondents and confirmed in established works (Jayne, Chamberlin, & Headey, 2014). Results from the survey (Table 6.2) additionally showed that most farm households did not apply chemical fertilisers. These, coupled with reductions in the number of livestock in the large ruminant sub-sector per household presupposes that most compound farms are mined with the result leading to unsustainability manifested in lower yields and increased farm sizes as supported by an observation made by an interviewee in Box 6.2. Related to nutrient mining is the constraint of soil erosion as most interviewees agreed that erosion occurred on their farms. Some erosion control measures used by households included diversions and the planting of grasses with deeper roots to prevent the washing of topsoils. Other households had no immediate ways of controlling the effects of water erosion and thus avoided the portions of plots affected. In line with how soils are handled during ploughing to reduce the incidence of water erosion, tractor service operators are difficult to work with. Because demand for tractor services exceeds supply, operators are noted not to adhere to recommended practices. They, for

instance, refuse to bond plots after ploughing or demand an additional fee for such a service. They are also noted to plough along instead of across slopes and will refuse to plough if a farmer is observed to be demanding that the recommended practices be followed.

Additionally, there is the challenge of tree felling for charcoal and fuelwood that could have some effects on the sustainability of the farming systems. This is exacerbated by the fact that most households do not deliberately plant trees on their farms as confirmed by both interview and survey results. *“I do not deliberately plant trees on my farms but do not cut down the trees with fruits that are edible like the Shea and Dawadaw trees either”* (Excerpt, 46-year male farmer, Kadema, June 2018). Another additionally noted that: *“the more trees are present on my farms' birds will be attracted, which will eventually destroy my crops”*. (Excerpt from an interview with a 38-year female Fumbisi). This and other reasons result in a reduced number of trees on farms. These practices expose the soil to erosion and also deprives it of biomass that serves as an organic fertiliser. In addition to these is the practice of bush burning, either in-game search or to prepare for the emergence of new grasses for livestock. This practice has its good and bad sides but it is generally noted to be a negative farm practice and have the potential of compromising the sustainability of the farming systems. Some farm households are of the view that soil-related constraints like water erosion and nutrient mining can be minimised by tree planting. They are, however, quick to point out that tree planting should be moderated than as too many trees will compete with their crops for nutrients with their shade depriving crops of sunlight needed to grow.

6.2.2 Internal economic forces affecting sustainable farming

A critical internal economic force to sustainable farming in Builsa is labour. If own labour is not provided by a farm household on its farming systems, then it is paid for either in kind or cash. Labour costs in the study area are observed by some to be relatively high in the Upper East Region. The cost of labour comes in two forms, which are direct (hired) and

indirect (communal) labour. Direct labour cost involves hired labourers who are paid according to the rate they have agreed with their client. Indirect labour involves communal labour centred on soliciting the labour of other households, which is returned in turns. There is a cost element to this, as a farm household is not only mandated to reciprocate labour it had enjoyed but additionally have to provide labourers with food, drinks and now cigarettes all pushing up the cost of communal labour.

Access to markets in the study area is constrained by the location and nature of roads to the market centres. Distance to major market by respondents is shown in Table 6.2.

Table 6.2: Distance to market by community and farming systems

| Farming system | N | Sandema (Km) | Kadema (Km) | Wiaga (Km) | Gbedembil (Km) | Fumbisi (Km) | Doninga (Km) | Chansa (Km) | Average Total (Km) |
|--------------------|-----|--------------|-------------|------------|----------------|--------------|--------------|-------------|--------------------|
| Bush farming | 228 | 11.5 | 13.5 | 9.7 | 18.7 | 10.8 | 28.1 | 19.6 | 14.0 |
| Compound farming | 430 | 8.2 | 16.7 | 7.8 | 18.4 | 10.1 | 27.9 | 19.7 | 11.2 |
| Irrigation farming | 15 | 4.8 | . | 6.4 | . | 9.7 | . | . | 6.5 |
| Valley farming | 183 | 8.6 | 20.6 | 8.6 | 18.8 | 10.5 | 29.5 | 20.9 | 13.2 |
| Riverine farming | 5 | . | . | 12.9 | 18.5 | . | . | . | 17.4 |

Source: Field data 2018

Results from Table 6.2 show a disparity in access to the major markets in the study area. This is related to poor infrastructure in support of the development of agriculture. The farming systems that are farther from the major markets are the riverine and bush systems with irrigation closer. Generally, town communities are closer markets than their village counterparts making it more difficult for villages to access major markets. Most crops harvested are conveyed to the market via head porting. With globalisation and the transportation improvements, tricycles are substitutes, which albeit comes with a fee. It is however interesting to note that not all can afford the cost of transporting their goods to the markets and are often forced to sell to local buyers at cheaper prices.

Most farm households are not able to adopt new technologies to support new farming practices. Farmers are unable to adopt new technologies because they are financially demanding, tedious to implement and time-consuming as an interviewee noted that:

“For instance, if rice seeds are to be broadcasted or transplanted, the farmer will prefer the quicker way, which may not yield the right results compared to the tedious way of transplanting. You need patience and time to implement some of the technologies, which most of the farmer’s lack”.

(Excerpt, retired Extension Officer, Gedema, June 2018).

Another is inadequate credit to apply chemical fertilisers as most farm households have no diversified means of accessing agricultural credit.

6.2.3 Internal social forces affecting sustainable farming

Internally, the social spaces within which farming is organised are conflicting spaces with multiple interpretations and usage by the different actors within. Depending on the way these spaces are used, the farming systems could be sustainable or not. It is noted for instance that there is a disagreement for the avoidance of and the use of alcohol during communal labour. Most household heads admit the use of alcohol add to the cost of labour but are also aware of low turn-out if it is known that you do not serve alcohol in such instances. There are also conflicts in the timing of social activities especially with regards to the organisation of funerals. Most funerals coincide with the beginning of the farming season. Some farm households observe that due to climate change, early planting could have saved them but due to some of these social activities planting is sometimes delayed leading to low yields if the rainy season is not prolonged. The start of the farming season is a collective action making it a challenge to act as an individual as most households who have not bought into your idea will leave their livestock idle, which might destroy your crops if you alone planted early on the compound farms. This suggests the lack of co-operation among farmers and declining use of the communal system of farming, which is a form of social safety net that ensures all have access to food.

Theft is an issue especially with maize farming and livestock keeping. Because livestock is raised using the semi-intensive system, they are left to look for pasture and water during the dry season. Livestock, especially cattle, have to travel over longer distances for pasture and water. This exposes animals to theft while some die as a result of disease conditions observed earlier. Theft is however not a widespread challenge as those in remote areas experienced less of theft compared to those around towns. Theft discourages the cultivation some crops on the bush farming systems especially maize. It also discourages some farm household from keeping livestock as they suffer losses anytime the thieves strike.

Beyond these are institutional constraints such as inadequate extension staff, non-existing field officers and limited logistics for effective extension work to be done. Beyond these is the challenge of co-operation between farmers and agricultural extension officers. Some extension officers are of the view that farmers do not work with them and refuse to take their suggestions. Most farmers in the study area do not receive agricultural extension services as shown in Table 6.3. They are also of the view that extension officers do not visit them regularly and on time. This observation corroborates the assertion by the district's departments of agriculture of inadequate extension staff in Builsa. More than a third of farm households have no access to extension services. Access to extension is more common with those who have riverine farms than farm household without this category of farming systems. Extension services are also more accessible to bush and valley farming systems than compound systems and this can be explained by the nature of crops grown on these systems.

Table 6.3: Access to extension services by farming system, community, wealth and sex

| Farming system | Do not have access to farming services No (%) | Have access to farming services Yes (%) | Total (%) |
|----------------------|--|--|-----------|
| Bush farming | 58.3 | 41.7 | 100.0 |
| Compound farming | 64.9 | 35.1 | 100.0 |
| Irrigation farming | 53.3 | 46.7 | 100.0 |
| Valley farming | 58.5 | 41.5 | 100.0 |
| Riverine farming | 20.0 | 80.0 | 100.0 |
| Total | 65.0 | 35.0 | 100.0 |
| Community | | | |
| Sandema | 70.8 | 29.2 | 100.0 |
| Kadema | 83.3 | 16.7 | 100.0 |
| Wiaga | 65.8 | 34.2 | 100.0 |
| Gbedembilisi | 0.0 | 100.0 | 100.0 |
| Fumbisi | 66.1 | 33.9 | 100.0 |
| Doninga | 21.9 | 78.1 | 100.0 |
| Chansa | 82.8 | 17.2 | 100.0 |
| Total | 65.0 | 35.0 | 100.0 |
| Wealth status | | | |
| Very rich | 0.0 | 100.0 | 100.0 |
| Rich | 42.4 | 57.6 | 100.0 |
| Neutral | 66.1 | 34.0 | 100.0 |
| Poor | 66.9 | 33.1 | 100.0 |
| Very poor | 91.1 | 8.9 | 100.0 |
| Total | 65.0 | 35.0 | 100.0 |
| Sex | | | |
| Female | 76.5 | 23.5 | 100.0 |
| Male | 61.8 | 38.2 | 100.0 |
| Total | 65.0 | 35.0 | 100.0 |

Source: Fieldwork, 2018

At the community level, village communities with potential for commercial farming have relatively better access to extension services than town communities. Access to extension is additionally related to wealth as wealthy households have better access to extension services with more males than females having access to extension services. Most farmers receive field services, which are related to crops, followed by veterinary and irrigation. The development of irrigation in the area is not encouraging as observed by some experts that the available dam serves only as water points for livestock during the dry season and cannot support dry season cropping. This is due to neglect over the years, which has left most dams silted.

Farmers are generally not satisfied with extension support in the study area as supported by the results in Table 6.4. More than half of farm households are satisfied with extension support with the rest expressing a diversified feeling about extension in Builsa.

Table 6.4: Farmer satisfaction with extension services by farming system, community, wealth and sex

| Farming system | Not satisfied (%) | Normal (%) | Satisfied (%) | Very satisfied (%) | Total (%) |
|----------------------|-------------------|-------------|---------------|--------------------|--------------|
| Bush farming | 3.2 | 34.7 | 47.4 | 14.7 | 100.0 |
| Compound farming | 2.7 | 41.7 | 41.1 | 14.6 | 100.0 |
| Irrigation farming | 0.0 | 42.9 | 42.9 | 14.3 | 100.0 |
| Valley farming | 5.3 | 31.6 | 39.5 | 23.7 | 100.0 |
| Other farming | 0.0 | 0.0 | 75.0 | 25.0 | 100.0 |
| Total | 3.2 | 41.1 | 41.8 | 13.9 | 100.0 |
| Community | | | | | |
| Sandema | 5.3 | 42.1 | 31.6 | 21.1 | 100.0 |
| Kadema | 0.0 | 33.3 | 66.7 | 0.0 | 100.0 |
| Wiaga | 4.9 | 61.0 | 31.7 | 2.4 | 100.0 |
| Gbedembilisi | 0.0 | 0.0 | 71.4 | 28.6 | 100.0 |
| Fumbisi | 2.6 | 41.0 | 53.9 | 2.6 | 100.0 |
| Doninga | 0.0 | 16.0 | 44.0 | 40.0 | 100.0 |
| Chansa | 0.0 | 60.0 | 40.0 | 0.0 | 100.0 |
| Total | 3.2 | 41.1 | 41.8 | 13.9 | 100.0 |
| Wealth status | | | | | |
| Very rich | 33.3 | 33.3 | 0.0 | 33.3 | 100.0 |
| Rich | 0.0 | 13.2 | 57.9 | 29.0 | 100.0 |
| Neutral | 0.0 | 58.2 | 38.2 | 3.6 | 100.0 |
| Poor | 6.9 | 41.4 | 37.9 | 13.8 | 100.0 |
| Very poor | 0.0 | 75.0 | 25.0 | 0.0 | 100.0 |
| Total | 3.2 | 41.1 | 41.8 | 13.9 | 100.0 |
| Sex | | | | | |
| Female | 0.0 | 52.2 | 30.4 | 17.4 | 100.0 |
| Male | 3.7 | 39.3 | 43.7 | 13.3 | 100.0 |
| Total | 3.2 | 41.1 | 41.8 | 13.9 | 100.0 |

Source: Field data 2018

At the community and wealth levels, communities that had higher access to extension had a higher number of satisfied households with wealthy household having higher satisfaction, respectively. This results from several reasons including the non-availability of extension staff to meet and interact with farmers regularly. There is also the issue of awareness as most farm households are not aware of agricultural extension as reported during focus group discussions. Additionally, some households do not see the relevance of agricultural extension as they often talk rather than providing practical solutions to their problems. They expect the extension to provide them with seeds, credit, and technology and to visit them regularly.

6.3 Suggestions for sustainable farming

Several strategies are suggested for improving the future of farming in Builsa. These are organised into ecological, economic, and social strategies of ensuring sustainable farming. Ecologically, climate change is noted to have a debilitating effect on farm households. To ameliorate the effect of climate change, irrigation farming is proposed as a way of ensuring food availability and job security for farm households all year round. Irrigation is almost non-existent in the southern parts of the study area even though there are dams developed. These dams have now become watering points for livestock and will need to be re-developed for dry season farming to ensure the sustainability of the farming system. Farmers are aware that deep ploughing with tractors affects the fertility of the soil over time. Some thus plough every other three years with tractors to protect their soils. The fertility of the soils, it is noted, can be sustained with organic manure. There is, therefore, need to encourage the livestock sector since it directly provides organic manure to farm households.

Economically, farm households envisaged the creation of efficient markets for the sale of farm produce as a way of ensuring the sustainability of the farming system. Markets should be accessible and efficient as some farm households attributed low marketability of their produce to challenges in access and low prices during certain times of the year. Even though there exist two functional markets in the study area, accessibility to these markets is a challenge, especially during the farming season. Most linking roads to the major markets are not motorable at the onset of rains, hampering the movement of goods and people during these time of the season. Additionally, the prices of goods, and especially livestock is very low during these times of the year. This discourages farm households from keeping more livestock or taking good care of their crops beyond a subsistence need.

Agriculture financing is a big challenge in Builsa. There are farmer groups in the study area. These groups are not as effective, leaving the organisation of farming to households.

Farmers should thus make their groups more effective so that they can access group credit for farming purposes. Experts are additionally calling for the use of out-grower systems, which can bring credit to farmers. They also urge that the value chain system with the agriculture sector should be developed in rural areas. In terms of labour, the communal farming system has been observed to be declining. Farmer households thus observed the strengthening of these systems would ensure the future of farming. This comes from the belief among Builsa' that no single person farms, that farming is a collective activity. But the individualisation of subsistence farming, which is not backed by capital will leave most farm households behind as their labour will not be sufficient to produce household energy requirements for the year. Access to technology is a way of achieving sustainable farming for most farm households. Help with technologies that enhance the crop yields will go a long way to improve the future of farming in the Builsa area.

Socially, there are challenges with the tenure system in the acquisition of land by non-indigenes and migrants interested in farming. Land in the study area is communally owned and allotted to households for productive purposes by compound heads or custodians of the land. Female members of the family do not own land but can be allotted plots for farming if they so desire. The land is not a scarce commodity in the study area and this is captured during the qualitative data collection to the effect that land is not a limiting factor to farm size expansion. As long as a person is a member of the community, chicken, Kola, and some drinks are needed to see the custodian of the land you intend to cultivate. It is not obligatory to share farm harvest with the custodian but people give a token often to cement the relationship for future transactions. Due to some policy attempts at land registration over the years, people have become conscious of ownership and this could pose a challenge to the development of subsistence agriculture in the future if not well addressed. Migrants have no tenure security to land as they are turned down after the first cultivation. This is

aggravated by the emergence of multiple claims over lands making it difficult to lease land to non-indigenes.

Farmer education is seen as one pathway to sustainable farming. It was observed during a focus group discussion that farmers learn new skills from peers. Farmers should be educated on the need to conserve crop biomass instead of burning stocks after harvest. They should also be educated on best practices within the farming systems through demonstration farms, and the proper use of agrochemicals. Enforcement of good agricultural practices at the local level is another social enabler. Farmers have to work in synergy with the extension officers and have to comply with or listen to advice from these officers. Non-compliant farmers should be referred to community leaders and chiefs for sanctions to be applied. There is a need for farmers to be organised in groups for ease of identification for support and dissemination of new methods of farming. Farmers are also to co-operate in a way that will smoothen their activities such as taking collective actions on a timely basis. If farmers co-operate, they can decide on when to plant, when to leave livestock freely on the compound farms and how to organise other related activities, which cannot be individually done. Peer educators in the communities help other colleagues to acquire new techniques of farming and growing new crops. Sustainable farming practices can thus be channelled through peers. There are laws to regulate farming in the area but the enforcement of these laws is the challenge.

6.4 Conclusion

To be sustainable also implies to continue to exist and to continuously perform your functions. This conceptualisation of sustainable farming provides answers to the question of the future of subsistence farming in the Builsa area. Generally, the future of farming is bright as observed by both farm households and experts. A lot of the valleys, especially in Weisi, Gbedembilisi, and Doninga, have been developed. This means both indigenes and

non-indigenes with resources can engage in commercial rice farming in the developed valleys. The survival of the farming systems is also measured by the increasing youth interest in farming activities in some parts of the area as an interviewee noted that:

“The future of farming in the Builsa area is bright. The youth is now very interested in agriculture making the future of farming very bright” (Excerpt, retired extension, Fumbisi, June 2018).

This and other views by both experts and farm households suggest that farming has a brighter future in the study area. However, the misuse and overuse of agrochemicals will threaten this future. Not all farm household are aware of the harmful nature of some agrochemicals. During one of the focus group discussion with males at Kadema, a member held the view that weedicides do not kill living organisms with blood. Mostly, farmers are not trained on how to use these agrochemicals by either agricultural extension officers or other professionals. It is dealers who only explain to them the quantity of water they need to mix with a litre of agrochemicals for weed or pest to be controlled. They are not trained on how to use protective gear, which may come with some health implications as some studies in Ashaiman found the concentration of agrochemical in the blood and breast milk of some urban vegetable farmers who abused them (Nyantakyi-Frimpong, Arku, & Inkoom, 2016). This could compromise the future of farming in the study area. Farm households are also not adequately trained on where and when to apply these chemicals. A conclusion was thus drawn from the qualitative data that the use of agrochemical could have effects on livestock health as they die at the onset of the early rains. Farm households observed that even if livestock are vaccinated, they still die when they feed on grasses or drink water that has come into contact with some of these agrochemicals especially weedicides.

CHAPTER 7

CONTRIBUTIONS OF MAJOR FARMING SYSTEMS TO FOOD SECURITY

7.0 Introduction

This chapter assesses the contribution of the aforementioned farming systems to food security. It takes a cue from the conventional definition of food security, which conceives of it as the availability, accessibility, utilisation, and stability of food in the lives of people. The chapter describes local conceptualisations of food security in Builsa. It further discusses the factors that determine household food security in Builsa and assesses the contribution of the various farming systems to the food security of farm households. The Builsa area has generally been a food provider to most parts of the Upper East area with a notable development of the rice valleys in Gbedembilisi in the 1980s; hence the need to discuss how transitioning farming systems are contributing to meeting current food needs.

7.1 Local conceptualisations of food security

Even though there are different conceptualisations of food security, it is conventionally accepted that people are food secured when they can manifest all the pillars (availability, stability, accessibility, and utilisation) of food in their lives and should be done in line with human dignity as supported by Yaro (2004b). Results from the qualitative data (focus groups, in-depth interviews, informal conversations, and expert interviews) show that people of Builsa have their conceptualisations of food security. They do this through the use of markers (determinants) of food security. These include the ability of crop yields to feed families throughout the year (sufficiency), the sale of surpluses to support other household needs, ability to finance the next farming cycle with resources from the previous farming cycle and non-farm sources, eating of preferred meals, control and access to food, and the ability to provide three meals in a day. This is supported by a view expressed by a participant during a focus group discussion that:

“I am food secure if my harvest can meet my food needs all year round with some of the yields left for sale to finance the next farming cycle. Also If I take care of my livestock and sales are used to support the next farming cycle”.

(Excerpt, 40-year male farmer, Kadema, June 2018).

This view is supported by another from an in-depth interview that:

“Yes, my household is food sufficient. However, it depends on the nature of the year. If it rains successfully, [adequate and well distributed] the produce I obtain can meet my food needs all year round. I am also food secure if I can sell surpluses of my farm produce for cash and if the produce of the farms can finance the next farming cycle”. (Excerpt, 55-year, widow, Doninga, June 2018).

Additionally, farm households support their food needs through both non-farm and off-farm activities as shown in Table 7.1.

Table 7.1: Participants in the non-farm sector

| Farming System | N | Builsa North (% participants) | Builsa South (% participants) | Total (% participants) | Chi2 (P-value) |
|--------------------|-----|----------------------------------|----------------------------------|---------------------------|----------------|
| Bush farming | 228 | 23.1 | 29.0 | 26.3 | 0.309 |
| Compound farming | 430 | 27.1 | 29.7 | 28.1 | 0.569 |
| Irrigation farming | 15 | 28.6 | 0.0 | 26.7 | 0.533 |
| Valley farming | 183 | 22.1 | 15.7 | 19.7 | 0.289 |
| Riverine farming | 5 | 0.0 | 25.0 | 20.0 | 0.576 |

Source: Field data 2018

There is a significant difference between farm households who participated in non-farm activities and combined it with bush or valley farming systems in the Builsa north and south districts. In Builsa south, households will combine non-farm work with bush farming while in the north, they combined it with valley farming. This is explained by urbanisation and the presence of non-farm opportunities relatively more in Builsa north. The inability of only the farm sector in meeting household food needs is confirmed by Hesselberg and Yaro (2006). Theoretically, it shows that farm households are multi-active and will participate in

different activities to ensure food security at the household level. Some non-farm activities undertaken by farm households include petty trading, agro-processing, mining and craftworks. Other farm households undertake activities such as hunting, dry season fishing, shea picking and harvesting of wild honey, which all augment household food needs directly through consumption and indirectly through the sale of these products to support the farm sector. Income gained from these sales is used to purchase food through the local markets. This is supported by evidence that the non-farm sector is important in strengthening household food security in rural areas Hoang et al. (2014); Senadza (2012). The earning from the non-farm sector in Builsa are very low and this concurs with finding by Dary and Kuunibe (2012) who noticed low earning from non-farm employment activities in the northern parts of Ghana. As households vary in their food needs, food security in Builsa is better assessed by factors that influence household food security by the various household heads.

7.2 Factors that determine household food security in Builsa

This section discusses what makes up food security in Builsa or what needs to be present for a household to be food secure. To be described as food secure a household in Builsa is supposed to satisfy certain criteria and it is these that are used to determine the food security status of farm households. The concept of food security evolves over time and in space with different ways of measuring it. At the local level households, view differs in what constitutes or not food security in line with differences occurring at both the national and international spaces in conceptualisations of food security as Coates (2013) observed differences in international conceptualisations of food security and how it is measured at the local level.

7.2.1 Foods security as ability of crop yields to feed families throughout the year

Generally, heads of farm households in Builsa view themselves as being food secure when there is the presence of enough food from harvest and other sources at the end of a farming

cycle to meet their food needs till the next harvest. When yields from the farming systems are not able to meet food needs with no other sources of procuring food, then they are food insecure. Conceptualisations of food security concerning sufficiency concur with the finding of Coates et al. (2006) whose cross-cultural study identified food sufficiency as a household measure of food insecurity. Some farm households in Builsa conceive of food sufficiency in two ways. The first being the ability to meet daily caloric needs from own production, which corresponds to the pillar of availability and the second is the ability to have surpluses for sale or the sale of other assets like livestock or household labour to purchase food, which falls within the accessibility pillar of food security. Farm households additionally expect this process to continue from one farming cycle to another farming cycle, thus connoting stability. It is also important to note that farm households expect their yields to be sufficient. Sufficiency here means the ability to meet food needs from own production with surpluses left to support other household needs in kind or cash, which is household-specific.

With this, the study sought to ascertain the proportion of households that are food sufficient through a survey. The results from the survey showed that less than half of farm households have food all year round as shown in Table 7.2. Close to half (41.2%) of farm households disagreed that they were food sufficient at the household level with those strongly disagreeing practising compound and irrigation farming. At the farming systems level, more than half (80%) of farm households who participated in riverine systems strongly agreed that their households were food secure relative to those who participated in other farming systems. This shows the importance of the riverine systems in contributing to food insecurity in rural areas, which are linked to high input use and reliance on agricultural modernisation. This concurs with the finding by Harris and Orr (2014) that the use of new technologies improves yields and income per cropping area in developing countries.

Table 7.2: Household food sufficiency by the farming system and community

| Farming system | Strongly disagree | Disagree | Neutral | Agree | Strongly agree | Total |
|--------------------|-------------------|----------|---------|-------|----------------|-------|
| Bush farming | 4.0 | 38.2 | 14.0 | 24.6 | 19.3 | 100.0 |
| Compound farming | 6.3 | 41.6 | 18.4 | 18.4 | 15.4 | 100.0 |
| Irrigation farming | 0.0 | 53.3 | 13.3 | 26.7 | 6.7 | 100.0 |
| Valley farming | 4.9 | 33.9 | 21.9 | 13.1 | 26.2 | 100.0 |
| Riverine farming | 0.0 | 20.0 | 0.0 | 0.0 | 80.0 | 100.0 |
| Total | 6.2 | 41.2 | 18.4 | 19.3 | 14.9 | 100.0 |
| Community | | | | | | |
| Sandema | 7.7 | 35.4 | 13.1 | 20.8 | 23.1 | 100.0 |
| Kadema | 0.0 | 44.4 | 27.8 | 22.2 | 5.6 | 100.0 |
| Wiaga | 6.7 | 45.8 | 20.8 | 20.8 | 5.8 | 100.0 |
| Gbedembilisi | 0.0 | 0.0 | 0.0 | 0.0 | 100.0 | 100.0 |
| Fumbisi | 6.1 | 51.3 | 24.4 | 17.4 | 0.9 | 100.0 |
| Doninga | 3.1 | 15.6 | 3.1 | 15.6 | 62.5 | 100.0 |
| Chansa | 6.9 | 44.8 | 24.1 | 20.7 | 3.5 | 100.0 |
| Total | 6.2 | 41.2 | 18.4 | 19.3 | 14.9 | 100.0 |
| Sex | | | | | | |
| Female | 7.1 | 50.0 | 21.4 | 13.3 | 8.2 | 100.0 |
| Male | 6.0 | 38.8 | 17.6 | 21.0 | 16.7 | 100.0 |
| Total | 6.2 | 41.2 | 18.4 | 19.3 | 14.9 | 100.0 |

Source: Field data 2018

At the household level, Gedembilisi had all households agreeing that they are food sufficient (100%) followed by Doninga (62.5%) with the rest of the communities having less than a quarter of farm households agreeing of being food sufficient. This is again explained by the presence of riverine systems, which are relatively water sufficient in these communities and allows for multiple cropping within a year. These are additionally new frontiers that have vast lands, which are relatively fertile compared to other communities. This finding confirms that of Alhassan (2015) who indicated that water availability is a positive contributor to household food sufficiency in the Upper East areas of Ghana. Additionally, male-headed households (16.7) are food secured than female-headed households.

Less than a quarter of farm households have access to food all year round with less than a quarter having to struggle with food shortage lasting more than three months in a year. This concurs with (Quaye, 2008) that average staple food production in the northern parts of Ghana cannot support farm households all year round. It, however, suggests that Ghana has made significant progress in reducing poverty since the 1990s as more than half of farm households can meet food needs all year round. Beyond these, farm household assigned

various reasons for not being self-sufficient in meeting food needs from own production and these are summarised in Table 7.3.

Table 7.3: Reasons for household food insufficiency

| Reasons | Frequency | Per cent |
|-------------------------------------|-----------|----------|
| Inadequate cultivable land | 70 | 15.5 |
| Insufficient labour | 66 | 14.6 |
| Natural disaster | 186 | 41.1 |
| Sickness | 12 | 2.6 |
| Inadequate knowledge and technology | 17 | 3.8 |
| Others | 102 | 22.5 |
| Total | 453 | 100 |

Source: Fieldwork, 2018.

Natural disasters like climate-induced drought and floods, pest infestations, and livestock diseases outbreaks contribute the highest to preventing farm households from being food secure. This confirms evidence that Africa’s agriculture is negatively affected by climate change (Slingo, Challinor, Hoskins, & Wheeler, 2005), with tropical and subtropical area likely to be affected by global climate variability and price fluctuations. The results also confirm findings by Brown and Funk (2008) and Yiran et al. (2016) on several hazards affecting agricultural activities in the interior savannah areas of Ghana. The other reasons include inadequate money to purchase food, insufficient funds to execute the farming activities, and poor harvest. Access to land as noted earlier is gradually becoming a challenge especially for migrants with relatively poor farm households finding it difficult to have access to labour during critical times of farm work such as planting and early weeding.

7.2.2 Food security as favourable climatic conditions to ensure a good harvest

The nature of the weather in a given year is critical to food security in Builsa as farming systems are entirely rain-fed. They rely on rainwater for all farm activities ranging from crops growing to livestock keeping. Based on this, a slight shift in weather conditions often has severe consequences on food security. Farm households thus conceive of food security

in terms of a favourable climatic condition during a farming cycle to ensure good outputs within the farming systems as noted by an interviewee that:

“I cannot have my farm produce meeting my food needs all year round when the weather is not favourable. But granted that there is a good year, I get food all year round from my farm systems.” (Excerpt, 42-year male farmer at Kadema, June 2018).

All things being equal, this farmer equates food security to a good year. A good year to him is when rainwater is adequate and evenly distributed from the beginning of the farming cycle to the end. In support of this, another respondent said:

“Food security exists if the season is good. Also, certain unforeseen circumstance like sudden sickness can affect me such that some of the food could be sold.” (Excerpt, 45-year female farmer, June 2018).

A good season connotes favourable weather patterns in a farming cycle. She is additionally conscious of good health as that is an insurer in rural areas. Food security to these farm households thus depends on the nature of the weather conditions in a given year. All things being equal if it rains successfully, and all other climatic variables are favourable, then they are food secure and vice versa. This confirms findings of Niles and Brown (2017) that households that experienced a drier than average year were 3.81 months food insecure compared to 2.68 months for household who experienced a wetter than average year. It additionally confirms findings by Ray, Gerber, MacDonald, and West (2015) who noted that climate variability affects crop yields across different regions.

7.2.3 Food security as eating preferred food

Another factor used by farm household to measure food security is the of consumption preferred foods. The main traditional grains of the Builsa area are millets, sorghum and groundnut and now maize with a legume mix. These are used in preparing different meals

ranging from their favourite TZ to flour and porridge. This has now shifted to the use of maize for most of these meals. It is important to note here that maize was not a major crop in Builsa and was not common in the preparation of the local dishes among farm households. However, maize is now not only used for TZ and porridge but also *Banku* and *Kenkey*. Farmers have thus shifted from eating dishes prepared from their preferred cereal crops (millets and sorghum) to the hitherto less-consumed maize. Even though farm households prefer millets-and sorghum-based dishes, low yields and other reasons such as the preference of the youth for maize are pushing them to cultivate and eat maize. This is supported by an excerpt from a medium-scale farmer who reported that:

“I do not plant my preferred crops. My children are no longer interested in millet-based foods like me so I plant maize. The farm systems no longer mimic my culture as we (Builsas) are noted as millet and rice cultivators. My culture is lost as I change my cropping systems. I cannot appease my ancestors with maize and cannot use maize for other cultural practices. Millet for these purposes has to be purchased from the market so I am not a true Builsa but a “White Builsa” and not food secure.” (Excerpt, 45-year widow, Gbedembilisi, June 2018).

This excerpt shows that most Builsa’s would have preferred millet to-maize-based meals. However, a combination of factors has limited yields of millet and sorghum in Builsa relative to maize as noted by an interviewee that:

“I prefer millet and sorghum to maize dishes. I cultivate maize because of the low yields from millet and sorghum. I used to fertilise my millet and sorghum on the compound farms from the dropping of my animals. But now the livestock is no longer viable coupled with the fact that maize seeds come with chemical fertilisers, which we buy from the market. When we apply the

chemical fertiliser to the millet, they overgrow and do not yield like the maize.

If the millet was high yielding I will not bother planting maize”. (Excerpt, 65-year female, Sandema, June 2018).

These and other views from focus group discussions, in-depth interviews and informal conversation show that most farm households, especially the older generation do not prefer dishes prepared from the crops they grow. It shows that beyond climate variability, the commercialisation of maize coupled with the taste of the younger generation is additionally leading to the consumption of food that is not preferred by the older generation. These factors have engineered a drastic shift in the increasing cultivation and consumption of maize to millet and this leaves out food preferences of the older generations. This development can not be described as sustainable and is supported by Feenstra (1997) who indicated that the continuity of a community’s food system is an indicator of its viability and sustainability. Millet is now grown in Builsa, not for food but for traditional purposes. Results from qualitative data (focus groups and interviews) suggest that, but for traditional purposes, millet would not be cultivated in the Builsa area at all. About this, most farm households accepted that they sometimes have to eat foods they do not like due to inadequate resources to procure their preferred foods as shown in Table 7.4. The results show that more than a quarter of farm households did not eat preferred foods all the time. Most of those who ate preferred foods practised riverine farming. This does not come from growing of preferred foods, as the ecological conditions of these systems allow for commercial crop cultivation. Cash from the sale of these crops is used to purchase preferred foods from the local markets. It also shows that farm households located in villages ate preferred foods relative to towns. This again is explained by access as commercial can easily be converted into purchasing power through the markets.

Table 7.4: Households’ degree of agreement or disagreement with the statement that they eat their preferred foods

| Farming system | Strongly disagree | Disagree | Neutral | Agree | Strongly agree | Total |
|--------------------|-------------------|----------|---------|-------|----------------|-------|
| Bush farming | 7.9 | 35.5 | 21.5 | 14.9 | 20.2 | 100.0 |
| Compound farming | 7.9 | 38.8 | 21.4 | 15.8 | 16.1 | 100.0 |
| Irrigation farming | 6.7 | 53.3 | 13.3 | 26.7 | 0.0 | 100.0 |
| Valley farming | 6.6 | 32.2 | 24.6 | 12.6 | 24.0 | 100.0 |
| Riverine farming | 0.0 | 20.0 | 0.0 | 0.0 | 80.0 | 100.0 |
| Total | 8.0 | 38.6 | 21.5 | 16.2 | 15.7 | 100.0 |
| Community | | | | | | |
| Sandema | 7.7 | 31.5 | 10.8 | 20.8 | 29.2 | 100.0 |
| Kadema | 16.7 | 33.3 | 22.2 | 22.2 | 5.6 | 100.0 |
| Wiaga | 7.5 | 40.0 | 29.2 | 17.5 | 5.8 | 100.0 |
| Gbedembilisi | 0.0 | 0.0 | 0.0 | 14.3 | 85.7 | 100.0 |
| Fumbisi | 7.0 | 45.2 | 33.0 | 12.2 | 2.6 | 100.0 |
| Doninga | 3.1 | 34.4 | 6.3 | 6.3 | 50.0 | 100.0 |
| Chansa | 17.2 | 55.2 | 13.8 | 13.8 | 0.0 | 100.0 |
| Total | 8.0 | 38.6 | 21.5 | 16.2 | 15.7 | 100.0 |
| Sex | | | | | | |
| Female | 9.2 | 42.9 | 21.4 | 15.3 | 11.2 | 100.0 |
| Male | 7.7 | 37.4 | 21.5 | 16.4 | 17.0 | 100.0 |
| Total | 8.0 | 38.6 | 21.5 | 16.2 | 15.7 | 100.0 |

Source: Field data 2018

This suggests farm households need to have multiple pathways to food security. The first is to continue cultivating traditional varieties of crops and keeping livestock that is not climate-smart if that will guarantee them preferred foods. The second is to modify landrace crops varieties and livestock breeds, respectively, to meet current conditions if food security is to be achieved, that is adopting climate-smart agriculture as supported by (Lipper et al., 2014).

7.2.4 The sale of surpluses to finance the next farming cycle and household activities

A determinant of household food security in Builsa is the ability of farm households to sell surpluses from farm outputs to finance the next farming cycle and to support other needs of the household like school fees, hospital bills and the purchase of diverse foods from the market. Households in Builsa perceive themselves to be food secure if they can feed themselves from their production and other income sources such that surplus food is left for other activities that contribute to the wellbeing of that household. This is attested to in the quotation below:

“My harvest can cater to my food needs. I only need to sell some of the produce to finance the next farming cycle. If I can do this then my food needs

will be met. I also finance the next farming cycle by taking good care of my livestock, which is used to support the next farming cycle”. (Excerpt, 46-year male farmer, Gbedembilisi, June 2018).

This excerpt shows that beyond immediate household food needs, farm households are conscious of the need to secure repeated production to ensure that their food needs can always be met. It further shows that financing the farming systems is not from resources accumulated from crop output only as it is supported by the livestock sectors. This, thus makes it important for households to keep livestock in addition to crop farming to increase their food security status.

7.2.5 Control and access to food

Food security is additionally determined in terms of the control of farm produce by members of farm households. Within households in Builsa, plots are segregated between males and females with crops grown not limited to either category. Females, however mostly grow groundnuts, rice, Bambara groundnuts, beans, and leafy vegetables. The control of farm produce in general is in the hands of the head of the farm household who is mostly a male figure as communities are patriarchal. However, male heads do not control the production of female members of their households as supported by the interviewee: *“After crops are harvested, I usually eat from the produce of my husband. I only use mine when that of my husband runs out”.* (Excerpt, 51-year female, Sandema, June 2018). This excerpt shows household food security is additionally determined by how freely household members especially females can have control and access to own produced food and from the husbands stock. This is supported by another interviewee:

“It is not only the man (household head in this instance) who has control over farm produce in my household as I have control over what I produce. There

is separate ownership of farm produce from my husband as he is in charge of his produce". (Excerpt, 42-year female farmer. Kadema, June 2018).

In support of this, results from focus group discussions with men show that women controlled their farm produce as noted that: *"I control the products that we cultivate together but not that of my wife' as she is in charge of hers"*. (Excerpt, 56-year male farmer, Sandema, June 2018).

7.2.6 Food security as the ability to provide three meals a day

The ability of a farm household to feed its members three times daily also determines its food security status. Most households can provide their members with three meals daily as noted by an interviewee that: *"Even though we are in the hunger season if you pay a visit to any household this morning you will find them eating. This means there is an increase in food availability"* (Excerpt, 65-year male farmer, Fumbisi, June 2018). A meal in Builsa was made of millet or sorghum porridge in the morning combined with a dough-nut made with beans or millet, beans with shea butter or rice and beans with stew in the afternoon and millet or sorghum TZ in the evening. Millet or sorghum TZ is sometimes substituted with rice balls and groundnut soup in the evening. This is, however, changing as most households have shifted to the consumption of maize-based dishes. Table 7.5 shows that only a small proportion of farm households face severe hunger in Builsa with variations in the farming systems practised by farm households. Most households practising riverine and bush system report less hunger compared to the rest of the farming systems.

Table 7.5: Hunger levels by farming systems and community

| Farming system | None / Slight hunger (%) | Moderate hunger (%) | Severe hunger (%) | Total (%) |
|--------------------|--------------------------|---------------------|-------------------|-----------|
| Bush farming | 54.0 | 41.2 | 4.8 | 100.0 |
| Compound farming | 46.7 | 47.7 | 5.6 | 100.0 |
| Irrigation farming | 40.0 | 60.0 | 0.0 | 100.0 |
| Valley farming | 50.8 | 44.3 | 4.9 | 100.0 |
| Riverine farming | 80.0 | 20.0 | 0.0 | 100.0 |
| Total | 47.7 | 46.6 | 5.8 | 100.0 |
| Community | | | | |

| | | | | |
|--------------|-------|------|------|-------|
| Sandema | 63.9 | 33.9 | 2.3 | 100.0 |
| Kadema | 22.2 | 66.7 | 11.1 | 100.0 |
| Wiaga | 35.8 | 56.7 | 7.5 | 100.0 |
| Gbedembilisi | 100.0 | 0.0 | 0.0 | 100.0 |
| Fumbisi | 44.4 | 45.2 | 10.4 | 100.0 |
| Doninga | 56.3 | 43.8 | 0.0 | 100.0 |
| Chansa | 31.0 | 69.0 | 0.0 | 100.0 |
| Total | 47.7 | 46.6 | 5.8 | 100.0 |
| Sex | | | | |
| Female | 38.8 | 48.0 | 13.3 | 100.0 |
| Male | 50.1 | 46.2 | 3.7 | 100.0 |
| Total | 47.7 | 46.6 | 5.8 | 100.0 |

Source: Field data 2018

Close to half of farm households face no hunger or are slightly hungry with a similar proportion being moderately hungry. Hunger is more severe in towns than in villages and is disproportionately higher among female-headed households than their male-headed counterparts. This observation confirms findings by Babatunde, Omotesho, Olorunsanya, and Owotoki (2008) and Tibesigwa and Visser (2016) that female-headed households are vulnerable to food insecurity as they often have fewer resources compared to their male counterparts in Sub-Saharan Africa. However, other observations in some parts of Asia by Mallick and Rafi (2010) shows that in societies where male and female have equal access to resources there is no significant differences food security status between male and female-headed households.

7.2.7 Food security as satisfying socio-cultural needs

Beyond direct cultivation, there are several socio-cultural ways through which farm households in Builsa meet their food needs. Some of these are inter-household food transfers, borrowing, engaging in non-farm work and migration. The focus of this study is however on household food transfers as a wide literature exists on either coping or adaptation strategies like migration, work in the non-farm sectors and limiting the number of children as ways of dealing with food security in rural areas (Hesselberg & Yaro, 2006; Jayne et al., 2014). Inter-household food transfer has been a traditional way of ensuring food security among farm households making it significant to understand how this is

transitioning. Although the practice exists, it seems to be declining as some farm households are no longer interested in it. This can be attributed to prestige as some farm households do not want to be talked or looked down upon and thus find it derogatory to ask for food from neighbours in times of need. Beyond prestige is the tendency of some relatively better-endowed household heads to expose neighbours who came to them for assistance. This is a practice that is observed by one of the interviewees at Sandema as not helpful. He noted that: *“I help other households in times of need, but now we disgrace ourselves, unlike our forebears who do this without revealing it to anyone”* (Excerpt, 90-year farmer, Kadema, June 2018). This excerpt, supported by several others from in-depth interviews and focus group discussion suggests that the practice of inter-household food transfers exist but farm households do not see it as an effective means of ensuring food security in a dignified way. This suggests that some households may not be food self-sufficient but will not approach other relatively sufficient households for help because of some social stigma with this mode of ensuring food security.

7.2.8 Dietary diversity as a measure of food security

Dietary quality and diversity are important in ensuring food security beyond the mere access and use of food. Farm households in Builsa eat a variety of food in addition to own produced food. These foods, which are outside their farm systems, are purchased through the market. This is supported by an excerpt from an interview with a farmer from Kadema. *“I eat a variety of food apart from my farm produce. I get these from the market. This is not because of hunger but just to diversify my food intake”*. (Excerpt, male farmer, Kadema, June 2018). This excerpt supports the observation that farm households who are relatively well-endowed diversify their food sources and may thus be more food secure than less-endowed households who are less likely to eat diverse foods. The role of markets rather than production diversity in ensuring dietary diversity and nutrition security is indicated by

Sibhatu, Krishna, and Qaim (2015) and Muthini, Nzuma, and Qaim (2018) that market access has positive effects on dietary diversity. It is important to state those farm households that cannot support themselves through their cultivation purchase food from the market but are more inclined to purchase local staples than foods from external sources. During the household survey, it was observed that relatively poor households did not consume palm soup, palm oil, bread, plantain and other foods that were outside the farm systems but made available through the markets. Some food items sold on the local market but not locally produced include palm-nut, yam, cassava, plantain, palm oil, bread and other pastry, mineral drinks. These are however not consumed by all households as the marginalised rarely purchased some of these foods from the market.

7.3 The role of transitioning farming systems in ensuring food security

This section attempts to link the contribution of the various transitioning systems to food security. Some farmers are of the view that new farm practices contribute more to higher yields than the traditional practices as noted by an interviewee that:

“The yields of maize per acre is about 8 bags (50kg per bag) while that of sorghum is about 1.5 bags leading me to shift to the sowing of maize. New varieties of sorghum like Kapala, Buakwa red and Buakwa white are now dominating. In terms of sorghum, very few of us now have the landrace varieties as these have been replaced by the enhanced varieties, which yield relatively higher”. (Excerpt, 45-year male farmer, Sandema, June 2018).

In support of this interviewee, another noted that:

“I prefer millet-based food but the millet does not yield much as there are no cattle and other animals that support millet cultivation with manure. With the maize, there is fertiliser in the market that supports its cultivation. If millet

will do well no one will have time with maize". (Excerpt, 51- year female farmer, Sandema, July 2018).

This interviewee would have maintained the old practices if they yielded expected results, but as it stands, to shift to new practices within the farming practices contribute relatively more to desired outcomes for farm households as another interviewee notes:

"I prefer millet to maize-based foods. I cultivate maize because of the low yields of millet. I used to fertilise my millet on the compound farms from the dropping of my livestock. But now the livestock sector is no longer viable for me. Also, maize seeds come with chemical fertilisers, which I buy from the market to support their cultivation. When I apply these chemical fertilisers to the millet, they overgrow and do not yield like the maize. If the millet was as high yielding, I would not bother planting maize". (Excerpt, 65-year female farmer, Sandema, July 2018).

These excerpts show that, beyond the assertion by some farm households that transitioning farm practices contribute more to yields than old farm practices, there is a subtle claim that millet does not respond well to chemical fertilisers. This is in contrast to findings by Bationo and Ntare (2000) who establish a link between high yields of pearl millet and the use of nitrogen (N) fertiliser; and that of El-Lattief (2011) who noted that millet responds positively to NPK fertilisers. Farm households have additionally argued that increases in yields within the transitioning practices is made possible through the use of both animal and machine power in the tillage systems as noted by an interviewee that:

"There are changes in farming systems. At first, in the absence of tractors, my farms were not as larger as they are today. Now, with the presence of tractors,

I have made some progress as I cultivate about 3 to 10 acres” (Excerpt, 48-year farmer, Gbedembilisi, June 2018).

The use of tractors is associated with expansions in the cropped area and the use of chemical fertilisers to boost soil fertility. This assertion, however, contradicts survey results, which show that close to a third of farm households agreed to old systems of zero use of chemical fertilisers being better than the transitioning systems in contributing to household food availability as shown in Table 7.6.

Table 7.6: Sufficiency of old systems in food provisioning

| Farming system | Not food sufficient | Food sufficiency | Total |
|--------------------|---------------------|------------------|-------|
| Bush farming | 29.0 | 71.1 | 100.0 |
| Compound farming | 29.8 | 70.2 | 100.0 |
| Irrigation farming | 33.3 | 66.7 | 100.0 |
| Valley farming | 23.0 | 77.1 | 100.0 |
| Other farming | 20.0 | 80.0 | 100.0 |
| Total | 29.9 | 70.1 | 100.0 |
| Community | | | |
| Sandema | 26.2 | 73.9 | 100.0 |
| Kadema | 33.3 | 66.7 | 100.0 |
| Wiaga | 29.2 | 70.8 | 100.0 |
| Gbedembilisi | 0.0 | 100.0 | 100.0 |
| Fumbisi | 35.7 | 64.4 | 100.0 |
| Doninga | 28.1 | 71.9 | 100.0 |
| Chansa | 34.5 | 65.5 | 100.0 |
| Total | 29.9 | 70.1 | 100.0 |
| Sex | | | |
| Female | 25.5 | 74.5 | 100.0 |
| Male | 31.2 | 68.8 | 100.0 |
| Total | 29.9 | 70.1 | 100.0 |

Source: Fieldwork, 2018

More than half (70.1%) of farm household agreed that the old farming practices contributed more to food sufficiency than the new practices. Farm household that agreed that the old practices were preferable to the new ones assigned reasons such as; chemicals destroying soil fertility, the use of chemicals make present farming difficult, chemicals pollute water bodies, not all can afford chemicals, loss of micro-biodiversity through new farm practices, the old practices yielded more, the old practices protected farmlands and the local environment.

Farm households who disagreed reasoned that the new practices increase crop outputs, the use of tractors associated with the new practices help bring more land under cultivation, chemical fertilisers compensate for nutrient mining due to continuous cropping, transition systems are associated with extension services, which introduce improved farming practices, the new practices require less labour, and makes farming easier and faster. The implications of these are how farmers are integrated into the neoliberal capitalist agenda, which tends to exclude poor households who can not adopt new technologies in the transitioning systems. This confirms findings by Vercillo, Kuire, Armah, and Luginaah (2015) who noted how the New Alliance reinforces the neoliberal economic development model in favour of wealthier farmers.

7.3.1 The role of integrated farming systems in ensuring food security

Subsistence farmers in Sub-Saharan Africa (SSA) are noted to produce about 70% of their food needs despite the challenges with their production as observed by Vercillo et al. (2015). There are some linkages between the farming system and food security in Builsa as no single system is capable of meeting the food needs of farm households. To understand the farming systems that contributed more to food security at the household level, a probit model was used and the results are shown in Table 7.7.

Table 7.7: Probit regression of the effect of farming systems on food sufficiency and food security

| VARIABLES | (1) Food Sufficiency | (2) Food Sufficiency | (3) Food Security | (4) Food Security |
|--------------------------------|----------------------------|----------------------------|----------------------|-------------------------|
| Bush farming | 0.545*** (0.124) | 0.352*** (0.135) | 0.206* (0.118) | 0.0404* (0.130) |
| Sex (Male=1) | | 0.370* (0.203) | | 0.0711 (0.180) |
| Marital status (married=0) | | -0.375* (0.193) | | 0.0815 (0.177) |
| Education status (education=1) | | 0.111*** (0.0412) | | 0.149*** (0.0404) |
| Irrigation (No=1) | | -0.0857 (0.511) | | -0.886* (0.485) |
| Extension (Yes=1) | | 0.320** (0.138) | | 0.354*** (0.134) |
| Loan access (Yes=1) | | 0.368* (0.138) | | -0.0275 (0.134) |

| | | | | |
|---------------------------|-----------|-----------|----------|-----------|
| | | (0.220) | | (0.213) |
| Water sufficiency (Yes=1) | | 0.147 | | 0.0322 |
| | | (0.150) | | (0.145) |
| Household size | | 0.263*** | | 0.185*** |
| | | (0.0587) | | (0.0574) |
| Constant | -0.699*** | -1.810*** | -0.0844 | -1.012*** |
| | (0.0918) | (0.233) | (0.0840) | (0.208) |
| | | | | |
| Number of observations | 451 | 451 | 451 | 451 |
| P-value (Prob < Chi2) | 0.000 | 0.000 | 0.000 | 0.000 |

*Note: Standard errors in parenthesis, *, **, and *** represent statistical significance at the 10%, 5% and 1% levels of significance*

The results show that at model one (1) more than half of farm households who participated in bush farming are more likely to be food sufficient than those who practised other farming systems. It also shows that farm households that are headed by a male, have had a formal education, have access to extension services and can access loans are more food sufficient and food secure than those without these characteristics. This concurs with findings of Nyariki (2011) that education, gender, market access and off-farm employment opportunities are linked to improving farmer performance. This does not show that bush systems are more relevant to farm household than the other systems as the relative contributions of the various farming systems to food security is important and supported by in-depth interviews and focus group discussions. An interviewee's view on the contribution of the farming systems to food security is chaptered in Box 7.1.

“Sequentially, I plant maize, groundnut and Bambara beans on the bush plots and only rice in the valleys. The compound farms are planted with maize and leafy vegetables. I use to plant millet and maize on the riverine systems but have now shifted to only maize because of the nature of the weather. The rains are not evenly distributed and this affects the millet so I now wait after harvesting the maize for the flood water to recede then plant cowpea on the same plots. The riverine system has space for more acreages than the compound farms. I also have the opportunity to cultivate the riverine plots twice in a year. I have completely abandoned millet on my compound farms as a result of birds and conflict with livestock. As the riverine, bush and valley systems contribute to crop output for household food security, the compound system is multifunctional and diversified as livestock is kept. It thus contributes more to food security.

Box 7.1: A female farmer' views on the relative contribution of her farming systems to food security

This excerpt shows that no single transitioning farming system is capable of meeting the food needs of farm households in Builsa. Farmers thus use an integrated strategy in meeting their food needs through multiple farming systems. This strategy is designed to cater for complementarities as resources from one system is used to support activities in other systems. The relative contribution of the farming systems to food security is important as noted by an interviewee that:

“I have a single field in the riverine system made up of about 5 to 6 acres. With the valley system too, I have a single field comprising of about 5 to 6 acres. With the compound system, the field is an acre. I farm more at the riverine and valleys than on the compound system. The reasons being that there is a conflict of interest on the compound farms. As crops are planted the chicken and guinea fowls, with the kids of goats, which cannot be tethered destroy them. They are all your and there is nothing you can do about it so you move away to where the livestock cannot reach to destroy crops to cultivate them.” (Excerpt, 95-year retired farmer Gbedembilisi, July 2018).

This excerpt supports the assertion that as more land is cultivated in the riverine and valley systems with crops cultivated for commercial purposes, the compound systems play a multifunctional role. They support farm households with short duration crops like early millet and maize to smoothen household hunger. They are added to most preferred in raising livestock, which is used to finance the riverine, bush and valley systems as noted by an interviewee that: *“ I sold my sheep to pay for the services of tractors to plough my fields in the farming season. I sold some Guinea fowls and chicken to control weeds on my fields ”*. (Excerpt, 34-year female farmer, Sandema, June 2018). This view was expressed by many interviewees in the Builsa area. Beyond the sale of livestock to support farm activities, the poultry sub-sector

is critical to household food security especially concerning the keeping of chicken and Guinea fowls. These provide the proteins needed by farm households and are additionally used for other cultural purposes such as ancestral sacrifices and funerals.

Most farm households recognise the multifunctional role of the compound systems in contributing to household food security as noted by an interviewee that: *“I have riverine, bush, valley and compound farms in term of crop farming but the compound farms are multifunctional and diversified as my livestock is also kept here, making the compound farm contribute more to food security”*. (Excerpt, 59-year-old female farmer, Gbedembilisi, June 2018). Others are of the view that the riverine and valley systems are more beneficial to them as noted by some interviewees that:

“The riverine farms contribute more to food security in this village (Gbedembilisi). With the bean plots, I can harvest between 30 to 50 bags of beans, which can easily be converted into cash. However, if not because of theft, the compound farms are better as it cost more to do beans farming”. (Excerpt, 46-year male farmer, Gbedembilisi, July 2018).

Relatively, all farming systems operated by farm household contribute to household food security. As the compound systems offer food to break the hunger season the riverine and valley systems provide the household with cash as commercial crops are cultivated on them and the bush systems serving as food buffers.

7.4 Conclusion

The farming systems in Builsa play a vital role in contributing to household food sufficiency and security as noted by farm households. Food security in Builsa is conceptualised differently using self-defined measures. These measures include the ability of households to feed themselves all-year-round through own production and non-farm sources, financing farming activities from previous outputs and other non-farm activities, the role of climatic

factors in ensuring a good harvest, the eating of preferred foods, dietary diversity and sale of surpluses from previous outputs to finance the next farming and other household activities.

These notwithstanding, most household heads accepted all-year-food-availability as an agreeable conceptualisation of food security. However, this is determined by several factors as successful rains, disease-free seasons, healthy livestock and household members as all contribute to household food security. Beyond identifying what constitutes food security, the farming systems contribute differently to household food security. As the compound systems are used for the cultivation of early maturing crops like early millet and maize, which are used to break the hunger season described here as the period between the onset of farming and the first harvest (Hunter, 1967), the valley and bush systems serve as buffers and additionally provide financial assistants are commercial crops are cultivated within these systems.

Households that practised bush farming with a combination of other farming systems are better off than those who do not combine bush farming in their systems. These systems are, however, limited to female-headed households due to distance and the apparent inadequate resources to maintain a bush farm. The riverine systems have greater potential in reducing poverty and improving food security at the household level as they allow for multiple cultivations of commercial crops (maize and beans). They are additionally capable of absorbing labour from neighbouring communities in the dry season beans farms if they are well organised. The transitioning systems have great potential in contributing to household food security in the Builsa area if better organised.

CHAPTER 8

CONCLUSIONS AND RECOMMENDATIONS

8.0 Introduction

This study sets out to assess transitions in local farming systems and to find out if farmers perceived their farming systems as sustainable. It additionally examined the contributions of the transitioning farming systems to household food security. Transitional studies within farming systems are important as societies are dynamic and there is a need to assess how actors within these societies respond to this dynamism. In doing this, it is necessary to outline the patterns and trajectories of progression in local farming systems. Sustainability studies are additionally important globally and locally due to population and affluence induced pressures on natural resources. The views and experiences of people in rural areas are often left out in debates on sustainability especially with regards to how implementation and measurement of sustainable farming should proceed yet they are the most affected. This study thus adds to discussions on transitional and sustainability studies on local farming systems and their contribution to household food security.

8.1 Transitioning farming systems in Builsa

The first objective assesses transitions in farming systems in the Builsa area. Findings show farm households practised multiple farming systems. These are the compound, bush, valley and now riverine farming systems in Builsa with changing farm practices within these systems. The riverine system is a new development that allows for multiple cropping and is used for cultivating crops (maize and beans) which are easily marketable. The most practised farming system is the compound systems followed by the bush, valley and riverine systems, however, the riverine systems have potential in reducing household food security as it allows for dry season farming. Dry season out-migration has been noted as a strategy to cope with household food shortages in these parts of the world (Rademacher-Schulz,

Schraven, & Mahama, 2013). This can, however, be reduced if the riverine system is made attractive in the dry season, which makes it capable of absorbing excess labour during these times of the year. Farm households are multi-active as they do not engage in one farming system with the different farming systems operated by households playing a complementary role in ensuring household food security.

The transitions are manifested in farm practices such as increasing farm sizes, which are made possible through changes in the tillage systems. This concurs with findings by Asante, Villano, Patrick, and Battese (2018) that usage of fertiliser and tillage equipment are linked to increases in cropped area and crop diversification. Generally, there are increases in farm sizes with farm household cultivating more acreages than had previously been. This is explained by state and stakeholder attempts at modernising agriculture in rural areas. However, compound farm sizes reduce with distance from town communities and increases toward village communities. This is the result of urbanisation taking more arable space for residential and non-farm enterprises in small towns in rural areas in line with the finding of Kuusaana and Eledi (2015) that, as towns grow, farming is pushed to the fringes and less favourable locations. Relatedly, Cobbinah et al. (2015) found changes in the peri-urban morphology of Kumasi where farmlands have been used for residential and other high valued purposes as towns grow. These changes, unlike that envisaged by Boserup (1965), are not linear and not influenced by only population pressure on land. Farm size expansion is explained, as Codjoe (2006) noted, by poverty and the availability of arable land. In the dry savannah areas of West Africa where peasant farmers are poor and cannot invest in intensive agriculture or are afraid of risk with imminent weather fluctuations, cropped area expansion becomes the desired strategy as further confirmed by Ridder, Breman, van Keulen, and Stomph (2004). It is additionally found that access to family and market labour coupled with the existence of functional input and output markets are critical to farm size

expansion in the northern parts of Ghana rather than population pressure which concurs with findings of Eileen Bogweh et al. (2017) and Ohene-Yankyer (2004). There are changes in crop cultivars as farm households have shifted to the cultivation of new varieties of existing crops. Maize was hitherto not a crop grown by most farm households in Builsa. Millets, sorghum and groundnuts are the major crops grown in the north-east areas of Ghana. This is however changing as the cropped area for maize is more than all crops grown in Builsa. Changes in crops cultivar is received with mixed results as poor households rely on own seeds, which produce less output compared to relatively wealthy households. This concurs with findings of Waldman, Blekking, Attari, and Evans (2017) that local seed availability, available information on seed performance and transfer of that information to the farmer is critical in farmer choice of seeds to plant as wealthy farmers are more likely to possess these characteristics. Farmers perceive seed performance in combination with climate change before deciding on which seeds to plant.

The farming systems are transitioning from millet, sorghum and beans mix to mono-crops of maize, groundnut and beans. This is attributed to several factors including climate variability, taste, and availability of external inputs for specific crop cultivation, commercialisation and marketability of crops such as maize, groundnuts and beans. Maize has however dominated the farming systems due to availability of external inputs for its production and training on cultural practices by extension support personnel. This has implications for the farming systems as children are likely to lose some essential vitamins from the non-consumption of foods from traditional crops like millet and sorghum. It additionally has ecological implications as maize is relatively nutrient demanding than millet and sorghum. The spread of new crops is relative with well-endowed farm households likely to abandon landrace varieties that are drought-tolerant and withstand poor soil conditions for early maturing varieties as it is in Gbedembilisi. The implication of this is

deepening contours of poverty and accumulation as poorer households will be impoverished with wealthier one accumulating more due to differential in access to modern seeds and the inputs needed for their cultivation.

There are transitions in the tillage systems from the use of the hand hoe to bullock ploughs and tractors. New developments are the use of donkeys in tillage and weedicides for land preparation. The bullocks and tractors fasten tillage as this is needed for timely sowing of seeds with the number of planting days shortened. The onset of planting has shifted from March to June under the influence of climate variability. The adoption and use of the new tillage technologies additionally help to expand the area under cultivation as farm households need more outputs than their annual caloric needs to enable them to finance other aspects of their lives such as payment of school fees and other social responsibilities. There are additionally shifts from the planting of own-produced seeds to purchased seeds from a certified dealer, extension agents and the open market. This could imply the local arrangement for seeds by poor households is undermined, which could result in delays in sowing by such households. The increasing use of agrochemicals is a new development in the farming systems. These are both weedicides and pesticides used as weed and pest control techniques, respectively, which augment household labour. There is however misuse of these chemicals in some instances as most farm households are not trained on the proper use and disposal of agrochemical products. This observation is supported by some studies in the Upper East Region that found that, in addition to the misuse of agrochemicals, most of these chemicals are expired thus endangering the health of agricultural workers and consumers (Fianko et al., 2011; Laary, 2012). In line with this is the increasing use of chemical fertilisers in all the farming systems but more with maize and beans cultivation. Storage for the crop sector has shifted to the use of bags as these ease measurement and sale. The livestock sector has witnessed the introduction of new breeds and improvement in

housing. It has additionally seen increases in the patronage of veterinary services. This sector contributes to household food security by supplementing the protein needs of farm households and income through sales to support the coping systems.

8.2 Local conceptualisations and assessment of sustainable farming

Objective two assessed sustainable farming and how farmers perceived of the sustainability of their farming systems. Ecological, economic and social markers of sustainable farming were generated from focus groups and informal conversations and were used to assess sustainable farming at the household level. The finding shows that sustainable farming is a concept with different meanings among farm households in Builsa. This concurs with several observations of the difficulty in defining and measuring sustainable farming (Bachev, 2016; Beland Lindahl et al., 2016; Deytieuxa et al., 2016; Kates et al., 2005; Pannell & Glenn, 2000; Schaller, 1993). Not all farm households have heard of the term sustainable farming. Some farm households have not heard of the term sustainable farming, others conceived of it as better outputs at the end of the farming cycle, ability to carry out planned activities at the right time and the ability to be responsible in taking care of crops and livestock with an ultimate aim of attaining desirable outputs. Generally, sustainable farming is a concept used by farm households to connote the profitability of their farming systems. As some farm households conceive of it in terms of increased outputs at the end of a farming cycle others consider it as a process. Farm households who used the process-based conceptualisation considered the timely availability of all the inputs needed for executing farm work as critical to sustainable farming.

Farm households do not think their farming systems are sustainable on the ecological, economic and social domains as they disagreed with most of the markers identified within them. There are however variations in perceived sustainability statuses within these domains as the ecological domain is seen as less sustainable compared to the social and economic

domains. This means sustainable farming cannot be wholly attained, as there are trade-offs in farm households pursuits of sustainable farming. These trade-offs emanate from the interrelated nature of the markers within and between the various domains of sustainable farming which concurs with findings of Kanter et al. (2018) and Valbuena et al. (2012). This finding confirms that of Giller et al. (2011) who stressed the need to apply household-specific sustainable solutions rather than ‘silver bullet’ solutions to entire farming systems in our attempt at practising sustainable farming. In sustainability studies, it has also been argued that there is the need to consider the ecological, economic and social dimension of farms in their context before deciding if they are sustainable or not as advocated by Bachev (2016) who explained the need to consider all domains in assessing the sustainability of farming systems.

8.3 Forces influencing sustainable farming in Builsa

The third objective discusses the forces that influence the sustainability of farming systems in Builsa. The findings show that a myriad of forces influences sustainable farming in the Builsa area. Forces that influence sustainable farming in Builsa are found to be exogenous and endogenous and this confirms the observation of Bachev (2016). The adoption of sustainable farming practices is influenced by ecological, economic and institutional forces (Tey et al., 2014) with these forces described as both economic and non-economic forces. Both external and internal forces operate within the ecological, economic and social domains to determine sustainable farming and household food security in the Builsa area. Some external forces critical to sustainable farming and food security in Builsa are climate change and variability, access to external inputs, markets and the neoliberal policies on agriculture. Climate change is a principal driver of shifts in the farming systems as it has reduced the number of growing days through moisture reduction in the agro-ecological systems as observed by farm households and concur with some studies (Sylla, Elguindi,

Giorgi, & Wisser, 2016; Sylla, Nikiema, Gibba, Kebe, & Klutse, 2016; Yira, Diekkrüger, Steup, & Bossa, 2017) with similar findings. This is leading to declining outputs as climate variability is linked to droughts, increased incidence of pest and diseases, floods and post-harvest losses as noted by farm households and supported by some studies in Central America where most smallholder farmers reported negative impacts of climate change on their farm outputs (Harvey et al., 2018). Vermeulen (2014) additionally observed negative impacts of climate change on food security across the globe. Climate change is found to have effects on other non-farm rural sectors such as shea processing, basket weaving and trading (Aniah et al., 2016). Associated with climate change, is the need to quickly till lands bringing in the use of bullocks and tractors, the need to cultivate early maturing varieties of crops and the introduction of new crops that have shorter maturity periods. This observation is in line with concepts of climate-smart agriculture observed by Campbell et al. (2014) where there is a need for government to support in providing needed inputs and infrastructure to farm households. The new ways of farming, however, need new investments portfolios by farm households such as timely access to tractors and other external inputs like herbicides, pesticides and chemical fertilisers. This is leading to patterns of exclusion and accumulation by poorer and wealthier farm households, respectively. Poorer households are gradually being excluded as they cannot access tractors and other external inputs to timely execute farm activities. These patterns confirm studies by Yaro (2013a) on the impact of neoliberal globalisation on local morality and institutions resulting in processes of dispossession and accumulation of the poor and rich, respectively, in the northern parts of Ghana. Climate change has additionally resulted in water scarcity to both the crop and livestock sectors leading to the emergence of supplementary feeds on the local markets for dry season livestock raising. This is a positive sign and a significant pathway to sustainable farming and food security especially if farm household can concentrate on the poultry and small ruminants' sub-sectors. Beyond climate change and variability is the role

of markets in influencing sustainable farming and food security. The finding shows that most farm households have difficulties assessing the markets especially those located in remote areas. Beside physical access, the seasonality of agricultural products often affects the food security status of farm households as food crop prices are lower at the time of harvest and higher some few months after. The difficulty in accessing markets for agricultural produce in Builsa confirm findings by Yankson et al. (2016) that, marketing is a major drawback to the agricultural sector in Ghana. Farm households do not produce for subsistence only but also with a motive to sell some output to finance other aspects of their lives other than food. Households are thus shifting to the cultivation of crops that have been commodified with a higher market value such as maize, beans and groundnuts. This is done for several reasons among which is the need to finance the education of children, to gain income to support other household needs and to be able to guarantee the continuity of the farm businesses as part of the income is re-invested into the farming systems. This observation concurs with the argument of economic globalisation, which is leading to agricultural intensification and the production of cash crops for the market (Luabe, 2015). These processes work in tandem with climate change to affect sustainable farming and food security in rural spaces as small farmers face what is termed the double exposure to climate change and to economic globalisation.

Internally, forces of transitions in farming are linked to the local ecological condition as farm households who participated in all the farming systems are more likely to apply and use modern technology that those who do not. The growing of cash crops is associated with the increasing use of external inputs and these are usually found on the bush, riverine and valley systems compared to the compound systems. Wealth is another internal force of transitions as cropped area expansion is aided by the use of external inputs, which is driven

by wealth. These in addition to taste and intergenerational demands also influence transitions in farming systems in Builsa.

8.4 The role of integrated local farming systems in ensuring food security

The fourth objective assesses the contributions of the farming systems to food security. Findings show that all the farming systems are necessary for ensuring household food security in Builsa. As the compound systems are necessary for breaking the hunger season described as the period between land preparation and the first harvest (Hunter, 1967), the bush and valley systems serve as an avenue for food buffers and the generation of surpluses to support household expenditure. Currently, the riverine systems further support household income as they are noted for the growth of market crops such as maize and cowpea.

Farmers in rural areas have own conceptualisations and measures of food security with these measures cutting across the conventional pillars of food security – availability, access, utilisation and stability (Berry, Dernini, Burlingame, Meybeck, & Conforti, 2015; Briones Alonso, Cockx, & Swinnen, 2018). A major conceptualisation of food security in Builsa is the ability of farm households to meet food and other basic needs from farm outputs and other sources year after year. This corresponds to food sufficiency and noted by (Coates, 2013) as one of the pillars in measuring food security. It is however found that not all farm households are food sufficient from own production as close to half of the farm households disagreed that they were food sufficient. Food sufficiency is described here as a household that can meet its food needs all year round from own production and other sources. Most of those who are food insufficient are likely to practise compound farming systems with about half of farm households having food all year round practising a combination of bush and other farming systems. Participation in bush farming is thus critical to food security among farm households in Builsa. The food sufficiency status of farm households is mediated by both exogenous and endogenous forces. This finding confirms that of Sibhatu and Qaim

(2018) that African farm households are insufficient in their food production and rely on markets for sufficient and quality food. In addition to this, farm households measured food security by relying on markers such as sufficiency of rainfall, eating of preferred foods, the ability to provide three meals in a day to household members and growing of preferred crops. As all these conceptualisations fall within the four pillars of food security, there is the need to consider seriously the cultural role of food in the local farming systems and this confirms the position of Alonso, Cockx, and Swinnen (2018) who emphasized the need to explore the cultural role of food security since food has cultural connotations. Beyond the ability to access food to meet the daily caloric needs, ensuring that food is nutritious, and having a combination of foods that can be easily digested, prepared and eaten in a hygienic environment is the need to identify with food. The identity with food makes it place specific as it performs some cultural functions for people in place. In this sense, the gods and other cultural practices of the Builsa' do not accept food prepared with any other crops than millet and sorghum thus making these crops significant to be identified with, as a true Builsa.

8.5 Conclusion

There are transitions in farm practices in Builsa with farmers shifting from the cultivation of traditional crops to new crops, which is not in line with the Green Revolution in the 1960s as it was in Asia based on improvement in traditional staple crop cultivars. Farmers are not only sowing improved varieties of traditional crops as they have shifted to maize as a major cereal and legumes like groundnuts and beans for commercial purposes. These transitions are not only motivated by population growth and its technological induced linear trajectory of farming systems envisaged by some agricultural geographers but a combination of both external and internal forces impinging on farm households.

Sustainable farming has different meanings to farm households and will demand a bottom-up approach in its measurement. This was achieved in this study by deriving variables to be

measured through focus group discussions on the ecological, economic and social domains of sustainable farming. These were then interpreted by the mean scores within each domain. This process allowed farm households to generate their variables and determine if they were sustainable or not. Farm households do not conceive of their farming systems as sustainable. Farming systems contributing differently to food security however, a new and promising farming system is the riverine system which is limited in the study area as it is only accessible to communities along the River Sisili. This system allows for the multi-growing of commercial crops such as maize and beans. It is labour intensive and if well-developed could serve as a source of employment to other communities especially on the bean fields during the dry season. A combination of the bush systems is critical to household food security as these systems serve as a buffer to the rest of the farming systems.

Food security has cultural and generational dimensions. This goes beyond the conventional pillars of availability, accessibility, utilisation and stability. Farm households need to produce food that does not only meet their caloric and nutritional needs but that are also acceptable to the gods and are capable of performing some cultural functions. There is additionally a generational gap in defining food security as the food needs of younger farm household members differ from the older ones. This has implications in defining crops and foods that meet needs at the local level.

The contributions of this work to knowledge are that farm household in the Builsa area practices multiple farming systems with transitions in farm practices within these systems over the years. Farmers have shifted from the cultivation of traditional varieties to improve varieties. The transitions also involved the use of animal and mechanical method, use of external inputs and expansion in acreage.

8.6 Recommendations

Transitions are to be expected in all aspects of human life including the farming systems that rural people draw their major livelihoods. These transitions should, however, take into consideration alternative options available to farm households and to offer more opportunities to disadvantaged households at the local level. Provision of farm inputs especially that of tractors and agrochemicals are suggested ways of sustaining the farming systems in Builsa. This should be done by major stakeholders such as the state and agricultural-related NGOs. Farm households need support either from state agencies or Non-Governmental Organisations on the supply of farm inputs. If the state provided subsidies on these it would be helpful to some farm households.

Providing farmers with credit to finance agriculture is critical at the local level as proposed by some household heads. This confirms findings that more than a third of Africa's agriculture is financed by farmers (Thorp, 2014). Agriculture finance is a problem in the study area and supporting farm households with credit can be healthy in improving outputs and maintaining soil quality. There is a need to additionally support poor farm households with improved seeds, fertilisers, tractor services, and other extension support to enhance sustainable farming and food security in Builsa. Training is needed on the proper handling of agrochemicals as the misuse of these pose health risks to both humans, livestock and the micro-ecology of the study area in general. This should be done by the state and local banks in the study area.

The livestock sector plays an integrated role in the farming systems as it is noted to contribute to increasing crop outputs through the provisioning of organic manure with livestock droppings. The sale of livestock is also noted to support crop cultivation as it is used to pay for tractor services and hired labour during crop cultivation. The livestock sector additionally contributes directly to household food security by providing the protein needs of

farm households. The support needed is in the forms of livestock housing structures, an improvement on the local breeds, introduction of new breeds that are disease resistant and making veterinary support services more accessing to farm households. This support should come from the District Department of Agriculture and some agricultural NGOs working in the Builsa area.

The farming systems can be made more sustainable by bridging the gap between Conservation Agricultural (CA) practices that are akin to traditional farm practices and the modernisation of farming systems based on the use of external inputs. While it is strongly argued that CA is beneficial to poor households, most farm households in Builsa are moving towards the reliance on the use of chemical fertilisers with the continuous supply of these questionable. This study thus proposes the intensification in the education of farm households on the benefits and use of CA practices in combination with modern inputs to enhance sustainable farming as these could have long term benefits.

The variation in farm households' conception of sustainability across farming systems and communities presupposes that different farming system contributes differently to sustainability and food security at the household level. There is, thus, the need to design household-specific solutions in addressing how the farming systems in each community can be sustained and can sufficiently contribute to food security. This demands a bottom-up approach to addressing sustainable farming and food insecurity at the local level rather than the one-size-fits-all approaches often proposed. This can be achieved with collaboration from the District planning office and the Department of Agriculture in the study area.

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APPENDICES

Appendix 1: Questionnaire for the survey

LOCAL FARMING SYSTEMS AND FOOD SECURITY IN THE BUILSA AREA OF NORTHERN GHANA

This questionnaire is directed towards subsistence farmers in the Builsa Districts of the Upper East Region of Ghana. It is aimed at measuring how farmers perceive the sustainability of their farming systems and the contribution of these systems to food security in the Builsa area. The study will lead to a policy suggestion that will enhance better performing farm systems. It will also present the peasant's side of the sustainability debate and contribute to our understandings of the prevalence of food insecurity in the Builsa area. Any data given will be used for academic purposes and all respondents will be treated anonymously.

Household Survey Questionnaire

Name of the Enumerator: Date:

District

Village

Compound

Household

Interviewee ID number

SECTION A: DEMOGRAPHY

Ask these questions for each of the members that have stayed with this Household for a period of **at least six months** over the last 12 months.

(Household members are defined as all those who normally live and eat their meals together here. Include household members temporarily studying elsewhere or travelling, but who spent AT LEAST SIX continuous months living and eating here).

Reference Period: The Past 12 months

| Member ID & Name (Start with the household head) | What is the sex of (Guest et al.)? 1=male 2=female | How old is Name | Relationship to the current head See code below | Is the primary respondent 1=Yes 2=No | Marital Status (ask only if A04 > 12 See codes below) | If A04 > 4, What is the highest level of education completed? see codes below | Is (Guest et al.) Currently attending school? 1=Yes >> A13 2=No | If A11=2, Why is (Guest et al.) Not in school? | Can (Guest et al.) Read? 1=Yes 2=No | Can (Guest et al.) Write? 1=Yes 2=No | What is the MAIN occupation of (Guest et al.)? | Answer for household members older than 7 years. | | | |
|--|--|-----------------|---|--------------------------------------|---|---|---|--|-------------------------------------|--------------------------------------|--|--|--|--|--|
| | | | | | | | | | | | | Did this person receive cash from informal/business activity? Include dividends (in the past 12 months) 1=Yes 2=No | How much income did Name receive from this Non-Farm business activity? Amount in Ghana cedis | Did this person receive in kind from salaried employment, wage activities, remittances or pensions? (in the past 12 months) 1=Yes 2=No | How much did Name receive as monthly income from this salaried employment? Amount in Ghana cedis |
| A | A02 | A03 | A04 | A05 | A06 | A09 | A10 | A11 | A12 | A13 | A14 | A15 | A16 | | |
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Codes

| Relation to head (A04) | | Reason why not member of HH (A08) | Marital Status (A09) | Education levels (A10) | | Reason for absence from school (A12) | Main Occupation (A14) | |
|---|---|---|--|--|--|---|---|---|
| 1= head 2= spouse 3= own child 4= step child 5= parent 6= brother/sister 7= nephew/niece 8= son/daughter-in-law 9= grandchild | 10=other relative 11=non-relative 12=brother/sister-in-law 13=parent-in-law 14=Worker 15=Adopted child 16=Grandparent | 1=left to find a job 2=left to attend school 3=married away 4=deceased 5=divorced/separated 6=living with other relatives 7= went missing 8=went back home 9=farm worker left 10=other specify | 1 = single 2 = monogamous married 3 = polygamous married 4 = divorced 5 = widowed 6 = separated 7=Cohabitation | None.....0 0 Pre-school.....01 P1.....1 1 P2.....1 2 P3.....1 3 P4.....1 4 P5.....1 5 P6.....1 6 JSS1/JHS1.....1 7 JSS2/JHS2.....1 8 JSS3/JHS3.....1 9 M1.....2 0 M2.....2 1 M3.....2 2 M4.....2 3 SSS1/SHS1.....2 4 SSS2/SHS2.....2 5 SSS3/SHS3.....2 6 | SHS4.....27 S1.....28 S2.....29 S3.....30 S4.....3 1 S5.....32 L6.....3 3 U6.....34 Voc/Tech/Computer/ Comm/Agric.....41 Teacher Training.....42 Nursing.....43 Polytechnic.....51 University.....52 Other Tertiary.....53 Other (specify).....61 | 0=Too young 1=Cannot afford expenses 2=Working 4=Pregnancy 5=Sickness/disability 6=Refused to continue schooling 7=Completed 8=Too old to be in school 9=Other (specify)___ | 1= Salary earner (e.g., teacher, policeman, etc.) 2= Casual wage earner 3= Farm labourer 4=Transportation business 5= Bicycle repair/mechanics 6= Brewing business 7= Brick making 8=Butcher 9=Carpentry 10=Charcoal burning 11=Clothes business (trading) 12=Construction 13=General-kiosk owner | 14=Miller 15=Trading farm produce 16=Trading fish 17=Trading livestock 18=Trading firewood/timber 19=Trading non-food goods 20=Farming 21=Tailor 22=Schooling 23=Other (specify) |

2. Which of the following is your main farming system?

1. Compound farming system []
2. Valley farming systems []
3. Bush farming systems []
4. Irrigated systems []

| | | | | | | | | | | | |
|-----------------------------|--|--|--|--|--|--|--|--|--|--|--|
| Valley system | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| Bush plots or upland system | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| Irrigated system | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| Others specify | | | | | | | | | | | |
| | | | | | | | | | | | |

6. Do you or any of your household members' engage in fishing? (**If Yes answer question 7** and if **No go to question 8**). 1. Yes [] 2. No []
7. How much do you earn from fishing per year? Gh¢
8. Which tree crops do you keep on your farms (**you can tick more than one in order of increasing presence by assigning 1, 2, 3, 4, 5...?**)
1. Teak []
 2. Mangoes []
 3. Shea trees []
 4. Dawadawa trees []
 5. Boaba []
 6. None []
 7. Neem trees []
 8. Local fruit trees []
 9. Others.....
9. How much did you earn last year from the forest crops? Gh¢.
10. Are there changes in the types of crops grown and the livestock kept over the past three decades? (**If Yes answer question 11** and if **No go to question 14**).
- a. Yes [] b. No []

11. Changes in cereals

| Name of crop | Old variety | Periods/years When did you stop using these varieties | New variety | Periods/years When did you start using these varieties |
|------------------|-------------|---|-------------|--|
| Millet | | | | |
| Sorghum | | | | |
| Maize | | | | |
| Rice | | | | |
| Others (Specify) | | | | |
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |

12. Changes in legumes

| Name of crop | Old variety | Period/years When did you stop using these varieties | New variety | Period/years When did you start using these varieties |
|------------------|-------------|--|-------------|---|
| Cowpea | | | | |
| Bambara Beans | | | | |
| Soya Beans | | | | |
| Groundnuts | | | | |
| Others (Specify) | | | | |
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |

13. Changes in livestock

| Livestock | Old Breed | Period/years When did you stop the old varieties | New breed | Period/years When did you introduce the new varieties |
|------------------|-----------|---|-----------|--|
| Cattle | | | | |
| Sheep | | | | |
| Goats | | | | |
| Poultry | | | | |
| Piggery | | | | |
| Donkeys | | | | |
| Rabbits | | | | |
| Doves | | | | |
| Others (Specify) | | | | |
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |

Channels of the spread of innovation

14. From which sources do you get to know about new ways of farming or new varieties of crops? (**Rank them in order of the most frequent source by assigning 1, 2, 3 ...**).

1. Radio []
2. Mobile phones []
3. Friends []
4. Extension officers []
5. Non-governmental organisations []
6. Others

15. Do these sources influence your decisions to grow new varieties of crops and keep new breeds of farm animals? 1. Yes []

2. No []

16. What drives changes in your farming systems? (**Rank them in order of the most important by assigning 1,2,3,4,5, etc. where 1 is the most important**)

1. Market for the new varieties []
2. Climate variability []
3. Changes in taste []
4. Availability or ease of access to improved seeds than local seeds []
5. Resistance of new varieties to diseases and drought []
6. Suggestions by Non-governmental organisation []
7. Government programmes []
8. Roll of extension officers []
9. Production of variety []
10. Quality []
11. Taste []
12. Productivity (They yield higher) []

17. Are there changes in the farm implements used over the past three decades? (**If Yes continue from question 18 and if No go to question 20**). 1. Yes []

2. No []

18. Which kinds of implements do you use in farming? (**Tick more than one according to the most frequently used by assigning 1, 2, 3, etc. where 1 is the most frequently used**)

1. Hoe []
2. Axe []

- 3. Machete []
- 4. Dibber []
- 5. Sickles []
- 6. Knifes []
- 7. Donkey drawn charts []
- 8. Animal skins []
- 9. Tractors []
- 10. Harvesters []
- 11. Planters []
- 12. Bullock drawn ploughs []
- 13. Millers []
- 14. Others

19. What do you think is the cause/causes of changes in implements used? (**Tick more than one in order of the most likely cause by assigning 1, 2, 3...**).

- 1. Response to increasing demand through the local markets []
- 2. Weather variability []
- 3. Availability of modern equipment []
- 4. Government policies []
- 5. Others

Soil fertility management

20. How did you maintain soil fertility previously? (**Rank them in order of the most dominant method used, by assigning 1, 2, 3...**).

- 1. Use of crop residue []
- 2. Use of cow dung and dropping from other animals []
- 3. Use of organic compost []
- 4. Rotation of plots or fields []
- 5. Crop rotations []
- 6. Others

21. What do you do with crop residues? (Rank them in order of the most dominant use, by assigning 1, 2, 3...).

- 1. Burn/compost/mulch []
- 2. Animal feed/removed? []
- 3. Used for sheds []
- 4. Used as a source of fuel []

29. Which types of herbicides/weedicides do you use?

1. Selective [] 2. Non-selective [] 3. Others

30. Are the chemical fertilisers and pesticides available on time and in the required amount?

1. Yes [] 2. No [] If no, why not?

31. Where do you get chemical fertilisers and pesticides?

1. Government []
 2. Cooperative Private store []
 3. Agent of fertilizer company []
 4. Other (specify

32. Did you receive any training on the use of chemical fertilizers and pesticides?

1. Yes [] 2. No []

33. Did you apply correctly as directed the amount of fertilizers and pesticides?

1. Yes [] 2. No []

Sustainability of the farming systems

34. Economic sustainability

| | Strongly disagree | Disagree | Neutral | Agree | Strongly disagree |
|---|-------------------|----------|---------|-------|-------------------|
| My current farming systems are profitable | | | | | |
| Farming activities generate enough income that lasts all year round | | | | | |
| Farm outputs are sufficient to meet household food needs all year round | | | | | |
| There is the presence of efficient markets for my produce | | | | | |
| There are good roads, storage other infrastructure that aid farming | | | | | |

35. Social sustainability of the farming systems

| | Strongly disagree | Disagree | Neutral | Agree | Strongly disagree |
|---|-------------------|----------|---------|-------|-------------------|
| Myself, children and grandchildren will continue to farm forever | | | | | |
| I am self-sufficient in own food production | | | | | |
| I eat my preferred foods all year round | | | | | |
| I have access to sufficient own or hired labour during farming activities | | | | | |
| I am satisfied with the farming job | | | | | |
| I earn some income working on the farms of others | | | | | |
| Our traditions and culture are sustained through our farming system | | | | | |
| I get paid jobs from farming related activities all year round | | | | | |

36. Environmental sustainability of farming systems

| | Strongly disagree | Disagree | Neutral | Agree | Strongly disagree |
|--|-------------------|----------|---------|-------|-------------------|
| Rainfall is not reliable | | | | | |
| Soil erosion is on the rise | | | | | |
| We can no longer drink from open water sources due to the use of pesticides and herbicides | | | | | |
| Crop outputs are declining per land area over the years | | | | | |
| There is a reduction in forest cover | | | | | |
| We have lost most of our traditional crops | | | | | |
| There is an increase in the use of chemical fertilizers and pesticides to maintain crop yields | | | | | |
| Our animals die as a result of agricultural chemical contamination | | | | | |

Non-farm activities

37. Do you or any member of the family earn some income from non-farm activities?

1. Yes [] 2. No []

38. If yes, what sources?

39. If no, why

40. How much GHC total in the last year (2017)?

Financial services

41. Did you make any cash saving in the last year? 1. Yes [] 2. No []

If yes, how much (GHC)

If no, why? Explain.....

42. In the past 3 years, have you obtained any loans? **(If yes, answer question 54 and if No proceed to question 57)** 1. Yes [] 2. No []

43. Where did you obtain the loan?

- 1. Rural Bank []
- 2. Commercial Bank []
- 3. Microcredit institution []
- 4. Farmers' Union []
- 5. Friends []
- 6. Family member []
- 7. Other (Specify:

44. No, reasons:

45. How much did you receive?

- 1. <5 Hundred Ghana cedis []
- 2. >=5 Hundred Ghana cedis []

Poverty level

46. Which wealth group do you belong, between the richest and poorest person in your village?

- 1. Very rich []
- 2. Rich []
- 3. Neutral []
- 4. Poor []
- 5. Very poor []

47. In 2017, how many months did your household not have enough food?

- 1. I have food all year round []
- 2. I have no food for less than 1 month []
- 3. I have no food between 2–3 months []
- 4. I have no food for more than 3 months []

48. What are the reasons for not having enough food?

- 1. Inadequate cultivable land []
- 2. Insufficient of labour []
- 3. Natural disaster []
- 4. Sickness []
- 5. Inadequate of knowledge and technology []
- 6. Others...

Extension services

49. Have you been receiving extension services? **(If Yes answer 50 and if No go to 55).**

- 1. Yes []
- 2. No []

50. Which of the following services have you received in the past year?

- a. Extension 1. Yes [] 2. No []
- b. Irrigation 1. Yes [] 2. No []
- c. Vet 1. Yes [] 2. No []

51. How often did you receive the support in the last year?

Extension

- 1. Rarely (less than 2 times) []
- 2. Regularly (3 times or more) []

Irrigation

- 1. Rarely (less than 2 times) []
- 2. Regularly (3 times or more) []

Vet

- 1. Rarely (less than 2 times) []
- 2. Regularly (3 times or more) []

52. Has there been any village or town meeting organized to assess the training needs of farmers regarding agricultural production techniques? 1. Yes [] 2. No []

53. Are you generally satisfied with the services provided by the extension system?

- 1. Not satisfied []
- 2. Normal []
- 3. Satisfied []
- 4. Very satisfied []

54. What do you further need from the extension services?

Water irrigation

55. Do you irrigate your crops? (If Yes answer question 57 and if No go to question 56).

1. Yes [] 2. No []

56. If No explain

57. How many crops are you able to grow in a year using irrigation?

58. Does the absence in irrigation affect your farming systems? Explain

59. During the last cropping season, was the water supply sufficient for your crops?

1. Yes [] 2. No []

60. If not, in which month (s) and why?

61. In the last five years, the area under irrigation has been

1. The same []
2. Increased []
3. Decreased []

Justification for the change

62. In the past five years, has there been any investment in irrigation infrastructure (dam, irrigation channel, and pump) in your village? 1. Yes [] 2. No []

63. Who is responsible for irrigation?

1. Village head []
2. Water user group []
3. Commune people committee []
4. Other (specify)
5. Don't know []

64. Are you generally satisfied with the services provided by the irrigation system?

1. Not satisfied []
2. Normal []
3. Satisfied []
4. Very satisfied []

Processing and market access

65. Is there any processing unit in the village? 1. Yes [] 2. No []

If yes, on what products?

66. How far is it to access the nearest processing unit? Km/mm

67. How far is it to access the nearest market? Km/mm

68. How easy is it to sell animals and crops?

1. Very difficult []

2. Difficult []

3. Neutral []

4. Easy []

5. Very easy []

Reasons:

69. Do you agree that your farming systems are sustainable?

1. Strongly disagree []

2. Disagree []

3. Neutral []

4. Agree []

5. Strongly agree []

70. Which farming system/ systems contributes more to household food security? (**Tick more than one and assign numbers with 1 signifying the most contributing farming system**)

1. Compound []

2. Bush []

3. Valley []

4. Upland []

5. Forestry []

6. Others specify []

71. Are the old systems of zero external input better in providing sufficient food on a sustainable basis than the newer systems of external input dependence?

1. Yes, explain.....

2. No, explain

Linkages between farming systems and food security

Dietary diversity

72. What is the nature of your menu for the day?

1. Millet porridge – Beans – Millet TZ with leafy soup []
2. Maize porridge – Beans – Maize TZ with leafy soup []
3. Rice Water – millet flour – Sorghum TZ with leafy soup []
4. Millet flour- pulses – rice balls with groundnut soup []

73. From which farms do you get most of the vegetables for your soup or your sauce vegetables?

1. Compound farms []
2. Valley farms []
3. Bush farms []
4. Irrigation farms []
5. Others specify

74. Why do you keep livestock? (Please rank reasons in order of your preferred reasons by assigning 1, 2, 3 ...)

1. Direct production []
2. Draught power []
3. Transport []
4. Source of manure []
5. Store of wealth []
6. Others specify

Anthropometric measures

| | | Strongly disagree | Disagree | Neutral | Agree | Strongly disagree |
|----|--|-------------------|----------|---------|-------|-------------------|
| 75 | Member of this household especially children are healthy | | | | | |
| 76 | The growth rate of children in this household is best. | | | | | |
| 77 | Household members are generally healthy | | | | | |
| 78 | Most members of my household suffer from insufficient food intake related wellness | | | | | |

79. What amount of food does the household consume in a week?

| Crop | Quantity consumed from owned farm (kg) | Purchased (kg) | Borrowed or gift (kg) |
|----------------|--|----------------|-----------------------|
| Maize | | | |
| Cassava | | | |
| Millet | | | |
| Sorghum | | | |
| Beans | | | |
| Groundnuts | | | |
| Vegetables | | | |
| Rice | | | |
| Yam | | | |
| Meat/fish | | | |
| Others specify | | | |

SECTION O: HUNGER SCALE

During the WORST MONTH, how often did you or any other HH member...

80. Have to go for a **whole day and night completely** without food **due to lack of resources** to get food?

1. Never 2. Rarely (1-2 times) 3. Sometimes (3-5 times) 4. Often (5+ times)

81. Have to sleep at **night hungry** because there was **not** enough food?

1. Never 2. Rarely (1-2 times) 3. Sometimes (3-5 times) 4. Often (5+ times)

82. Have to go a **whole day and night without** eating anything at all because there was **not** enough food?

1. Never 2. Rarely (1-2 times) 3. Sometimes (3-5 times) 4. Often (5+ times)

83. Have to **limit the frequency** of meals because of lack of resources?

1. Never 2. Rarely (1-2 times) 3. Sometimes (3-5 times) 4. Often (5+ times)

84. Have to eat a **smaller meal** than you felt you needed because of lack of resources/food?

1. Never 2. Rarely (1-2 times) 3. Sometimes (3-5 times) 4. Often (5+ times)

85. Have to eat food that you **did not like** to eat because of a lack of resources to obtain other types of food?

1. Never 2. Rarely (1-2 times) 3. Sometimes (3-5 times) 4. Often (5+ times)

86. Have to limit the **variety** of foods you ate because of lack of resources?

1. Never 2. Rarely (1-2 times) 3. Sometimes (3-5 times) 4. Often (5+ times)

Thank you for your time.

Appendix 2: Guide for focus group discussions

Profile

Facilitator:

Note taker:

Community/district:

Date:

Time started:

Time ended:

Type of farmer group (Male or Female)

Type of discussion (farming systems)

Age group.....

Number of farmers participating:

Introduction

The aim of this research is to understand how farm household conceptualise sustainable farming and if they think their farming systems can contribute to food security. By participating in this study, you will help extend the discourse on sustainable farming and help in offering constructive suggestions towards sustaining the farming systems.

Nature of the farming systems in the Builsa area.

1. Can you tell me about this community in terms of what people do for a living?
2. What are the major farming systems practiced – describe them – practice, crops, inputs, harvest, type of farmers, purpose, reasons for choice, etc.

3. What determines the farming systems you use? – ecology, economics, social factors etc.
4. Can you describe the cropping systems within the broader farming systems?
5. What is the role of livestock within the farming system? – describe how these are kept, integrated with crops, functions and importance
6. What are the major challenges facing each farming system? – don't mix these up
7. What do you like about your farming systems and what don't you like about them?

Transitions in the farming systems

8. Can you describe the changes in the farming systems over the past 30 years?
9. What forms of changes have occurred in terms of: Farm size, Labour, crops, inputs, integration with livestock, etc.?
10. Are there changes in the ways cultivated and forest lands are managed in the past three decades?
11. Can you tell me about the changes in the cropping systems such as: Implements used in land preparation and weed control; Types of seeds.; Methods of planting; Methods of pest control; Methods of harvesting and storage; How seeds are acquired for planting; How produce are marketed; How produce are process and stored; How produce are shared within and between households
12. What are some of the drivers of these changes in the farming systems? [*drivers such as Media, Self-experimentation, Climate related, Markets, Dietary changes, Government induced, Technological induced, NGO initiatives, others*]
13. What assistance do you receive from agricultural extension officers – how have these helped shape your farming practices

The concept of sustainable farming

14. What are some of the farming practices?
 - a. Do you farm in-between trees?
 - b. What do you do with the stocks or residue of your crops?
 - c. What are your cropping sequences
 - d. What are some of the practices you use to conserve soil fertility?
 - e. How do you integrate trees or forestry with crops?

Measuring sustainable farming

15. How do you rate farmers in terms of best friend of the environment? That is to say the person is not destroying the soil, water bodies, crops, endangering livestock etc.

Economic dimension

16. Are farming systems profitable? (differentiate between profitable and viable farming)
17. Are they viable?
18. Do you get enough income from your farming systems? Estimate the amount of money you derive from each farming and crop system annually. (May be at the beginning of the discussion it is important to all come to terms with what a farming system is – so we have Dickson and Benneh classification of compound farming system, upland and valley. Are these the main ones or do they have others, eg dry season farming as a system. Read on the difference between farming and cropping systems. Cropping is a subset of farming.)
19. Are the farming systems capable of providing your food needs all year round?

Social dimension

Can you describe the land tenure system in this community? How does one access land, and what rights are associated with different forms

What categories of people have poor access to land in the different farming systems and why? How does this affect their ability to farm sustainably?

Do you pay for that land or is given freely?

How is farm labour acquired in this community? Family or hired labour and what relations are involved?

Will you encourage your children to continue the farming work in the future].

Environmental

Do you experience increase incidence of soil erosion?

Are crop yields declining and why?

Do you use crop residue or animal droppings to fertilize your fields?

Do you apply chemical fertilizers and weedicides to manage weeds?

How do you manage your pest?

Do you have sufficient water to farm all year round?

Do you grow different kinds of crops on the same piece of land?

(Always good to take each farming system, describe it, who is involved, viability, benefits and contribution and challenges)

Appendix 3: In-depth interview guide

Profile

Interviewer:

Community/district:

Date:

Time started:

Time ended:

Type of farmer: Small, medium or large.

Gender: Male; Female.

Age.....

Name of farmer:

Telephone Number:

Livelihood activities in the Builsa area.

1. What are the livelihood activities in this village?
2. Can we identify all the activities you engage in for a living throughout the year?

Nature of farming systems in the Builsa area over the past three (3) decades.

3. What was the nature of your farms in the past three decades? In terms of:
 - i. Farm types.
 - ii. Number of fields.
 - iii. Size of each field.
4. Which are the largest and the smaller? (Probe for reasons)

5. What kinds of crops do you grow on these fields? Let us arrange them in descending order by field.

Transitions in farming systems

6. Are there changes in your farming systems over the past 30 years
7. Can we discuss these changes in terms of:
 - i. Crops grown and livestock kept (Probe reasons, sources and effects of new crop and livestock varieties on farmers)

The concept of sustainable farming

8. How do your farm activities protect the environment? Is it possible to discuss this in terms of:
 - i. Farm practices that maintain soil fertility and improve yields
 - ii. Farm practices that combine tree crops
 - iii. Farm practices that reduce soil erosion
 - iv. Farm practices that lead to increases in the number of livestock kept.
9. Do your farm activities lead to increased output? Let us discuss this in terms of:
 - i. Having enough food all year round from your farming activities.
 - ii. Being able to generate enough income from farms and farming related activities.
 - iii. Having hired labourers who help in the farming activities.
 - iv. Being able to support farm activities from the livestock sector.
10. Are farming activities self-fulfilling? Can we discuss this in terms of:
 - i. Growing crops and keeping livestock that provides your preferred foods.
 - ii. Growing crops and keeping livestock that protects and strengthen your identity.

- iii. Ability to help extended family members in need from farm produce.
- iv. Being able to fulfill some cultural demands with certain kinds of crops.

Constraints and enablers to sustainable farming

- 11. What are the things that affect the success of your farming systems?
- 12. What can be done to enhance continuous farming in this village?

Linkages between farming systems and food security

- 13. What kinds of foods do you prefer in this village?
- 14. Are your preferred foods coming from your own farms or elsewhere?

Policy contribution

- 15. What can we do to ensure that the farming systems in this village are sustainable?

Let us consider this from the contribution of:

- i. Farmers
- ii. Government and other stakeholders in the agricultural sector.

Appendix 4: Expert interview Guide

Profile

Interviewer:

Community/district:

Date:

Time started:

Time ended:

Type of expert:

Gender: Male; Female

Age.....

Name of expert:

Telephone number:

Profession:

Livelihood activities in the Builsa area.

16. What are the livelihood activities in this area?

17. Can we list all the farming and related activities throughout the year?

Nature of farming systems in the Builsa area over the past three (3) decades.

18. Can you describe the nature of the farms over the past three decades in this area?

(Probe on crops and livestock mix, inputs and yeilds).

Transitions in farming systems

19. Are there changes in the farming systems over the past 30 years?

20. Can we discuss these changes in terms of:

- ii. Cultivable area.
- iii. New varieties of crops grown with the **reasons and sources** of these varieties.
- iv. New farm implements being used in the farming systems with the **reasons and sources** of these new implements.
- v. To what extent are these transitions contributing to outputs in the farming systems.
- vi. What are the drivers of these transitions?

The concept of sustainable farming

- 21. What is sustainable farming?
- 22. What are the markers of a sustainable farm?
- 23. Are you or your outfit pursuing any sustainable farming practices in the Builsa area?
- 24. Can you describe farm practice in this area as sustainable?

Constraints and enablers to sustainable farming

- 25. What are the constraints to the sustainability of farming systems in this area?
- 26. What can we do to enhance sustainable farming in this area?

Linkages between farming systems and food security

- 27. Will the new farming systems meet the food needs of most farmers in this area?

Policy contribution

- 28. Are there policies that encourage sustainable farm practices in the Builsa area?
- 29. Do farmers adhere to these practices?
- 30. If not, why the non-compliance.
- 31. What can we do to ensure that the farming systems in this area are sustainable? Let us consider this from the contribution of:

- iii. Farmers
- iv. Government and other stakeholders in the agricultural sector.

Specific questions

- 32. Will you say modern farming is contributing more to food security (Agriculture extension)?
- 33. Are there more nutrition related sickness currently compare with the past three decades (Health experts)?
- 34. What is the future of farming in this area (Retired extension officer)?