Chapter 1: Introduction

1.1 Introduction and Study Context

Producing a range of crop and livestock commodities throughout the year has the potential to reduce risk and improve incomes and livelihoods among rural farm households in Ghana. This integrated crop-livestock farming system may also improve biodiversity and maintain a sustainable production environment. However, in Ghana, integrated crop-livestock farming system is characterised by low productivity and slow uptake of technologies. Increasing the productivity of these farming systems is important not only for the welfare of smallholders but also for enhancing national food security. This study evaluates the role of technology adoption and efficiency in improving the productivity of integrated crop-livestock systems in Ghana.

Ghana's reliance on agriculture for the provision of food, employment and foreign exchange continues to grow (Institute of Statistical, Social and Economic Research (ISSER), 2013). Over 60 per cent of the Ghanaian population depends on agriculture for their livelihood (Al-Hassan & Diao, 2007). Agriculture continues to be the largest sector of Ghana's economy, contributing about 39 per cent of gross domestic product (GDP) (ISSER, 2013) and serves as a major source of income for most households.

Food production in Ghana has not kept up with the human population growth, potentially due to increasing pressure on natural resources resulting in excessive deforestation, soil degradation, and loss of biological diversity (Food and Agriculture Organization (FAO), 2010). Thus farmers, who depend heavily on these resources for food, are adversely affected. Furthermore, extensive tillage and grazing may lead to soil and pasture degradation, particularly if practised in areas of marginal quality. This necessitates the need for technologies and production systems that enhance productivity and, at the same time, preserve the natural environment. Integrated crop-livestock production systems enhance productivity and ensure a sustainable production environment through a more efficient use of resources (Delgado et al., 1999; Owen et al., 2005). This farming system is essential for ensuring food security, particularly across Sub-Saharan Africa (Kristjanson & Thornton, 2004; Herrero et al., 2007).

One of the inherent features of agricultural production is that it is characterised by various forms of risk. Previous studies have shown that agricultural diversification can reduce production and marketing risks, as well as household income instability (Chavas & Di Falco, 2012; Joshi et al., 2004). The key benefits of agricultural diversification can be classified into three categories: economic, social and agronomic (Johnston et al., 1995). Economic benefits include seasonal stabilisation of farm income to meet other basic needs such as education, household food security and risk mitigation (Chavas & Di Falco, 2012; Lin, Dean & Moore, 1974). Diversification can reduce risk by optimising income from a range of activities that are subject in different ways to varying weather and market conditions. The social benefits include more stable employment for farm workers and resources throughout the year. Conservation of soil and water resources, reduced disease, weed and insect infestation, reduced erosion, increased soil fertility, and increased yields are among the most important agronomic benefits of diversification (Caviglia-Harris & Sills, 2005; Iiyama, Maitima & Kariuki, 2007; Mainik & Rüschendorf, 2010).

In Ghana, diversified farming is common with almost 90 per cent of farmers producing a range of crops and livestock in an integrated system. Major crops in these systems include cereals (mainly maize and rice), legumes and oilseeds (cowpea, groundnut and soybean) and roots and tuber crops (such as yam and cassava). Major livestock types include small ruminants (mainly sheep and goats), cattle, pigs and poultry. An integrated crop-livestock farming system includes the production of a combination of one or more crops with one or more livestock type in a single production period. This farming system can enhance farmers' livelihoods by providing them with a stable source of income. It also provides them with funds for financing other farming activities, for instance, farmers may sell livestock to finance cropping activities and vice versa. In addition, it has the potential to improve farm productivity. In the wake of the increasing human population in Ghana, integrated crop-livestock systems have the potential to meet the increasing demand for protein and quality foods.

To contribute in understanding the potential of integrated crop-livestock farming systems in Ghana, this study examines the nature and patterns of adoption of improved technologies, diversification and mix efficiency in integrated smallholder crop-livestock systems. The remaining sections of this chapter are structured as

follows. Sections 1.2 and 1.3 present the problem statement and research objectives. The significance of the research is discussed in Section 1.4. Finally, the structure of the thesis is outlined in Section 1.5.

1.2 Problem Statement and Research Questions

The integrated crop-livestock farming systems in Ghana are characterised by low productivity and low uptake of both improved crops and livestock production technologies (Ministry of Food and Agriculture (MOFA), 2010). Improved agricultural productivity has been found to be the engine for long-term food security due to its potential to enhance employment, income generation and nutritional wellbeing (Al-Hassan and Diao, 2007). Consequently, Aryeetey and McKay (2004) found that a reduction in the growth of the crop subsector partly accounted for the high incidence of poverty in many parts of Ghana. Improving overall agricultural productivity involves improvements in both the technology as well as the efficiency of the farmers. In spite of its importance, these integrated farming systems are characterised by a number of challenges.

Firstly, Ghanaian agriculture is characterised by the low uptake of improved technologies and low productivity. The issue of low productivity can be addressed through improved technology adoption (Mugera and Ojede, 2014) and efficiency. Some efforts have been made by the Government of Ghana, in conjunction with other development agencies, to promote a number of improved technologies in both crop and livestock production across the country in an attempt to address this low productivity. Evidence suggests that smallholder adoption of improved agricultural technologies is low (Asuming-Brempong et al., 2011; Faltermeier & Abdulai, 2009; Langyintuo & Mekuria, 2008; Morris, Tripp & Dankyi, 1999; MOFA, 2010, Olarinde et al., 2011; Ragasa et al., 2013; Wiredu et al., 2011). Improved crop and livestock technologies in Ghana include the yam minisett technology, improved crop varieties such as the dual-purpose legumes and cereals, and improved breeds of livestock. One important question that arises is: “Has the adoption of these technologies really increased productivity of smallholder farmers?” To address this question in a holistic way, this research first examines the patterns of adoption and its effect on productivity to understand this issue from both individual crops and livestock perspectives and, then from an integrated crop-livestock perspective. This will provide information on the rates and determinants

of adoption and their influence on improving productivity in crop-livestock systems. Furthermore, it will provide information that can be used to develop policies to enhance the adoption of improved technologies in integrated systems and, ultimately, increase productivity.

Secondly, in spite of governmental efforts at encouraging farm diversification as a risk mitigation strategy and also a mechanism for enhancing food security and stable incomes among smallholders, the question of whether cost-savings (economies of scope) and synergies resulting from joint production of two or more outputs are evident in integrated systems remains unanswered. Diversification studies in Ghana have focused largely on livelihoods and their determinants (Aneani et al., 2011; Fausat, 2012; Knudsen, 2007; Lay & Schüler, 2008; Senadza, 2012). To the best of my knowledge, no empirical evidence of economies of scope in crop-livestock systems in Ghana has been studied. Neither has there been any study undertaken that identifies the determinants of diversification decisions in crop-livestock systems. This research addresses this empirical gap by examining whether economies of diversification exist when farmers diversify their output combinations in integrated crop-livestock systems and identifies the determinants of diversification decisions among smallholders in Ghana. Such information will provide valuable insights to farmers on the respective cost-effective output combinations. Additionally, to enhance the production of such output combinations, policymakers and development agencies will be equipped with the factors to consider in promoting the production of such diversified output combinations for improved household incomes and livelihoods.

Thirdly, the underlying production technology currently employed by crop-livestock farmers is characterised by inherent rigidities both in the input mix as well as output combinations. This makes it challenging for farmers to alter their input and output mixes to enhance productivity once the production process has commenced. Although efforts have been made to understand productivity in crop-livestock systems in Ghana (e.g., Abdulai & Huffman, 2000; Abdulai, Nkegbe & Donkoh, 2013; Asante et al., 2013; Shamsudeen, Donkoh & Sienso, 2011), these studies focused on single-output, multiple-input cases and do not account for the change in productivity that results from changing input and output mixes, referred to as mix efficiency. To understand how the fixity in input mixes can be relaxed to enhance productivity, this research examines mix efficiency from both the input

and output perspectives. The results from this analysis will provide a better understanding of the output and input mixes that need to be focused on to enhance productivity in integrated systems. Examining the mix efficiency of these farming systems also provide information that will equip Ghanaian farmers with the ability to identify the most productive input and output mixes in their production processes. Furthermore, it is expected to assist policymakers to develop and evaluate appropriate policy alternatives to assist farmers develop more efficient input and output mixes. Such information identifies the relevant areas of intervention for efficient production in small-scale crop-livestock farming systems.

1.3 Research Objectives

The main purpose of this study is to understand the role of improved technologies and integrated crop-livestock production systems in enhancing the productivity of smallholder farmers in Ghana. To achieve this, in this study, we have three major objectives:

1. to evaluate the nature of adoption of improved technologies in key crop, livestock and integrated crop-livestock farming systems;
2. to estimate the determinants of diversification and measures of economies of diversification in crop-livestock systems among smallholders in Ghana; and
3. to evaluate the role and determinants of mix efficiency in TFP in crop-livestock farming systems.

The first objective focuses on adoption of improved technologies in integrated crop-livestock farming systems. Examining the nature of the patterns of adoption and how this influences performance of crop-livestock farmers is essential especially because productivity can be improved through improved technologies. In doing so, the effect of adoption of yam minisett technology in the efficiency of yam production is evaluated because yam is one of the major crops produced by the farmers. Similarly, the role of improved integrated crop-livestock management practices in technical efficiency of small ruminants is also examined. Finally, the adoption of dual-purpose[1] cowpea and groundnut production systems are also

[1] Dual-purpose legumes provide good yields and improved soil fertility, together with high-quality fodder for livestock (Lapar & Ehui, 2004; Mapiye et al., 2007).

evaluated taking into account the role of exposure (knowledge of both the existence and the characteristics of the varieties) and access to seed.

After the discussions on adoption of improved technologies in crop-livestock systems, Objective 2 examines whether the evidence for economies of scope in integrated crop-livestock systems. Subsequently, also in Objective 2, the discussions on the key drivers of diversification are examined and presented. To understand the productivity of multi-output, multi-input production systems, the third objective investigates mix efficiency and its determinants.

1.4 Significance of the Research

By examining the impact of exposure and access to seed on the adoption of dual-purpose cowpea and groundnut varieties, this research provides useful information on the potential for promoting innovative multipurpose technologies that provide immediate gains to farmers in terms of income and food security while improving soil fertility. Furthermore, the study contributes to determination of appropriate policies by providing valuable information to guide the design of effective strategies for promoting the adoption of the dual-purpose cowpea and groundnut varieties and the corresponding technologies in integrated crop-livestock systems. Adoption of these varieties is expected to improve environmentally sustainable crop-livestock productivity in Ghana.

Livestock efficiency studies, particularly involving small ruminants, have not examined the important role of integrated crop-livestock management practices in small-ruminant systems. This study fills this empirical gap in the small-ruminant efficiency literature by highlighting the critical role of integrated crop-livestock management practices in the performance of small-ruminant farming systems.

A number of studies have examined ‘exposure’ as a barrier to agricultural technology adoption mainly in the rice industry (Asuming-Brempong et al., 2011; Dandedjrohoun et al., 2012; Diagne, 2010; Dibba et al., 2012; Dontsop Nguezet et al., 2013). However, except for Dontsop Nguezet et al. (2013), none of these investigated the effect of lack of access to seeds on adoption. This research adds to the discussion and contributes significantly to the empirical literature on adoption by examining how lack of exposure and access to dual-purpose groundnut and cowpea seed influence the potential adoption of these varieties in Ghana and Sub-Saharan Africa.

Unlike studies that have examined the determinants of diversification as a joint decision-making process (Aneani et al., 2011; Fausat, 2012; Knudsen, 2007; Lay & Schüler, 2008; Senadza, 2012; Tasie, Offor & Wilcox, 2012), by applying the appropriate tests, this research separates the determinants of diversification into the discrete and continuous decisions; thus, assisting policymakers develop recommendations for understanding farmers' decision-making processes.

Empirical studies on mix efficiency are limited (Tozer & Villano, 2013; Hadley, Fleming & Villano, 2013). This research presents the first empirical study that examines mix efficiency in a diversified, integrated crop-livestock farming system in Sub-Saharan Africa. Essentially, it identifies the most efficient output and input mixes and the drivers of mix efficiency within crop-livestock farming systems in Ghana. Finally, this research is among the few to use fractional regression models to explain variations in data envelopment analyses (DEA) scores. These have often been investigated using ordinary least-squares (OLS) regression and Tobit models which have been found to be biased and inconsistent.

1.5 Structure of the Thesis

This introductory chapter and Chapter 2 present discussions on the background of the study area and the research approach. The empirical analyses are presented in individual paper based formats delineated by individual objectives and analyses used.

Chapters 3, 4 and 5 present empirical results and discusses the adoption of improved technologies in integrated crop-livestock systems. Given that yam is a major crop produced by the farmers in the study area, Chapter 3 presents discussion on the effects of yam minisett technology adoption on technical efficiency. This gives a better understanding of how an improved technology can influence productivity. To appreciate how similar technologies affect the performance of farmers in livestock systems, Chapter 4 presents discussions on the role of integrated crop-livestock management practices on technical efficiency and technology gaps in small-ruminant production. Chapters 3, 4 and 5 address Objective 1.

Objective 2 involves empirical analyses and discussions on diversification in integrated crop-livestock systems in Ghana. These are presented in Chapters 6 and 7. Chapter 6 presents results and discussions on economies of scope and

complementarities in diversification in integrated crop-livestock systems. It examines whether economies of diversification and complementary synergies are evident when smallholder diversify in integrated crop-livestock systems. The aim is to present the justification for further investigations into identifying and examining the factors that influence crop-livestock diversification in Chapter 7.

Achieving Objective 3 involves analysing the performance of the integrated crop-livestock sector in Ghana. Chapter 8 present results and discussions on mix efficiency and farm-level productivity in integrated crop-livestock farming systems in Ghana. It investigates whether mix efficiency is substantial in the smallholder crop-livestock systems in Ghana. This then allows for the discussions in Chapter 9 which involves the drivers of farm-level mix efficiency in integrated crop-livestock farming systems in Ghana.

Chapter 10 presents an integration of the results to draw conclusions. This includes a summary of the results, implications and recommendations, suggestions for future research and concluding remarks.

Chapter 2: Background, Study Area and Research Approach

2.1 Introduction

The purpose of this chapter is to describe the setting and framework for this study. The chapter is divided into seven sections. Section 2.2 presents an overview of the agricultural sector and the Ghanaian economy. Section 2.3 discusses the importance of the crop and livestock sectors in Ghana and features of the different agroecological zones involved. Section 2.4 provides an overview of the study area. Section 2.5 outlines the main approaches used in addressing the research objectives. This includes an outline on the empirical framework and the research approach. Section 2.6 describes the sampling and data collection procedures. The final section contains brief concluding comments.

2.2 Agriculture and the Ghanaian Economy

The agricultural sector is vital to economic growth and development of Ghana. In the national development agenda, agriculture is identified as a sector that can lead the growth and structural transformation of the economy to maximise the benefits of accelerated growth (MOFA, 2010). The agriculture sector is responsible for about 21per cent of gross domestic product (GDP) (Figure 2.1), and was the largest foreign exchange earner in 2013 (ISSER, 2013).

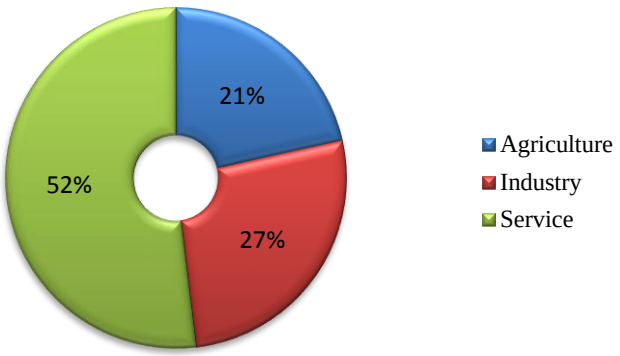

Figure 2.1:Percentage Shares of the Economic Sectors in GDP in 2014
Source: Ghana Statistical Service, 2015

Until recently, the agriculture was the largest employer, accounting for over 40 per cent of the total workforce (Ghana Statistical Service (GSS), 2014). Ghana

produces a variety of crops and livestock across various climatic zones. Agricultural crops, including yams, grains (cowpea, groundnut, maize, rice, soybean and millet), cocoa, oil palms, kola nuts, and timber form the basis of Ghana's agricultural production (ISSER, 2013).

The first Ghana Growth Poverty Reduction Strategy (GPRS I, 2003–2005) prioritised the modernisation of agriculture to spur rural and regional development. Similarly, in the second Growth and Poverty Reduction Strategy (GPRS II, 2006–2009) and its sequel, the Ghana Shared Growth and Development Agenda I (GSGDA, 2010–2013), agriculture was expected to lead the growth and structural transformation of the economy and maximise the benefits of accelerated growth.

The general performance of the agriculture sector relative to other sectors from 2003 to 2014 is presented in Figure 2.2. The figure shows that agriculture contributed immensely during the first quarter of the 12-year period (2003–2005), but afterwards its position was dislodged by the service sector which was the fastest growing sector over the rest of the period. Although the average growth rate of the GDP of the agriculture sector between 2003 and 2014 was about 4.5 per cent, that of the service sector was about 7.9 per cent (MOFA, 2013). The faster growth rate in the service sector is not likely to drive agricultural growth significantly because of weak linkages between the two sectors in Ghana. However, agriculture still contributes a significant proportion of the national GDP.

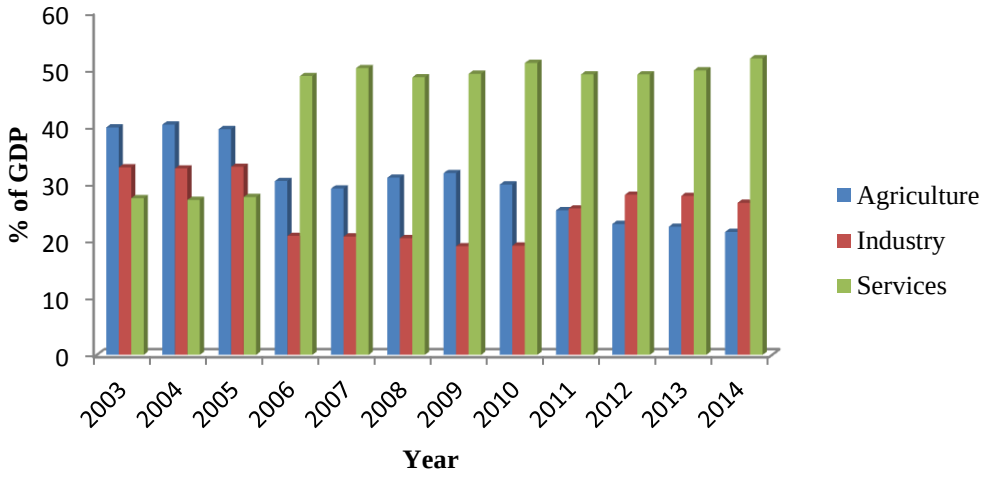

Figure 2.2: Share of Agriculture in the GDP during 2003–2012 at 2006 constant prices (%)
Source: Ghana Statistical Service, 2015

Agriculture is dominated by smallholder systems in Ghana. About 90 per cent of farm holdings are below two hectares in size, although there are some large farms and plantations, particularly for rubber, oil palm and coconut and, to a lesser extent, rice, maize and pineapples. The main system of farming is traditional, using mainly the hoe and cutlass as farming tools with minimal mechanisation. Regional agricultural production varies with the amount and distribution of rainfall, soil type and fertility. Most food crop farms are intercropped. Monocropping is mostly associated with larger-scale commercial farms (MOFA, 2010).

2.3 Importance of the Crop and Livestock Sectors

In Ghana, the term 'agriculture' incorporates both crop and livestock production. This section highlights the importance of both sectors to agricultural GDP and the entire economy.

2.3.1 Crop Subsector

Areas planted to different crops have increased only marginally since 2003. The overall percentage increase in the cultivated area between 2003 and 2012 was about 17.3 per cent or, an average, of about 1.9 per cent per year over the period (MOFA, 2013). The overall increase in production of all arable crops between 2000 and 2012 was about 41.1 per cent or 4.6 per cent per annum over the period (MOFA, 2013). Evidence suggests that agricultural growth has been mainly due to land area expansion as opposed to yield increases (Al-Hassan & Diao, 2007; MOFA, 2010). The growth rates of the agricultural GDP from 2003 to 2014 are presented in Table 2.1.

Overall, the crop subsector growth rate in agricultural GDP between 2003 and 2014 was about 7.8 per cent and is second to the cocoa subsector (8.6 per cent) which is also the largest foreign currency earner in the economy. Although the growth rate of the crop subsector is second to that for cocoa, the subsector over the years has been the largest contributor to the agricultural GDP, contributing about 65 per cent in 2014 (Figure 2.3).

Table 2.1: Growth Rates in Agricultural GDP by Subsectors at 2006 Constant Prices

Year	Subsector				Ag GDP rate
	Crop/Livestock	Cocoa	Fisheries	Forestry	
2003	5.3	16.4	3	6.1	6.1
2004	5.4	29.9	3.5	5.8	7.5
2005	3.3	13.2	-1.2	5.6	4.1
2006	3.5	2	15	2.6	4.5
2007	3.4	-8.2	-7.2	-4.1	-1.7
2008	13.7	3.2	17.4	-3.3	7.4
2009	14.6	5	-5.7	0.7	7.2
2010	9.6	26.6	1.5	10.1	5.3
2011	8.8	14	-8.7	-14	0.8
2012	6.0	-6.9	9.1	6.8	2.3
2013	8.3	3.7	5.7	4.6	5.7
2014	11.3	4.3	-5.6	3.8	4.6
Av (2003–2014)	7.8	8.6	2.2	2.1	4.5

Source: Ghana Statistical Service, 2015.

Increases in total factor productivity (TFP) are found to account for about 60 per cent of the agricultural sector growth between 2001 and 2005 and some of that growth can be traced to specific productivity-enhancing interventions as well as the cocoa sector (World Bank, 2007).

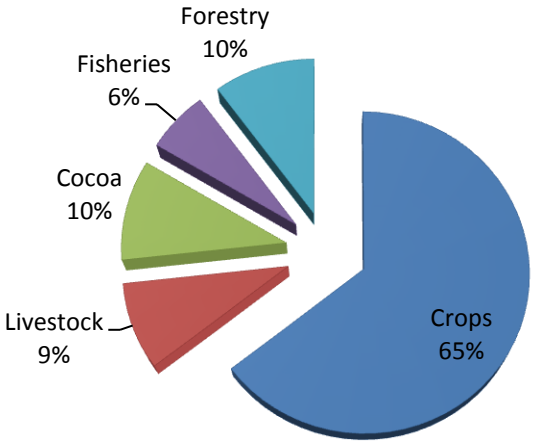

Figure 2.3: Agricultural GDP by Subsectors in 2014
Source : Ghana Statistical Service, 2015

2.3.2 Major Food Crops in Ghana

The major food crops are maize, yam, rice, cassava, cocoyam, plantain and sorghum. Common fruits and vegetables include pineapple, citrus, banana, pawpaw, mango, tomato, pepper, okra, garden eggs (eggplant) and onion.

The trends in production and yields of major crops from 2003 to 2012[2] are presented in Figures 2.4 and 2.5, respectively. The production indices depict a generally increasing trend over the period for all the crops except cocoyam and sorghum. However, in 2011, there was a general drop in the indices for most of the crops except millet. The trend shows that yam, plantain, maize and rice production are among the important crops cultivated in the country. However, yam, cassava and plantain emerged as the most important food crops in terms of yield (Figure 2.5). These staples are essential for ensuring domestic food availability at both household and national levels. For instance, yam production, increased between 2010 and 2012 which corresponded to more than doubling of the yields during this period. Yam plays an essential role both as subsistence and a cash crop. Farmers cultivate yam as a means to make quick cash to support the financial needs of their households. It is the only crop that is celebrated[3] by the people of Ghana and West Africa, in general.

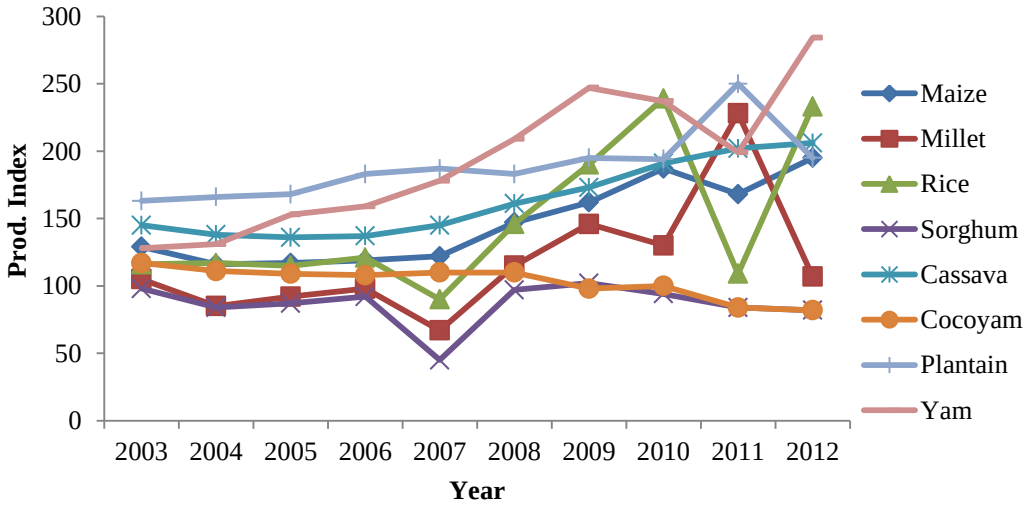

Figure 2.4:Trends in Indices of Production of Selected Food Crops (2000=100)
Source : MOFA, 2013

[2] This data is released by MOFA every two years and the current available data is up to 2012. Hence, the data for Figures 2.4–2.6 and Tables 2.2 and 2.3 are only up to 2012.
[3] The harvesting of new tubers is usually celebrated as traditional festivals in yam growing areas of Ghana and Nigeria.

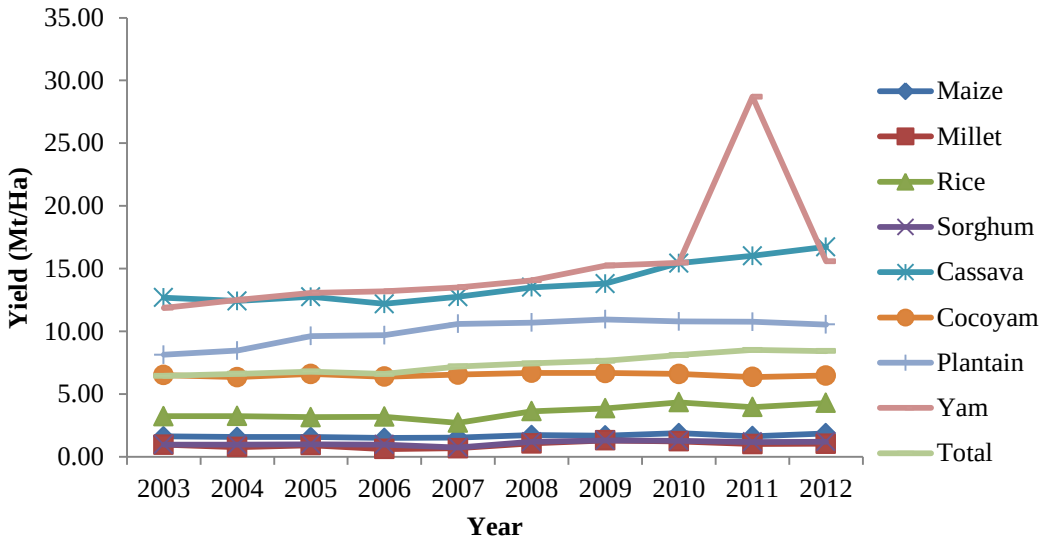

Figure 2.5: Trends in Yield of Selected Food Crops (2000=100)

Source : MOFA, 2013

2.3.3 Livestock Subsector

The livestock subsector is dominated by smallholders who are mainly crop farmers who also keep livestock such as small ruminants to supplement their incomes and/or for security purposes. There are a few well-organized commercial poultry and pig operations. The trends in the livestock population in Ghana from 2003 to 2012 are presented in Figure 2.6. Generally, there has been an increasing trend in poultry, pig and goat population. However there was a sudden increase in pig production between 2006 and 2007, due to the increased patronage of the meat in the Ghanaian social setting. Populations of cattle and sheep have been fairly stable during this period.

The total domestic meat production increased from about 77,235Mt in 2003 to 127,038Mt in 2012 (Table 2.2), representing about a 65 per cent increase over the decade. Poultry contributed the greatest proportion to total domestic meat production, followed by beef. The remaining was shared almost equally among chevon (goat meat), mutton and pork. At the same time, data on meat imports indicates an increasing trend over the same period, as presented in Table 2.3. These figures include dressed or processed livestock, dairy products and animals imported live for slaughter. It suggests that a high proportion of cattle slaughtered annually are imported from the neighbouring northern Sahelian countries in the West African subregion, particularly Mali and Burkina Faso. During this period, there is no record of importation of chevon into the country, implying that domestic

production has been able to support consumption despite its high demand (Table 2.3).

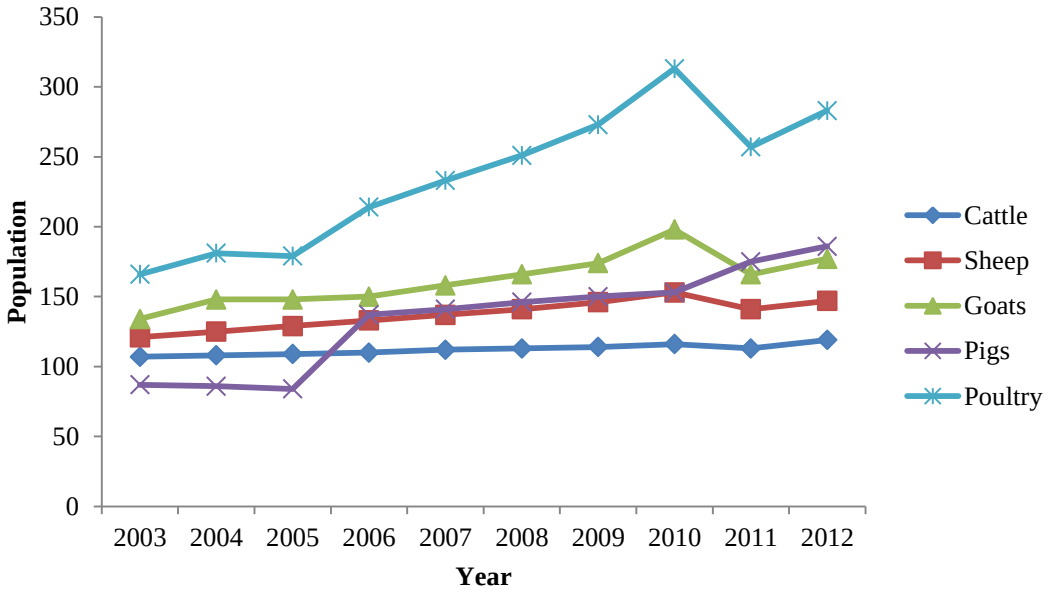

Figure 2.6: Livestock Population in Ghana, 2003–2012 (2000=100)
Source: MOFA, 2013

Table 2.2: Domestic Meat Production during 2003–2012

	Meat (Mt)					
Year	Beef	Mutton	Chevon	Pork	Chicken	Total
2003	18,486	13,568	13,884	10,181	21,116	77,235
2004	18,686	14,004	15,308	9,979	22,982	80,959
2005	18,874	14,450	15,300	9,744	22,709	76,582
2006	19,140	14,913	15,588	16,027	27,224	92,893
2007	19,346	15,390	16,364	16,498	29,630	97,229
2008	19,553	15,831	17,180	17,002	32,249	101,895
2009	19,768	16,389	18,038	17,512	34,656	106,363
2010	19,993	16,916	19,226	18,010	37,247	111,392
2011	20,592	17,491	20,341	19,072	41,008	118,504
2012	21,221	18,087	21,198	20,224	46,308	127,038

Sources: MOFA, 2013

Both meat and milk production satisfy about 30 per cent of the national animal protein requirements (MOFA, 2010), the remainder is met by imports. There is therefore the need for pragmatic efforts to increase meat production by increasing productivity and efficiency in livestock production.

Table 2.3: Meat Imports into Ghana during 2003–2012

	Meat Imports (Mt)					
Year	Beef	Mutton	Chevon	Pork	Chicken	Total
2003	1,112	2122	-	9882	32939	4,6055
2004	2,587	2053	-	7756	39089	51,485
2005	6,332	3640	-	10287	40591	60,850
2006	10,586	4839	-	13291	44758	73,474
2007	16,250	6887	-	10552	63276	96,965
2008	13,135	5961	-	5,487	89889	114,472
2009	12,338.4	6,153	-	3,150	67069	88,710
2010	11,176	4,285	-	2,717	71163	89,340
2011	14,823	4,520	-	2,507	87409	109,259
2012	16,704	2,575	-	1,786	75160	96,224.

Source: MOFA, 2013

2.3.4 Agricultural Development Policies and Interventions

It is expected that the modernisation of the agricultural sector will assist transform the country into a food-secure economy with full employment and reduced poverty. In view of this, governments have implemented a number of agricultural policies and interventions that identify infrastructure development, agricultural research and extension as a means to achieving greater agricultural productivity and household livelihoods. Ghana's agricultural policies before 1983 included price controls, input and credit subsidies, obligatory credit allocations, and heavy state involvement in production, distribution and marketing (Stryker, 1991). The input subsidies and guaranteed minimum prices were abolished in 1992.

In 1986, the 'Ghana Agricultural Policy: Action Plan and Strategies' was developed. The aims: were to ensure self-sufficiency in cereals, starchy staples and animal protein food (with priority for maize, rice and cassava in the short term); maintain adequate buffer stocks for price stabilisation and food security; and improve institutional facilities such as research, credit and marketing. However, implementing this policy was challenging because of the weak institutional capacity (Brooks, Croppenstedt & Aggrey-Fynn, 2007). Subsequently, the Agricultural Services Rehabilitation Project was implemented by the Government of Ghana in collaboration with the World Bank from 1987–1990. The aim was to strengthen institutions to be able to formulate and implement agricultural policies

and programmes, improve the delivery of public sector services, and improve the procurement and distribution of agricultural inputs by way of privatization. Failure of the Agricultural Services Rehabilitation Project to strengthen the institutional capacity led to the Medium Term Agricultural Development Programme from 1991 to 2000 which largely aimed at increasing productivity and competitiveness in the agricultural sector. Other policies and programmes which were implemented after these included the Agricultural Research Programme, the National Agricultural Extension Programme and the Fisheries Capacity Building Project.

The current agricultural policy in Ghana is derived from the Food and Agriculture Sector Development Policy I (FASDEP I) that was developed in 2003. The goals of this policy include food security, poverty reduction, supplying raw materials to industry and ensuring the sector's continued contribution to GDP, foreign exchange and government revenue. However, this was criticised by a Poverty and Social Impact Assessment committee for agricultural policy for being a one-size-fits-all policy that does not account for the diverse needs of different stakeholders in the agricultural sector, notably the very poor and women. Consequently, FASDEP II was developed as a revision of FASDEP I. The main objective stated in the FASDEP II in 2007 was the modernisation of agriculture and increased productivity of Ghanaian farmers.

The Medium Term Agriculture Sector Investment Plan (METASIP) in 2010 is the implementation plan of FASDEP II and comprises six programmes that represent Ghana's priorities with food security, emergency preparedness and increased growth in incomes being the major areas for investment.

Implementation of the METASIP includes interventions such as the Roots and Tuber Improvement Programme and Roots and Tuber Improvement and Marketing Programme (RTIMP) which aim at improving farmers' access to improved planting materials for increased yam productivity. Other interventions include the Sustainable Integration of Crop-Small Ruminant production systems in West Africa (SIIC-SR) project. This project aims at increasing the productivity of crop-small ruminant production through improved integrated crop-small ruminant technologies such as the dual-purpose legumes.

2.4 Overview of the Study Area

Ghana consists of six agroecological zones, reflecting a range of climatic, vegetation and soil types. These are classified as tropical rainforest, semi-deciduous forest, forest-savannah transition, coastal savannah, guinea savannah, and Sudan and Sahel savannah (Table 2.4). The bimodal rainfall pattern in the tropical rainforest, semi-deciduous forest, and forest-savannah transition zones leads to a separation into major and minor cropping seasons. In the Guinea savannah and the Sudan and Sahel savannah zones, the unimodal distribution results in a single growing season. The seasonal conditions and rainfall patterns determine the type of agricultural enterprise that can be carried out in each zone. These conditions ensure that food crop production is concentrated within the semi-deciduous forest, forest-savannah transition and part of the Guinea savannah zones. Commercial crops such as cocoa and oil palm are concentrated in the tropical rainforest zone.

Table 2.4: Rainfall Distribution by Agroecological Zones

Agroecological Zone	Mean annual Rain (mm)	Growing Period (Days)	
		Major season	Minor season
Tropical Rainforest	2,200	150–160	100
Semi-Deciduous Forest	1,500	150–160	90
Forest-Savannah Transition	1,300	200–220	60
Coastal Savannah	800	100–110	50
Guinea Savannah	1,100	180–200	
Sudan and Sahel Savannah	1,000	150–160	

Source: Meteorological Services Department, Accra.

This research is confined to the forest-savannah transition agroecological zone of Ghana. This zone has a unique environment that is conducive to the production of a diversity of crops and livestock (Ghana Districts Repository, 2014). The soils are largely clay loam, which are well aerated, deep and light coloured. Average annual rainfall ranges between 1200–1400mm, with mean temperature of 25^{o}C. The transitional nature of this climatic zone has led to a migration into the area by farming households from different ethnic groups and cultures. These climatic and social factors have resulted in both the widest range and highest quantity of crops being cultivated in this zone. It comprises of two main regions, a greater part of the zone covers the Brong Ahafo region whilst the remaining stretches across the Ashanti region.

Specifically, this research involves smallholders in the Atebubu-Amantin (A-A) and Ejura-Sekyedumase (E-S) districts. These districts were also selected because of their high sheep and goat population density, high potential for crop-livestock integration, low market access, high poverty index, along with proximity to existing good sheep and goat practice centres (MOFA, 2010). Agriculture plays a vital role in these districts and employs about 70 per cent and 68 per cent of the labour force in the A-A and E-S districts, respectively. In view of this, the districts have attracted several agricultural development projects and non-governmental organisations (NGOs) to assist them. Crops produced include maize, rice, cassava, yam, cowpea, and groundnuts, as well as vegetables like pepper, okra and garden eggs. Livestock production has gained increasing interest, particularly as a result of the presence of the Livestock Development Project, and a sheep breeding station of MOFA which is located in the A-A district. This station serves both districts and plays a significant role in producing improved livestock breeds for farmers. In addition, the districts have benefited from a number of agricultural development projects such as the Inland Valley Rice Development Project, the Root and Tuber Improvement and Marketing Project and the New Rice for Africa (NERICA) Rice Dissemination Project, alongside other NGOs that provide extension services to farmers at various levels.

The A-A district covers an area of about 1,996km^2 and is located between latitudes 7.23^{o}N and 8.22^{o}N and within longitudes 0.30^{o}W and 1.26^{o}W. The E-S district is approximately 1,782.2km^2 and is located between latitude 7.90^{o}N and 7.36^{o}N and within longitudes 1.50^{o}W and 1.39^{o}W (see Figure 2.7). The populations in 2013 were estimated at about 106,000 and 81,000 for the A-A and E-S districts, respectively (Ghana Statistical Service, 2013). The districts are characterised by bimodal rainfall patterns with average annual rainfalls ranging from between 1,300–2,200mm and 1,500–1,600mm for districts A-A and E-S, respectively.

However, rainfall is generally erratic and unreliable. The average temperatures in both districts are about 28°C, although low temperatures are mostly experienced during the major rainy season that between June and July. Major farming systems practiced in these districts include mixed farming, mixed cropping and monocropping (MOFA, 2013). Mixed farming is the system where a farmer is engaged in both crop production and the rearing of farm animals (integrated crop-livestock systems). Mixed cropping involves the growing of different types of

crops on the same piece of land, whereas monocropping refers to the situation where a single crop is cultivated on a piece of land for a particular season or year.

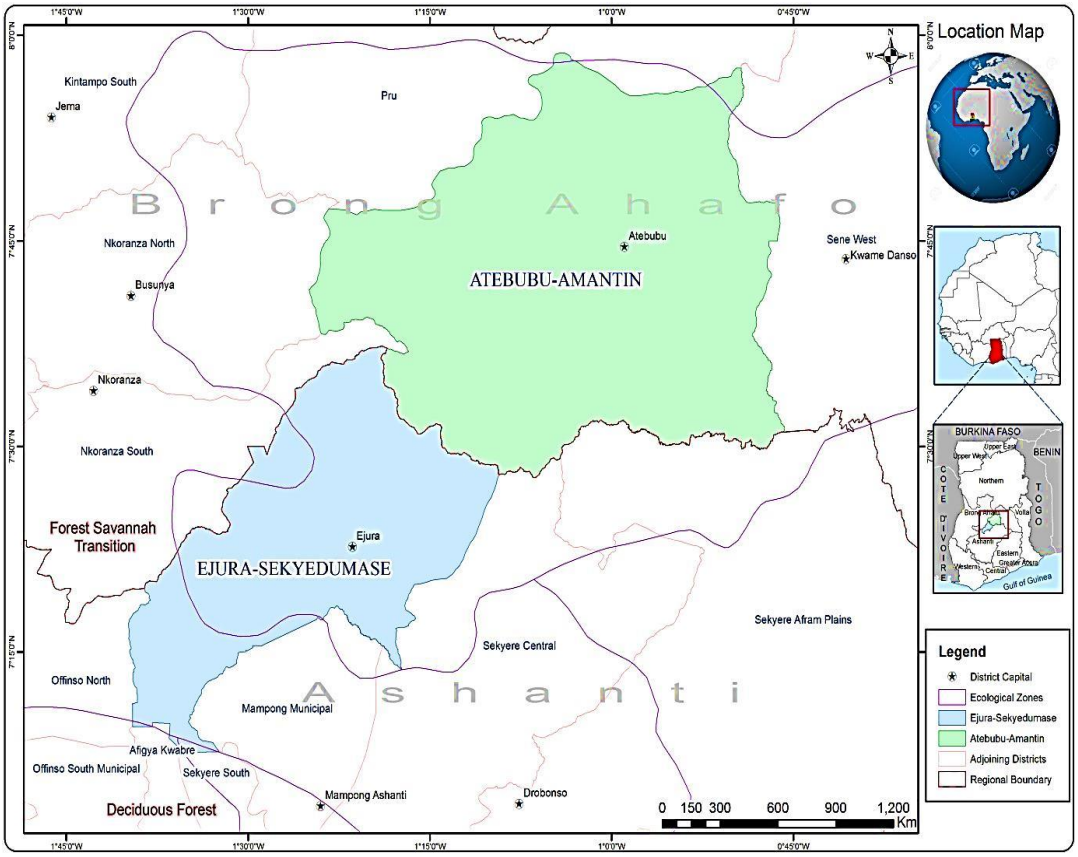

Figure 2.7: Map of Ghana Showing the Study Districts
Source: *CIRGES, University of Ghana*

Agricultural production in these districts is rainfed with no irrigation infrastructure and is dominated by the traditional shifting cultivation system.[4] The districts are among the leading producers of most local staples.

Major livestock types include cattle, goats, sheep and poultry, with duck, guinea fowls and pigs also produced. The livestock husbandry systems are generally free range[5] and mainly dominated by female producers (MOFA, 2013). Inadequate forage or fodder, high cost of veterinary drugs, and pests and diseases are major constraints to livestock production in these districts. Common livestock diseases include Peste des Petits Ruminants (PPR), pneumonia and diarrhoea (MOFA, 2013). Livestock production is a major source of livelihood for many people,

[4] This refers to a system of land cultivation in which, after clearing, the weeds are allowed to dry and are burned on the land before planting the next crop.
[5] This is a livestock husbandry system where the animals are allowed to go out to feed on their own at the early hours of the day and return to their shed when night falls.

especially in times of emergencies. Some level of integration is evident in the district, particularly the use of manure as crop fertiliser.

2.5 Empirical Framework and Research Approach

This section discusses the framework for analyses and the approaches used in each of the chapters to achieve the specific objectives of the research. A schematic presentation of the scope of the research is presented in Figure 2.8. This study employs various microeconometric approaches to evaluate the nature of adoption of technologies, performance, extent of diversification and the indicators of mix efficiency in integrated crop-livestock systems in Ghana. The analyses include a search for evidence of diversification economies in integrated systems, identifying the effects of risk on diversification as well as estimating the impact of diversification on mix efficiency. Prior to the above discussion, an analysis of the adoption of improved technologies and their effects on farm performance are presented as well as the adoption of dual-purpose legumes. Various approaches are applied to address the specific objectives of the study and details are presented in individual chapters.

As part of the analyses to achieve the first objective, Chapter 3 involves estimating the effect of the adoption of yam minisett technology on the technical efficiency of yam farmers in Ghana. First, the estimates for the adoption of yam minisett technology are obtained using the probit model. The predicted adoption scores and adoption dummies are also included in estimating the technical efficiency using stochastic frontier analysis (SFA).

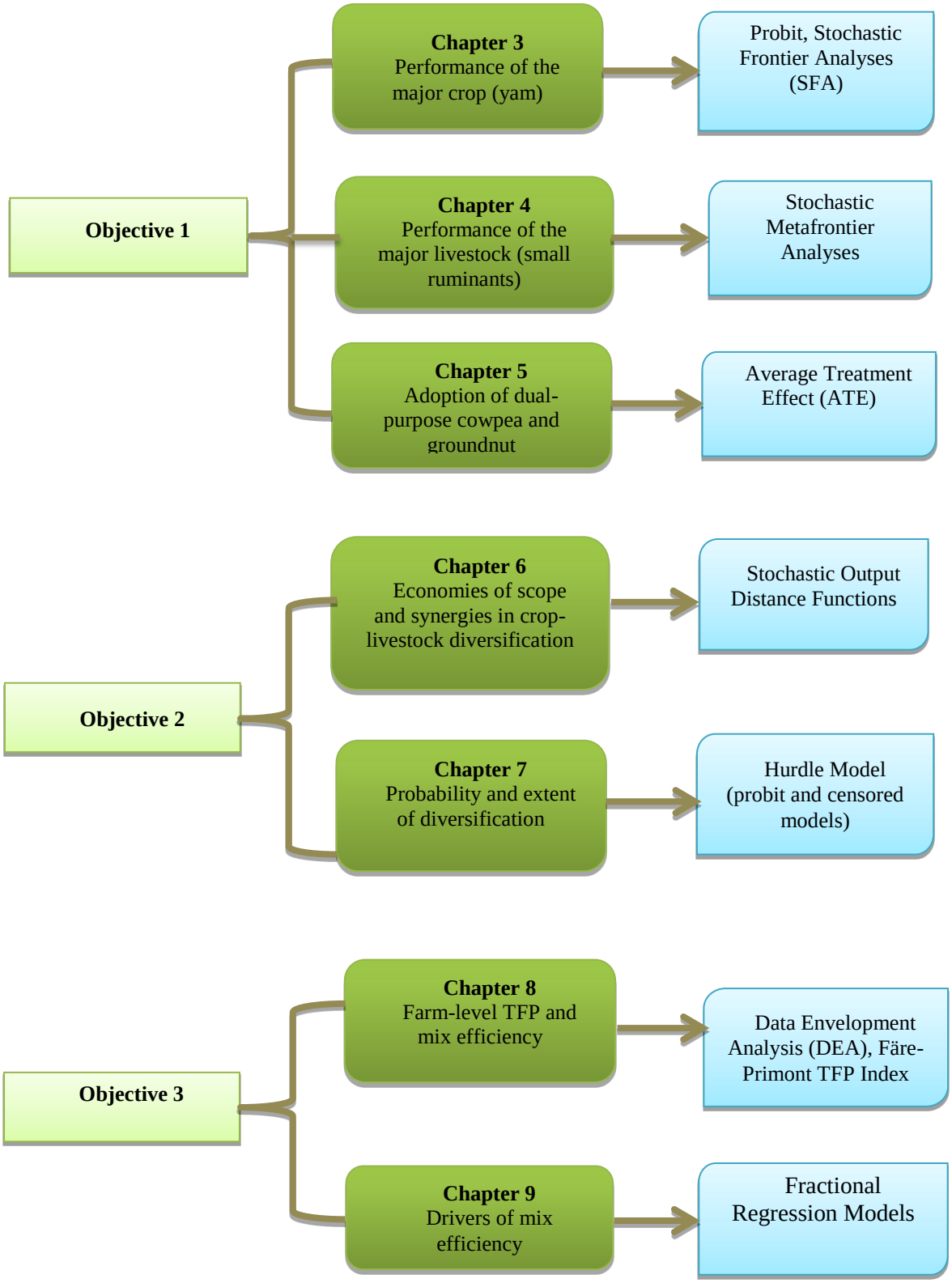

Figure 2.8: Schematic Presentation of the Scope of the Research in the Assessment of the Integrated Crop-Livestock Farming Systems

In Chapter 4, the role of integrated crop-livestock management practices on the productivity of the small-ruminant production across the selected districts are examined using the stochastic metafrontier framework. The method allows us to estimate the technical efficiencies in small-ruminant production for each district and the metatechnology ratios. The integrated crop-livestock management practices are included in the inefficiency effects variables, relevant tests are carried out and the results discussed. The final analyses in Objective 1 investigate the role of exposure and access to seed in exploring the potential adoption of dual-purpose cowpea and groundnut varieties using the average treatment effect (ATE) methodology. These analyses are presented are presented in Chapter 5.

For Objective 2, we investigate the economies of scope and complementary synergies in crop-livestock diversification by employing the stochastic distance function approaches and associated models; the results are presented in Chapter 6. In Chapter 7, the hurdle model is used to investigate the factors influencing various diversification categories. This model allows the factors influencing both the probability of diversifying and the extent of diversification to be investigated simultaneously. However, for purposes of comparison and standardisation, the Herfindahl index is used in estimating crop, livestock and crop-livestock diversifications.

For Objective 3, we examine the role of mix efficiency in integrated crop-livestock systems. By using a DEA-based approach measures of total factor productivity are obtained and decomposed into various efficiency measures including mix efficiency. Details of the methods of analysis and results are presented in Chapter 8. To understand the drivers of mix efficiency, the fractional regressions models are used in the analyses and discussions, as presented in Chapter 9.

2.6 Data and Sampling Procedures

To address the specific objectives of this research, two main databases are used to execute the analyses. The first source of data was a database accessed with permission from the CSIR-Crops Research Institute, Ghana. It provides information required for the analyses of the performance of the major crops and livestock produced by the farmers in the study area. The data for the first database was collected before the beginning of this research; this database was used for the

preliminary investigation prior to the research and formed the basis for the collection of the second database. The second database provides the data for the rest of the analyses in the study. Details of the sampling procedures are presented in Chapters 3 and 4. This section presents an overview of how the databases were collected.

2.6.1 Sampling Procedures

Multi-stage sampling techniques (purposive and random sampling) were adopted to select the respondents from the forest-savannah transition agroecological zone. In the first stage, this agroecological zone was purposively selected for the study. It presents an ideal agroclimatic environment for the production of most of the common staples in the country and also for livestock production.

The first database provides adequate information on the crop-small-ruminant producing communities and households operating in the Ashanti and Brong Ahafo regions. Selection of the sample units began with first randomly selecting from the two regions using a list of crop-small-ruminant producing regions. Three districts (Atebubu-Amantin, Ejura-Sekyedumase and Nkoranza South districts) were purposively selected from these regions. These districts were selected on the basis of their high density of sheep and goats, high degree of integration of crop-livestock systems and market access. From each district, a maximum of 23 communities are randomly selected. From each community, between five to 10 households were randomly selected from a list of crop-livestock producing households. In all, 510 farm households were selected. However, the proportion of sampled farmers producing specific crops and/or small ruminants varied within the sample; hence other pertinent information regarding this database specific to the respective analyses are described in Chapters 3 and 4.

The second database provides the data for the analyses for the rest of the chapters. It involves all farm households in the communities. The sampling procedure follows that for the first database described above but with additional communities and households within districts. Two districts (Ejura-Sekyedumase and Atebubu-Amantin) were purposively selected. From each of the two districts selected, 12 communities were randomly selected from a list of crop-livestock

producing communities in the district provided by the extension department. For each community, a minimum of 25 households[6] were randomly selected for the study. In all, 608 farm household were interviewed. The gender distribution of the respondents across the districts is presented in Table 2.5.

Table 2.5: Distribution of the Respondents by Gender and Districts

District	Atebubu-Amantin		Ejura-Sekyedumase		Overall Total	
	N	%	*N*	%	*N*	%
Male	260	42.8	204	33.6	464	76.3
Female	46	7.6	98	16.1	144	23.7
Total	306	50.3	302	49.7	608	100

2.6.2 Data Collection Procedures

Data for the analyses include farm-level output and input quantities and costs, together with data on the crops and livestock produced. Information on the type, incidence and impact of risk on crop and livestock production was collected, together with information on the present and future risk management strategies.

The data collection was in two phases, the first phase involved interviews with key stakeholders, in which key personalities such as the chiefs, elders and/or seasoned and well-experienced farmers were interviewed about issues relating to agricultural production in the area. Questions were also prepared in a checklist[7] (see Appendix 1b) that was designed to capture general community-based information, production characteristics, incidence and frequency of risk at the community level. The second phase involved face-to-face interviews with crop-livestock producing households which captured more detailed information at the farm-household level.

The formal survey elicited information from the participants using formal questionnaires (see Appendix 1a). Enumerators were trained during which time the rationale behind each question, and how it should be asked, were thoroughly discussed. In addition, some pilot surveying was done to test the questionnaire and the survey procedures in two villages per district that were not selected in the

[6]Generally, the head of household is interviewed, however, in situations where the head is unavailable or wishes to delegate a member to speak on behalf of the household, information relating to the household head and the entire household are obtained from such representative.

[7] The checklist was basically a list of community-based questions to solicit information at the community level.

survey. During the formal survey, enumerators were randomly assigned to the respondents and they engaged the respondents in personal interviews using the questionnaire as the instrument for eliciting the information.

The questionnaire was structured in four main parts. The first part captured data on demographic and household factors. The remaining parts contained information on farm-level output and input quantities and costs for the production of the various crops and livestock. Information regarding technology adoption and issues of integration was also captured. Data on risks and the incidence of risk on crop and livestock production were also captured and the final section captured information on household assets and food insecurity (Appendix1b). From a central point, the enumerators were transported to selected communities in the morning and returned in the evening. After the enumerators completed their surveys each day, short meetings were held to discuss the challenges and issues encountered in the data collection during the day. In addition, the questionnaires were checked by field supervisors each day for possible errors. Depending on the gravity of the errors, enumerators were sent back to the respondents to correct the errors.

2.7 Concluding Remarks

This chapter presents discussions on the background, research approach and the study area. The significance of agriculture in the Ghanaian economy discussed. It includes description of the selected agroecological zones and districts. In addition, the frameworks of analyses including the approaches used in addressing the specific objectives of the study are discussed. Finally, a description of the sampling procedure and data collection approaches are presented. To provide a proper context of the specific empirical analysis being conducted in individual chapters, the remainder of the thesis is structured such that, although the chapters are linked, each chapter is autonomous; hence, information regarding the study area, sampling and data collection may be repeated in individual chapters where appropriate.

Chapter 3: Effects of Adoption of Yam Minisett Technology on Technical Efficiency among Yam Producing Households in Ghana[*]

Abstract

This chapter uses cross-sectional data collected from 375 smallholder yam farmers in 2010 to examine whether adoption of yam minisett technology had an effect on the technical efficiency of production of yam farmers. We correct for endogeneity in adoption and employ the stochastic frontier analysis to investigate the effect of adoption of the technology on the technical efficiency of production. Our analysis suggests average technical efficiencies of 85.4 and 89.2 per cent in the Ashanti and Brong Ahafo regions, respectively. In addition, the effect of adoption of the technology on the technical efficiency of smallholder farmers was positive and significant in the Ashanti region but negative in the Brong Ahafo region. Our results provide information to improve the uptake of production technologies and its effect on smallholder yam farmers of Ghana.

Keywords: Yam, minisett technology, technical efficiency, Ghana

[*] This chapter is the final version of the paper published in the *African Journal of Agricultural and Resource Economics* with the citation; Asante, B.O., Villano, R.A, and Battese, G.E. (2014). The effect of the adoption of yam minisett technology on technical efficiency of yam farmers in the forest-savanna transition zone of Ghana, *African Journal of Agricultural and Resource Economics.*9(2), 75–90.

Chapter 4: Improved Crop-Livestock Management Practices, Technical Efficiency and Technology Ratios in Extensive Small-Ruminant Systems in Ghana

Abstract

This paper evaluates the performance of smallholder farmers in three districts of the forest-savannah transition agroecological zone of Ghana and examines the effect of integrated crop-livestock management practices on the technical efficiency of production of small-ruminant outputs of farmers. Using farm-level data collected from a sample of 510 farmers from the Atebubu-Amantin (A-A), Nkoranza-South (N-S) and Ejura-Sekyedumase (E-S) districts, a metafrontier production function model is used to estimate the mean technical efficiencies of farmers in each district and their metatechnology ratios. Small-ruminant outputs of the farmers are significantly influenced by the inputs, herd size, capital, labour, feed and veterinary expenses, in at least one of the three districts and for the metafrontier function. Further, the efficiency of production of small ruminants is affected by integrated crop-livestock management practices such as access to improved pasture, the use of ash, neem, and tetracycline in one or more of the three districts. The efficiency of farmers is also influenced by age, education, participation in projects and access to extension advice of the farmers in one or more districts. The results indicate that there are significant differences in small-ruminant production technologies across the three districts and that the production technology in A-A district is superior to the ones in use in the other two districts. The results underscore the need for investments in research and extension in developing and disseminating relevant integrated crop-livestock management practices and complementary training that leads to more efficient small-ruminant production and, consequently, increased farm income.

Keywords: Integrated crop-livestock management practices, technical efficiency, metatechnology ratio, extensive small-ruminant systems.

Chapter 5: Exposure and Adoption of Dual-Purpose Cowpea and Groundnut Varieties among Integrated Crop-Livestock Producing Households in Ghana

Abstract

Adoption of dual-purpose cowpea (DPC) and dual-purpose groundnut (DPG) is encouraged in integrated crop-farming system because of their benefits in terms of better yields, improved soil structure through nitrogen fixation, and good source of dry matter residue for feed or ground cover. Using data from 608 farmers, the chapter applies the concept of average treatment effect to estimate the population potential adoption rates of the DPC and DPG varieties and their determinants among crop-livestock farmers in Ghana. Population adoption rates of DPC and DPG could reach 78 per cent and 85 per cent, under full exposure, and up to 83 and 94 per cent, respectively, if they have access to seed. Furthermore, even under complete exposure, there are still adoption deficits of 5 and 8 per cent for DPC and DPG, respectively, due essentially to lack of access to seed. Effective dissemination, access to credit, research and extension can enhance exposure, access to seed and ultimately, the adoption of DPC and DPG varieties among crop-livestock farmers.

Keywords: Average treatment effect, dual-purpose, integrated crop-livestock systems, cowpea, groundnut, adoption, Ghana.

Chapter 6: Analyses of Complementary Synergies and Economies of Diversification in Integrated Crop-Livestock Farming Systems in Ghana

Abstract

Agricultural diversification may provide synergies in farm enterprises, spread production risks and improve income stability of farmers. This chapter investigates characteristics of crop-livestock diversification among smallholders in the forest savannah agroecological zone of Ghana. We use an econometric model to obtain evidence that economies of diversification and risk were significant in determining diversification decisions of farmers. Crop-livestock diversification is a desirable strategy for improving overall farm productivity among smallholders in Ghana. Economies of diversification were found to be significant among specific output combinations such as cowpea and yam, cowpea and small ruminant, groundnut and other livestock, and yam and other crops in integrated crop-livestock production system. Furthermore, output combinations such as cowpea and yam, cowpea and small ruminants, groundnut and other livestock, yam and other crops were found to exhibit decreasing effects on risk and downside risk exposure. The results indicate that to improve crop-livestock productivity through diversification, policymakers need to encourage production of these output combinations among smallholders in Ghana.

Keywords: Complementary synergies; economies of scope and scale diversification; crop-livestock farming

Chapter 7: Determinants of Crop-Livestock Diversification among Rural Farm Households in Ghana

Abstract

This study examines the drivers of diversification among crop-livestock farming systems in Ghana. Agricultural diversification has been identified as one of the mechanisms for managing household food security and poverty in developing economies, because it can spread the risk among multiple production enterprises and provide a range of food items for the households. By examining the diversified farming systems of 608 smallholders in Ghana, this paper presents empirical evidence to confirm and support the development of effective strategies that enhance diversified farming systems. The estimated mean diversification indices were 0.45, 0.32 and 0.59 for crop, livestock and crop-livestock diversification systems, respectively. Using the Cragg two-step regression model, this chapter shows that the decision to diversify and the extent of diversification are distinct decisions affected by different sets of factors. Likewise, the effect of these factors also varied across the three categories of diversification examined. Careful consideration needs to be given to the selection of factors and appropriate methods for examining the diversification process to avoid confounding recommendations. The findings underscore the importance of households' access to tillage equipment, fertilisers, credit and market information in encouraging farmers to diversify.

Keywords: Agricultural diversification, integrated crop-livestock, Cragg two-step model, Ghana

Chapter 8: Mix Efficiency and Farm-Level Productivity in Integrated Crop-Livestock Farming Systems in Ghana

Abstract

This chapter investigates the components of farm-level total factor productivity and examines the role of mix efficiency in integrated crop-livestock production systems in Ghana. Examining mix efficiency is crucial given the inherent nature of input and output fixity in the Ghanaian agriculture that limits the ability of farmers to exploit productivity gains from varying input or output mixes. A Färe-Primont productivity index is estimated and decomposed into various efficiency components. The result suggests that mix inefficiency is consistently greater than technical and scale inefficiency, using a model with an input orientation. This validates the significance of mix inefficiency in crop-livestock farming in Ghana. However, input-mix inefficiency was found to be consistently higher than output-mix inefficiency, which suggests that crop-livestock farmers are relatively able to obtain gains in productivity from altering their output mixes more than altering input mixes. Future research and development efforts on mix efficiency in crop-livestock farming and agriculture, in general, need to take account of examining input-mix inefficiency. Strategies to improve productive efficiency in Ghanaian agriculture should also emphasize improvements in mix efficiency such as policies that induce farmers to alter their input and output mixes.

Keywords*:* Mix efficiency, integrated crop-livestock systems, productivity analysis, Färe-Primont TFP index.

Chapter 9: Drivers of Farm-Level Mix Efficiency in Integrated Crop-Livestock Farming Systems in Ghana

Abstract

This chapter examines the drivers of mix efficiency in integrated crop-livestock farming systems in Ghana. Using data collected from selected regions, a Färe-Primont index of total factor productivity is estimated and decomposed into various efficiency components, including mix efficiency. Results indicated that factors such household size, land ownership extension, age, crop-livestock diversification and distance to markets contributed to mix inefficiency in integrated crop-livestock systems. To exploit gains in crop-livestock productivity and improve food security, through modifications to input and output mixes, development interventions need to consider these factors. Furthermore, supporting extension programmes with the necessary logistics would ensure effective advice and training on productive input and output mixes.

Keywords: Mix efficiency; integrated crop-livestock production; Färe-Primont index of total factor productivity; Ghanaian agriculture

Chapter 10: Summary, Policy Implications and Conclusions

10.1 Introduction

The purpose of this chapter is to synthesise the results obtained from the various empirical analyses in the thesis, thus, integrating the key findings of the various chapters.

Seasonal and climatic conditions as well as poor institutional and infrastructural support leads to financial difficulties and poverty in many smallholder households in countries such as Ghana. Integrated crop-livestock production systems have the potential to smooth out the financial effects of these conditions by allowing farmers to produce multiple products and selling at different times of the year. These systems can also play a role in increasing biodiversity and maintaining a sustainable ecological environment. However, in Ghana these farming systems are characterised by low productivity and slow uptake of technologies. Increasing productivity and uptake of improved technologies is central, not only for smallholder welfare, but also the influence that lack of productivity has on national food security.

Improvements in productivity can be obtained through both improved technologies and improvements in productive efficiency. This study explores patterns of adoption and the role of improved technologies in the performances of farmers in yam production and in small-ruminant production in an integrated crop-livestock setting.

Given the multi-output and multi-input nature of the integrated crop-livestock farming system, efforts at enhancing productivity need to take into account how changing input and output mixes can enhance the total factor productivity (TFP), which is referred to as mix efficiency. The concepts of diversification and mix efficiency have not been adequately studied in crop-livestock systems. Some research has focused on examining these concepts in terms of crops or livestock, especially diversification, but not in diversified integrated crop-livestock farming systems. Previous efficiency studies in agricultural production have focused on technical efficiency, scale and other efficiency measures. However, integrated crop-livestock farming in Ghana, involves small-scale farmers producing multiple outputs using multiple inputs, such that, in the short run, they are faced with input fixity and limited options in varying output mixes. Thus, there is a need for

research that investigates mix efficiency and its sources in these integrated farming systems. This will provide policymakers, industry and related stakeholders with information that can assist in ensuring the timely availability of a range of production inputs to allow smallholders to respond to climatic and market signals when making their production decisions.

The overall objective of the research is to evaluate the dynamics of the nature of adoption of improved technologies, diversification and mix efficiency in integrated smallholder crop-livestock systems in Ghana. The specific objectives were to:

1. evaluate the nature of adoption of improved technologies in key crops and livestock and in integrated crop-livestock farming systems;
2. estimate the determinants and economies diversification in crop-livestock farming systems among smallholders in Ghana; and
3. evaluate the role of mix efficiency in TFP in crop-livestock farming systems and its determinants.

10.2 Overview of the Study and Summary of Results

Chapter 2 discusses the study area and research approach. It details the analytical framework and highlights the methodologies used to meet the objectives. The empirical results are discussed under three main themes: analyses of improved technologies in integrated crop-livestock systems; analyses of diversification; and analyses of TFP and mix efficiency. The results of the research are summarised and discussed in the subsequent subsections in line with these themes.

Adoption of improved technologies in integrated crop-livestock systems are analysed in Chapters 3, 4 and 5. These technologies are analysed in terms of the crop and livestock types (yam and small ruminants), and in terms the dual-purpose varieties, in integrated crop-livestock production in Ghana. The results indicate that the adoption rates of the yam minisett technology are estimated at 78 per cent and 51 per cent in the Ashanti and Brong Ahafo regions, respectively. Consistent with the theory and other previous studies (Ojehomon et al., 2012; Tambo & Abdoulaye, 2012; Wiredu et al., 2012; Asuming-Brempong et al., 2011; Mariano, Villano & Fleming 2012), the results indicate that adoption is influenced by farmers' age, education, household size, being a native of the community, and extension contacts. The minisett technology is found to improve yam production outputs and the performance of farmers in both districts. The mean estimated technical

efficiency scores were about 85 per cent and 89 per cent for the Ashanti and Brong Ahafo regions, respectively, and were positively influenced by the minisett adoption, particularly in the Ashanti region.

To better understand the role of integrated crop-livestock management practices in small-ruminant production systems, the analyses in Chapter 4 shows that the small-ruminant production technologies in three districts of the Ashanti and Brong Ahafo regions were not the same. Major factors found to significantly influence small-ruminant production were herd size, capital, veterinary and feed expenses, and integrated crop-management practices such as access to improved pasture, storage of crop residue, and the use of neem, ash and tetracycline. It was also observed that while there appear to be significant differences in the performance within and between districts, there are indications that there is a potential to attain the maximum attainable output in each district, as indicated by the maximum value of one for the metatechnology ratios.

Given the potential of dual-purpose legumes in enhancing the productivity of integrated crop-livestock systems and their impacts on household income and food security, Chapter 5 presents the actual and potential adoption rates of dual-purpose cowpea (DPC) and dual-purpose groundnut (DPG) varieties and their implications on crop-livestock productivity in Ghana. Specifically, the analyses accounted for incomplete exposure and access to the seeds for these varieties. The analyses suggest that the DPC and DPG adoption in Ghana could reach 78 and 85 per cent, respectively, if all the crop-livestock farmers were exposed to the varieties and up to 83 and 94 per cent, respectively, if, in addition to complete exposure, the entire farming population had access to DPC and DPG seed. Inadequate access to seed resulted in adoption gaps of nine and ten per cent for DPC and DPG, respectively.

Accordingly, the population adoption gaps were 42 and 47 per cent (and 47 and 55 per cent) for DPC and DPG, respectively, due to incomplete exposure (and incomplete access to seed). These results indicate that exposure and access to seed are key constraints to adoption and, thus, underestimate the true population potential adoption rates for DPC and DPG varieties in Ghana. The results also indicate that farmers who have access to credit, belong to farmer-based organisations (FBOs), have contacts with extension and research, and are natives of their communities are more likely to adopt the DPC and DPG varieties. These

results highlight the importance of extension activities and provision of services that ease the financial constraints of farmers in promoting technologies in Ghana.

The nature and extent of diversification are analysed and results presented in Chapters 6 and 7. The analysis of economies of diversification reveals evidence that diversification economies and risk are significant in crop-livestock diversification decisions among the farmers. Specifically, economies of scope are significant in crops such as cowpea, groundnut and yam, in combination with small-ruminant production. Also, diversity in the production of outputs such as cowpea with other livestock, and also groundnut with yam were found to reduce exposure to production risk. Similarly, producing cowpea with yam, cowpea with small ruminants, yam with other livestock, and groundnut with other livestock also reduced exposure to downside risks in production.

Given that there is evidence of synergies and positive economies of scope in crop-livestock diversification, the analysis of the determinants of diversification in Chapter 7 show mean diversification indices of 0.45, 0.32 and 0.59 for crop, livestock and crop-livestock systems, respectively. This indicates that, farmers are more diversified into crop-livestock production Furthermore, both the discrete and continuous crop-diversification decisions were influenced by factors such as extension, use of plough tillage, the quantities of fertiliser used, and quality of road networks. For livestock diversification, the significant factors included access to market information, access to credit, distance to market, and quality of road networks. The two decisions regarding crop-livestock diversification were largely determined by the use of plough tillage, off-farm income, access to credit, access to extension, market information, and income stability.

Chapters 8 and 9 present analyses and results on mix efficiency in integrated crop-livestock systems. To understand whether mix efficiency is relevant in integrated crop-livestock systems, analyses of the role of mix efficiency in TFP are presented in Chapter 8. The results highlight the significance of mix inefficiency in crop-livestock farming in Ghana. They indicate that the mean output-orientated mix inefficiency is lower than the mean technical and scale inefficiency in crop-livestock production. Given the input orientation, however, the means of input-orientated technical efficiency, residual input-orientated scale efficiency and the input-orientated mix efficiency were estimated at 88, 91, and 84 per cent, respectively. This demonstrates that the mean input-orientated mix inefficiency is

consistently greater than mean technical and scale inefficiencies in crop-livestock production. Crop-livestock farmers are relatively more output-orientated mix efficient than being input-orientated mix efficient.

With the understanding of the important role of mix efficiency, particularly in this farming system, the study identifies the drivers of mix efficiency. The analysis and results are presented in Chapter 9. The results reveal positive effects of household size, land ownership, perception of soil fertility, contact with extension programmes, and membership of FBOs on mix efficiency. Conversely, mix efficiency was negatively influenced by the age of the household head, access to off-farm income, and distance to the nearest major market. To translate changes in scope into enhanced productivity in crop-livestock systems requires the establishment of policies that address these factors.

10.3 Policy Implications and Recommendations

10.3.1 Adoption of Improved Technologies in Crop-Livestock Systems

Given the low productivity of crops and livestock farming in Ghana, identifying and understanding ways of increasing this productivity would have significant effects on smallholder incomes and food security both at the household and national levels. One of the ways of increasing productivity is though adoption of improved technologies that increase productivity.

The analyses of the adoption of improved technologies in crop-livestock systems suggest the need for pragmatic policies to encourage the adoption of technologies such as the yam minisett technology, integrated crop-livestock management practices in small-ruminant production, and adoption of dual-purpose cowpea and groundnut varieties in integrated crop-livestock systems. The critical role of extension services in technology adoption is identified and their effect on farmers' performance evaluated. For the yam minisett technology, there has been some efforts by the government through the roots and tuber improvement and marketing programme (RTIMP) and related projects which have offered some training on the minisett technology to farmers. However, the adoption rates are still low and the issues of applying the technology to ensure efficient yam production are still deficient. Accordingly, continuous provision of training to

enhance the smooth transformation of adoption efforts into efficient yam production is encouraged.

The existing extension services that supported the RTIMP project could also be strengthened to ensure sustainability possibly by establishing good practice centres for minisett technology in appropriate districts. For instance, the extensive implementation strategy of the RTIMP, in which local farmers are identified and empowered to produce seed yams through the minisett technology, should be continued in order to enhance farmers' access to improved planting materials. A cost-effective approach through the use of locally-available inputs is suggested to increase the adoption and efficiency of production.

In Chapter 4, the small-ruminant production practices in the Atebubu-Amantin district are found to be better than in other districts. There is, therefore, the need for investments in research and extension to develop and disseminate relevant integrated crop-livestock management practices (ICLMPs). This would lead to a more efficient small-ruminant production and, consequently, increased incomes of farmers in the Nkoranza-South and Ejura-Sekyedumase districts. One such intervention is the sustainable intensification of integrated crop-small ruminant (SIIC-SR) project in West Africa for which Ghana is the regional host. This project has been implementing some of the ICLMPs, however, the scope of this is limited to the project communities. There is the need to ensure the sustainability of this project for countrywide adoption of these technologies to encourage efficient small-ruminant production.

The results suggest that farmers in all three districts have the potential to overcome their constraints and improve their productivity. Thus, appropriate policies and strategies aimed at supporting small-ruminant farmers to improve production need to be encouraged. This may include establishment of a national pasture policy that promotes community-based pasture for improved small-ruminant production in Ghana. A similar policy has been implemented successfully in Mongolia (Taylor, 2006), where community-established pasture has successfully led to improved livestock productivity. In the case of Ghana, such a policy is capable of providing feed for livestock within the community, especially during the dry season. This could involve the establishment of community-based pasture areas or over-sowing existing community-based pastures with drought-tolerant legume pastures. This has the potential to ensure the availability of good quality feed,

especially during the dry season when feed is limited. This requires research and extension efforts in developing and disseminating drought-tolerant species of existing legume forages such as stylosanthes and pigeon pea. The use of tetracycline, ash and neem extracts are initial steps farmers undertake to manage symptoms of external parasites in small ruminants. Research and development efforts need to tap into, and investigate further, the adaptability and sustainability of these practices for potential upscaling to help farmers reduce the disease-related mortality rates and ensure sustainable small-ruminant systems.

To ensure a sustainable increase in crop and livestock productivity in crop-livestock farming systems in Ghana, increasing the adoption of DPC and DPG varieties is critical. Given the significance of the varieties for providing good yields of grains and an appreciable amount of fodder for livestock, while improving the fertility of the soil, investments in increasing the dissemination and availability of seed to farmers are critical policy considerations. Factors such as access to credit and research and extension services are identified for effective targeting of strategies for promoting exposure, access to seed and adoption of the DPC and DPG varieties in Ghana. To enhance credit access through input credit schemes, the approaches used by the 'block farm' system of the Ministry of Food and Agriculture (MOFA) in Ghana should be extended. For example, government could partner with and empower private input-credit providers to ensure timely access to essential farm inputs to farmers when required by reducing the acquisition time through reduced demand for collateral and competitive interest rates.

The results indicate that supporting crop-livestock farmers with access to credit and extension services would improve adoption of the DPC and DPG varieties. This will enhance their ability to purchase the necessary resources for effective adoption of these varieties. This could be supported by enhancing public and private investments to improve farmers' access to extension and research through the agricultural extension services, FBOs and the national agricultural research institutions. This will ultimately enhance crop-livestock integration and potentially lead to significant and environmentally-sustainable crop-livestock productivity gains with their attendant effects on farm incomes and household food security.

10.3.2 Diversification in Crop-Livestock Systems

The results discussed in Chapters 6 and 7 indicate that there is evidence of complementary synergies and economies of scope in crop-livestock diversification and, hence, the potential to improve farm productivity. However, although the results indicate that, diversified farmers are more productive than specialised farmers, the benefits from diversification are only evident if farmers diversify into particular commodity combinations. To improve productivity and associated benefits from crop-livestock diversification, policymakers need to encourage the production of cowpea, groundnut and yam, in combination with small ruminants, such as sheep and goats.

In addition to economies of scope, to reduce risk exposure in crop-livestock systems, the integration of commodities such as cowpea with yam, cowpea with small ruminants, yam with other livestock, and groundnut with other livestock outputs should be further encouraged. Finally, to obtain the associated benefits from crop-livestock diversification there is a need for policymakers to highlight the importance of the production of these specific output combinations in crop-livestock systems among smallholders in Ghana. This will reduce food insecurity and poverty among rural farm households and the entire rural population.

10.3.3 Factors Influencing Diversification in Crop-Livestock Systems

For diversification to achieve the desired benefits, policy and development agencies need to consider enhancing farmers' access to information, capacity building and improved institutional and infrastructural support. This requires including diversified systems related extension advice and the supply of information to farmers in areas where diversified farming systems are feasible. Providing training to farmers on the most productive cost-effective output combinations has the potential to eliminate the perceived risks associated with the production of these combinations.

Farmers' access to tillage equipment and fertiliser also needs to be improved. The efforts by MOFA through the establishment of mechanisation centres where farmers can access tillage equipment should be reinforced through effective monitoring and maintenance of implements. In addition, partnering with interested private investors may be helpful in improving farmers' access to tillage equipment. The fertiliser subsidy programme, in which coupons are provided to farmers to

purchase fertilisers at subsidized prices, needs to be implemented effectively to ensure timely availability within reasonable proximity.

10.3.4 TFP and Mix Efficiency in Crop-Livestock Systems

The results in Chapters 8 and 9 indicate that total factor productivity is estimated at an average of 52 per cent whereas the optimal TFP was 77 per cent. This suggests that with the available resources, there is the potential for productivity to be increased by 25 per cent. This could be made possible by enhancing the TFPE. Accordingly, the key components of farm-level TFPE in crop-livestock systems, from both the input and output orientations, are technical efficiency, mix efficiency, and residual scale efficiency. However, besides technical and scale inefficiency, mix inefficiency is another important performance measure to consider in crop-livestock production. It is more challenging for crop-livestock farmers to improve productivity by altering their input mixes due to fixity in production inputs. Future research and development efforts on mix efficiency in crop-livestock farming and agriculture need to take account of input-mix inefficiency.

Strategies to improve productive efficiency in Ghanaian agriculture also need to emphasise policy improvements that encourage farmers to alter their input and output mixes. These strategies need to take account of the fact that changes in commodity selection in smallholder households may take time.

10.3.5 Factors Influencing Mix Efficiency

Given the essential role of mix efficiency in enhancing overall farm productivity in crop-livestock systems in Ghana, understanding the drivers of mix efficiency is important for farmers, policymakers and stakeholders. These are discussed in Chapter 9. In the short term, it is recommended that policies focus on supporting extension programmes with the necessary logistics to ensure effective advice and training to determine productive input and output mixes. Others include promoting integrated crop-livestock farming systems that have the potential to improve soil fertility in the long run and, hence, contribute to the long-term sustainability of crop-livestock systems in Ghana. Finally, the government should focus on improving the quality of the roads, especially by increasing the number of access roads to rural farming communities. Improved roads will enhance crop-livestock

farmers' timely access to inputs, which, in turn, will enable them to adjust input mixes according to production circumstances and to enhance their mix efficiency, productivity and food security.

10.4 Limitations and Areas for Future Research

Understanding diversification and mix efficiency in line with adoption of improved technologies in crop-livestock farming systems is a complex process. Some of the limitations and their recommendations for future research are presented below.

The empirical analyses are based on cross-sectional data. The data were collected from small-scale farmers through interviews. While efforts have been made to account for variation in responses between and within districts, some variables may be subjective. The use of cross-sectional datasets assumes a static nature of the production systems. To account for the dynamic nature, especially in the analysis of the decomposition of TFP indices, mix efficiency and diversification, longitudinal or panel data would allow an analysis and discussion of trends of TFP indices over time. Future research needs to conduct complementary surveys to obtain panel datasets that present the relevant variables over time. This could allow for a more thorough analysis of TFP and mix efficiency over time.

In Chapter 3, propensity score matching approach was used to control for possible biases due to observed variables. In reality, however, self-selection may also be affected by some unobservable covariates particularly in the case of adoption where the treatment is endogenous; there is the possibility of noncompliance. Also the integration of the predicted adoption probabilities into the SFA production frontier in the analyses will not always resolve the endogeneity in nonlinear models. The joint estimation approach by Greene (2010) which takes into account both observed and unobserved biases by jointly estimating the adoption model is suggested for future analysis.

Mix efficiency was estimated essentially by computing and decomposing TFP indices using the nonparametric DEA approach which does not account for random errors. Future research should estimate the indices and mix efficiency using the parametric stochastic frontier analysis (SFA) approach for possible comparisons implications.

In Chapters 3, 4 and 5, this study focused on the adoption of only one major crop and livestock type. A more a comprehensive approach would be to examine the adoption of other major crops such as maize, rice and cassava would also be useful in order to better understand the implications of adoption on food security and poverty. In Chapters 6 and 7, the analyses focused on how complementary synergies and risk could influence farmers' choice of crop and livestock output combinations. In these chapters, the effects of climate-based variables on the choice of crops and livestock output combinations were not analysed because of lack of data. Including such variables may provide valuable information in understanding the dynamics of the impacts of climate change on crop-livestock productivity, and hence, it is suggested for future research.

The efficiency analyses in Chapters 5, 8 and 9 used models that did not include the effect of state- or climate-based variables that can highly influence the onset, types and choice of various farm activities. Future research could use a state-contingent approach in order to better understand the importance of these factors. Finally, most of the efficiency analyses such as technical efficiency, scale efficiency and mix efficiency, considered only the production side. Examining allocative efficiency, which incorporates the effect of input prices, is suggested for future research. Furthermore, fractional regressions models were used to examine the determinants of DEA mix efficiency scores. An alternative is to use the double-bootstrapping approach. Further research that examines ways of incorporating the double-bootstrapping approach into estimating mix efficiency is recommended.

The analyses in Chapter 6 focused only on the output combinations that reduce risk and downside risk exposure, however, the concept of risk preferences of farmers and their risk attitudes were deficient, hence is recommended for future research. Furthermore, the issue of adoption of technologies when risk preferences are accounted for, as well as the effect of risk preferences on productivity, may be useful areas for providing relevant policy directions

10.5 Concluding Comments

This thesis contributes to the literature in various ways. Theoretically, in order to understand the complexity of agricultural production systems in Ghana and SSA, one need to consider examining the production systems in terms of individual crops, individual livestock and then in a framework that allows an integrated crop-

livestock farming to be examined. Methodologically, this study identifies and investigates the effect of improved crop-livestock management practices in understanding diversification and performance and of these systems using various microeconometric approaches. In addition, the study extended the efficiency literature by investigating the drivers of mix efficiency in an integrated farming system. Empirically**,** this study is among the first to apply the relevant tests of separability in applying the Cragg two-step model in investigating the continuous and discrete diversification decisions which has for a long time been investigated as a joint decision. The study also the first to apply the fractional regressions models to examine the drivers of mix efficiency in an integrated system.

Additionally, this study is to provide empirical evidences that can be used by researchers, policymakers, extension agents, and other non-governmental organisations in developing strategies to improve the livelihoods of crop and livestock farmers in Ghana. This study highlights the importance of adoption of improved technologies, both in the crop and the livestock sectors, in an individual or integrated setting. It is imperative for different stakeholders to evaluate and address the constraints to adoption of these technologies. The study also suggests that diversification is an integral strategy to deal with the issues of poverty among farmers resulting from non-regular flow of income. While diversification is already promoted as a way to diversify sources of income and mitigate risk associated with farming, it is, important also to address the constraints to adoption.

Furthermore, this thesis addresses the complexity of integrated farming systems, including finding evidence of economies of scope, investigate synergies and complementarities between different enterprises and examines the effects of mix efficiency on total factor productivity. This information is vital to the farmers, policy and development partners in enhancing the productivity of crop-livestock farming systems which ultimately would increase the incomes, reduce poverty and enhance livelihoods of rural farm households in Ghana.

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Appendices

Appendix 1a: A Questionnaire for the Farm Household Survey on a Microeconometric Assessment of the Integrated Crop-Livestock Production Systems

0A. Background information

Item	Response	Code
Name of respondent		
Farmer ID		
Name of Community		
District code		
Name of the Enumerator		
Date of interview		

Checked & signed off: Bright Asante: _____ **date:** _____ **District code:** *1 = Atebubu/Amantin, 2 = Ejura*

DEFINITION OF CONCEPTS

For the purpose of this survey, the following concepts are used:

A **household** is a group of people who live together and eat together from the "same pot".

A household member refers to those who have lived with this household in the last 12 months.-

A **respondent** is the head of the household who plays the major role in decision making both economic and social within the household.

The information regarding crops and livestock production in this survey relates to the immediate past season.

A. General Information and Household Characteristics

1. Gender of respondent *(1: Male, 2: Female)*	
2. How old are you?	
3. Have you had formal schooling? (*1=Yes, 2=No.)* If no, go to Q5.	
4. How many years did you spend in school? *(Years of schooling).*	
5. What is your current marital status? *(1 Single; 2=Married; 3=Divorced; 4=Separated; 5=Widowed)*	
6. How many wives do you have? OR (*for female respondents only*) How many wives does your husband have?	
7. How many persons are in this household?	
Of the total household members, can you please tell us:	
8. How many are males?	
9. How many are females?	
10. How many are engaged in household farm activities?	
11. How many are engaged in non-farm activities?	
12. What is your main occupation? (*1 = farmer, 2 = salaried position, 3 = own business, 4 = other_____)*	

B. <u>Land Access and Tenure</u>

We would like to ask about your household's access to land:

13. How much land area does your household own?	Acres
14. How much land area is communal land that your household has access to?	Acres
15. How much land area was rented in by your household the last 12 months?	Acres
16. How much *customary land (clan or tribe or family) area* does your household have access to?	Acres
17. How much land area is sharecropped by your household?	Acres
18. How much area is used by your household for crop production?	Acres
19. How much area is used by your household for livestock production?	Acres
20. Do you have access to adequate arable land in this community? *(1=Yes, 0=No)*	
21. What are the main constraints to obtaining adequate arable land for your production in this community?	
High rents; (1=Yes, 0=No)	
Not belonging to a clan/family; (1=Yes, 0=No)	
Being a female; (1=Yes, 0=No)	
Other (specify)…….	
22. Did *you grow crops and rear livestock in the immediate past season? (1=Yes, 0=No)*	

C. Crop Production Resources, Output and Utilisation; *NB: outputs are crops quantities directly harvested in the immediate past season, All costs to be quoted in GH₵*

Crop	What crops did you grow last season? *(Tick the appropriate)*	How much land area was planted to these crops? (Acres)	What is the cost per acre if rented	What is the name of the main variety planted?	*What planting arrangements did you apply to these crops?	What was the total output **harvested** in 2013?		Of this, what quantity was **consumed** by your household?		Of this, what quantity was **sold**?		What was the selling price per unit at harvest	What was the selling price per unit 6 months after harvest	What was the selling price per unit before the next planting season	Of this, what quantity was given out as **gifts**?	
						Qty	*Unit code	Qty	Unit code	Qty	Unit code				Qty	Unit code
Maize																
Rice																
Cowpea																
Groundnut																
Pepper																
Garden egg																
Okra																
Cassava																
Yam																

D. Input Use for Crop Production *I now want to ask about the inputs for the crops that you cultivated in the immediate past season. All costs to be quoted in GH₵.*

Crop	Seed use			Fertiliser use								Was the fertiliser a subsidized one	Agrochemical use *(Pesticide=1, herbicide=2)*			
				1st application				2nd application								
	What Qty. was used?	Unit Code	What was the cost per unit?	What type was applied? Code	What Qty. was applied?	Unit Code	What was the cost per unit?	What type was applied? Code	What Qty. was applied?	Unit Code	What was the cost per unit?		What type agrochemical was applied	What qty. was applied?	Unit Code	What was the cost per unit?
Maize																
Rice																
Cowpea																
Groundnut																
Pepper																
Garden eggs																
Okra																
Cassava																
Yam																

Fertiliser code: *0=None; 1=NPK; 2=UREA; 3=Ammonium sulphate; 4=(dry) manure; 5=(fresh) manure; 6=ash; 7=compost; 8=household waste; 9=crop residue; 10= other (specify)*

Unit code: *1=150kg bag;2=130kg bag; 3=50kg bag; 4=kgs; 5=grams; 6=litre;, 7=tonnes;8=numbers;9=wheelbarrow load; 10=tricycle load; 11=head load; 12=other (specify)* **……..**

Planting arrangements code: *1=monocropping; 2=mixed cropping; 3=crop rotation; 4=don't know*

E. Labour Use for Crop Production ***NB:*** *please complete each activity (row) at a time before picking the next activity (row)*

Crop	Activity	Household labour			Communal Labour			Hired Labour			What was the cost if c**ontract labour was** used
		How many **persons** were involved?	How many **days** were used to complete this activity?	How many **hours** were spent per day?	How many **persons** were involved?	How many **days** were used to complete this activity?	How many **hours** were spent per day?	How many **persons** were involved?	How many **days** were used to complete activity?	How many **hours** were spent per day?	
Maize											
Rice											
Cowpea											

Activity codes: *1=land clearing; 2=pre-planting herbicide application; 3=ploughing; 4=harrowing; 5=sowing; 6=1st weeding; 7=2nd weeding; 8=1st fertilizer application; 9=2nd fertiliser application; 10=post-herbicide application; 11=pesticide application; 12= bird scaring; 13=harvesting; 14=threshing; 15=winnowing; 16=milling; 17=mound making; 18=staking; 19=other…….*

Crop	Activity	Household labour			Communal Labour			Hired Labour			What was the cost of **contract labour** used in activity
		How many **persons** were involved?	How many **days** were used to complete this activity?	How many **hours** were spent per day?	How many **persons** were involved?	How many **days** were used to complete activity?	How many **hours** were spent per day?	How many **persons** were involved?	How many **days** were used to complete activity?	How many **hours** were spent per day?	
Groundnut											
Pepper											
Garden eggs											

Activity codes: *1=land clearing; 2=pre-planting herbicide application; 3=ploughing; 4=harrowing; 5=sowing; 6=1st weeding; 7=2nd weeding; 8=1st fertiliser application; 9=2nd fertiliser application; 10=post-herbicide application; 11=pesticide application; 12= bird scaring; 13=harvesting; 14=threshing; 15=winnowing; 16=milling; 17=mound making; 18=staking; 19=other…….*

Crop	Activity	Household labour			Communal Labour			Hired Labour			What was the cost of **contract labour** used in activity
		How many **persons** were involved?	How many **days** were used to complete activity?	How many **hours** were spent per day?	How many **persons** were involved?	How many **days** were used to complete activity?	How many **hours** were spent per day?	How many **persons** were involved?	How many **days** were used to complete activity?	How many **hours** were spent per day?	
Okro											
Cassava											
Yam											

Activity codes: *1=land clearing; 2=pre-planting herbicide application; 3=ploughing; 4=harrowing; 5=sowing; 6=1st weeding; 7=2nd weeding; 8=1st fertiliser application; 9=2nd fertiliser application; 10=post-herbicide application; 11=pesticide application; 12= bird scaring; 13=harvesting; 14=threshing; 15=winnowing; 16=milling; 17=mound making; 18=staking; 19=other…….*

F. Livestock Output and Utilisation

Provide information *on the* ***number of livestock managed, sold, purchased, lost and consumed*** *by your household in the immediate past season. (All prices in GH₵)*

What livestock did you rear last season?	How many did you manage last season?	Of this, how many were *sold*?	What was the *unit selling price?*	What is the minimum selling price for the season?	What is the maximum selling price for the season?	Did you *purchase* any additional ones? (*1=Yes, 0= No*)	If yes, how many were *purchased*?	What was the *unit purchasing price*?	Of the livestock managed how many *died*?	How many of this livestock were *consumed* by your household?	How do you perceive the demand for your crops and livestock products to be? (*1= high, 2=moderate, 3= low)*
Cattle											
Goats											
Sheep											
Chicken											
Guinea fowl											
Duck											
Other											

G. Inputs Use for Livestock Production. *I now want to ask about the inputs for the livestock that you reared in the immediate past season. All costs to be quoted in GH₵*

Livestock	How much did you spend on **feed?**	How much did you spend on **water?**	How much did you spend on **supplements** e.g. salt lick	How much was spent on b**asins**?	How much was spent on **transport**?	How much was spent on v**eterinary services**?	How much was spent on **housing**?
Cattle							
Goats							
Sheep							
Chicken							
Guinea fowls							
Duck							
Other							

Unit code: *1=150kg bag; 2=130kg bag; 3=50kg bag; 4=kgs; 5=grams; 6=litres; 7=tonnes;8=numbers; 9=wheelbarrow load; 10=tricycle load; 11=head load; 12=other (specify)*

.....

H. Labour Use for Livestock Production

Livestock	Activity	Family Labour			Communal Labour			Hired Labour			What was the cost of **contract labour** used in activity
		How many **persons** were involved?	How many **days** were used to complete activity?	How many **hours** were spent per day?	How many **persons** were involved?	How many **days** were used to complete activity?	How many **hours** were spent per day?	How many **persons** were involved?	How many **days** were used to complete activity?	How many **hours** were spent per day?	
Cattle											
Sheep											
Goats											
Chicken											
Guinea fowl											
Duck											

Activity Code: *1=Feeding; 2=Herding; 3=Cuts and carry; 4=Pasture establishment; 5=Deworming; 6=Pen construction; 7=dipping; 8=collection of household waste; 9=pasture maintenance; 10 =cleaning pens; 11 =Watering; 12=Tethering; 13=Vaccination; 14=other……*

I. Reasons for Producing both Crops and Livestock

If you were producing crops and or livestock in the immediate past season, please indicate if the statements below were factors in your decision making.

Statements *(tick the appropriate box)*	Strongly disagree	Disagree	Indifferent	Agree	Strongly agree
*1. To obtain a **stable source** of household income*					
2. To ensure availability of food for the household throughout the year					
3. To meet the demand for certain crops and or livestock products in the market					
4. To respond to higher prices at certain times of the year					
5. To reduce the total cost of production					
6. To enhance soil fertility through the use of manure and crop residue to soil					
7. It provides available feed for livestock using crop residue					
8. It provides funds to support cropping activities through the sale of livestock					
9. It provides funds to support the purchase of new breeds of livestock					
10. It provides draft power for cropping activities					

J. Income and Expenditure profile of household

Income: *Besides crop and livestock incomes, what were your other income sources in the immediate past season? All amounts should be quoted in GH₵.*

Income Sources	Amount	Income Sources	Amount	Income Sources	Amount
How much was from trading?		How much was from selling charcoal?		How much was from **livestock** processing?	
How much was from remittances?		How much was from **crops** processing?		How much wages did you receive from agric. labour	
How much was from selling firewood?		How much was from pensions?		Other _____	
23. Did any member of your household receive any payment for salaried employment? (*1=Yes 0=No)*					
If yes, how much was for each household member?	1.	3.	5.	7.	
	2.	4.	6.	8.	

Expenditures: What were your expenditures during the immediate past season? (Amounts in GH₵)

Expenditures source	Amount spent	Expenditures source	Amount spent	Expenditures source	Amount spent	Expenditures source	Amount
Crop processing		Food expenses		Remittances to relatives		Taxes	
Livestock processing		Social contributions at functions		Transport		Trading	
Light/electric power		Contributions to associations/groups		Schooling		Other	
Medical expenses		Accommodation maintenance		Rent			
Clothing		Pharmaceutical products		Fuel			

K. Credit Access

24. Did you borrow ***money*** for your production activities in immediate past season? *(1=Yes; 0=No),* if no, go to Q31.	
25. If yes, how much? (GH₵)	
26. From which major source? *(1=Bank; 2=Money lender; 3=Neighbor; 4=Relative; 5=NGO; 6=Project; 7=Cooperative; 8=company 9=Other, specify: _____)*	
27. Was it received on time? *(1=Yes; 0=No.)*	
28. Are you able to repay? *(1=Yes; 0=No.)*	
29. If NO, why *(1= poor harvest, 2= livestock outbreak; 3=low prices of produce; 4= other specify: _____)*	
30. If yes, in what form was it repaid? *(1=cash, 2=crop produce, 3= livestock, 4= other assets, specify: _____)*	
31. Did you borrow any ***inputs*** for your production activities in mediate past season? *(1=Yes; 0=No),* If no, go to 37.	
32. If yes, What was the approximate value (GH₵)	
33. From which major source? *(1=Bank; 2=Money lender;; 3=Neighbor; 4=Relative; 5=NGO; 6=Project ; 7=Cooperative; 8=company; 9=Other; specify: _____)*	
34. Was it received on time? *(1=Yes; 0=No.)*	
35. Are you able to repay? *(1=Yes; 0=No.)*	
36. If yes, in what form was it repaid?(1=cash; 2=crop produce; 3= livestock; 4= other assets; specify: _____)	
37. If you did not receive credit what was the reason(s)? (*1=Not interested;2=No available credit facility; 3=Did not look for credit; 4=Had no collateral; 5=High interest rate; 6=other ……)*	

How easy was it to get credit from the following financial sources? (*Tick the box*)	*Don't know*	*Very hard*	*Hard*	*Easy*	*Very easy*
1. Bank					
2. Micro finance institution					
3. Cooperative/savings group or credit union					
4. Government credit program					
5. Village buyer/wholesaler					
6. Village moneylender					
7. Relatives					

L. Extension and Market Access

	Response	Unit
38. What is the distance from the farm to the nearest produce market?		
39. What is the distance from the farm to the nearest input market?		
40. What is the major means of transport to these markets *(1=truck; 2=motorcycle; 3=bicycle; 4=foot; 5=other……..)*		
41. How far is your house to the agric. extension agent?		
42. What is the distance from your farm to the nearest tarred road?		
43. Did any member of this household had contact with agricultural extension agents in the last 12 months? (*1=Yes; 0=No)*		
44. If yes, how many times did this happen in the immediate past season?		
45. Did any member of this household participate in any agricultural training in the immediate past season? (*1=Yes; 0=No)*		
46. If yes, how many times did this happen in the immediate past season?		

Distance unit code: *1=Miles, 2= Km*

Please provide information on organizations maintaining or having maintained links with the household (including farmer groups and local organisations)

What is the Name of the organisation?	What type of org. is this? (Code)	What is the primary activity of this org.? (Code)	What type of relationship do you have with this org.? (Code)	What Benefits did you obtain from this org.? (*write those that apply*) (Code)

Organisation type Code: *1=National Agricultural Research Institution*s (CSIR-SARI or CSIR-CRI or CSIR-SRI or CSIR-FRI or CSIR-WRI or Universities)*; 2=Extension services; 3=NGO; 4=Project; 5=Farmer's organization; 6= International Agricultural Research Institution; 7=Microfinance Institution; 8=Other (specify)……...).* **Relationship Code:** *1=seed donation, 2=seed purchase by the institution, 3=sale of seed by the institution, 4=technical advisory carried out by the institution, 5=trainings, 6=credit in kind (e. g.7=credit in cash, 8=Equipment allocation (farming equipment), 9=sales of fertilizers, 10=fertilizer donation, 11=other (specify……..).* **Primary activity Code:** *1=Income generating for group members, 2=Group marketing of products, 3=Group production of products, 4=Group access to inputs and extension services, 5=Mobilizing saving and credit for group members, 6=Promotion of improved farming practices, 7=Mutual support/Social services, 8=Other……..).* **Benefits Code :***1=Gift of seeds 2=purchase of seed 3=sale of seeds 4=training 5=advice 6=credit 7=provide equipment 8=sale of fertilizer 9=gift of fertilizer 10=tractor service 11= veterinary drugs 12 = improved breeds 13 = feed 14 = mineral lick 15 = watering facility 16 = donkey and cart 17 = Easier access to inputs, 18=Easier access to markets of products, 19=Easier access to extension services, 20=Easier access to credit, 21=Easier access to transport, 22=Better input and output prices.*

M. Crops-Livestock Integration and Technology Adoption

47.	How do you store your crop residues? *(1 = Left as standing hay, 2 = Open storage, 3 = Storage in an enclosed area)*	
48.	Do you feed your crop residue to your livestock? *(1 = Yes, 2 = No, 3= Sometimes)*	
49.	If yes or sometimes, when do you start feeding your stored crop residues?*(1 = Just after crop harvest, 2 = in Periods of feed scarcity)*	
50.	If yes or sometimes, for how long do you feed your stored crop residues?*(1 = 1-2 months, 2 = 3-4 months, 3 = 5-6 months)*	
51.	Do you sell excess stored feed or crop residue? *(1 = Yes, 2 = No, 3= Sometimes)*	
52.	If yes or sometimes, how much do you sell a kilogram of stored residue? GH₵ ……..	
53.	If yes or sometimes, what quantity did you sell in the immediate past season?.....	
54.	Did you purchase any stored feed or crop residue in the immediate past season? *(1 = Yes, 2 = No, 3= Sometimes)*	
55.	If yes or sometimes, how much do you purchase a kilogram of stored or crop residue? GH₵ ……	
56.	If yes or sometimes, what quantity did you purchase in the immediate past season?.....	
57.	Do you confine/tether your sheep and goats during the rainy season? *(1 = Yes, 2 = No, 3= Sometimes)*	
58.	Do you practice supplementary feeding? *(1 = Yes, 2 = No, 3= Sometimes)*	
59.	If yes or sometimes, what supplementary feeds do you offer? (*1=Groundnut haulm 2=Cowpea haulm 3=rice straw 4=cowpea chaff 5=soybean haulm 6=soybean chaff 7=maize chaff 8=maize stover, 9=sorghum head 10=millet stalk 11=household food leftover 12=stylo 13= pitomash 14=other (write those that apply)*	
60.	What do you do with animal feaces/or animal manure? *(1 = for compost. 2 = apply on soil 3= throw away, 4= Do nothing)/*	
61.	Are you aware of dual purpose cowpea and groundnut varieties? *(1= Yes, 0= No)*	
62.	If yes, did you cultivate any dual purpose **cowpea** variety in the immediate past season? *(1 = Yes, 0 = No)*	
63.	If no, skip to next question, if yes, *what was the area planted to this variety*?	**Acres**
64.	If yes, did you cultivate any dual purpose **groundnut** variety last year? *(1 = Yes, 0 = No)*	

65. If no, skip to next question, if yes, *what was the area planted to this variety*?	**Acres**
66. Did you use of pigeon pea to feed animals in the immediate past season? *(1 = Yes, 0 = No)*	
67. Did you use of tetracycline to control diseases in sheep and goats? *(1 = Yes, 0 = No)*	
68. Use of ash and neem seeds to control insect pests? *(1 = Yes, 0 = No)*	

N. Access to Market Information

	1=yes, 2=No, 3= sometimes, 4= don't know	If yes or sometimes, what is the most important source of such information? (*source codes)*	If yes or sometimes, what is the most important medium you used to obtain such information? (*medium codes)*
1. Do you receive information on prevailing crops output prices?			
2. Do you receive information on prevailing livestock prices?			
3. Do you receive information on prevailing crops input prices?			
4. Do you receive information on prevailing livestock input prices?			
5. Do you receive information about when the crops products are highly needed in the market?			
6. Do you receive information about when livestock products are highly needed in the market?			
7. Do you have information on the market taxes on your crops and livestock products?			
8. Are you able to obtain information if prices of crops are expected to increase or decrease?			
9. Are you able to obtain information if prices of crops are expected to remain the same?			
10. Are you able to obtain information if the prices of livestock are expected to increase or decrease?			
11. Are you able to obtain information if the prices of livestock are expected to remain the same?			

Source Code: *1=Colleague farmers, 2=Community traders, 3=Markets, 4=buyers,* **medium codes***: 1=By personally visiting the market, 2= media (mainly radio and TV), 3=phone calls*

O. Perception of Risk Factors

Tell us the how you respond to the following statements as they pertain to the community and production activities? Do you strongly disagree, disagree, are indifferent, etc.

Statement	Not applicable	Strongly Disagree	disagree	Indifferent	Agree	Strongly agree
1. *Erratic rainfall is a serious threat to crops production*						
2. *Erratic rainfall affects livestock production*						
3. *Floods are a potential threat to crops and livestock production*						
4. *Extreme temperatures are serious threats to crop production*						
5. *Strong destructive winds are a serious potential treat to crops production*						
6. *Pests and diseases causes major causes of losses to crop yields*						
7. *Pests and diseases causes major causes of losses to livestock*						
8. *Sickness/illness reduces labour availability for crop production*						
9. *Sickness/illness reduces labour availability for livestock production*						
10. *Death of a member of the family or community can bring production to a halt for days*						
11. *Incapacitation can result retirement from crop and livestock production*						
12. *Theft is a major threat to crops and livestock production*						
13. *Fire, damages or property losses is a major threat to production activities*						
14. *Low prices demotivate me from increasing my production the next season*						

15. *Low demand is the most depressing factor in crop production*						
16. *Low demand is the most discouraging factor in livestock production*						
17. *Removal of subsidies has resulted in reduction in crop production*						
18. *Increased interest rates has discouraged me from borrowing to support production*						

P. Risk Factors

Provide information on the following risk factors as they occur in your crops and livestock production

Risk factor	If yes, how often has this happen in the last ten years?	If yes, what crop was mostly affected?	What proportion of losses from this crop was as a result of this risk?	If yes, what livestock was mostly affected?	What proportion of losses from this livestock was as a result of this risk?	What immediate action was taken to manage the situation (Code)	What measures were put in place to manage future occurrences (Code)
1. *Have you ever experienced **erratic rainfalls** on your farm (1=Yes, 0=No)*							
2. *Have you ever experienced **floods** on your farm(1=Yes, 0=No)*							
3. *Have you ever experienced **droughts** on your farm (1=Yes, 0=No)*							
4. *Have you ever experienced **strong destructive winds** on your farm (1=Yes, 0= No)*							
5. *Have you ever experienced **pests and diseases** on your farm (1= Yes, 0= No)*							
6. *Have you ever fallen **sick** during a cropping season? (1=Yes, 0= No)*							
7. *Has any member of the family or community **died** during the cropping season? (1=Yes, 0=No)*							
8. *Have you ever experienced **theft** on any of your inputs , produce or property (1=Yes, 0=No)*							
9. *Have you experienced **fire** and other damages to your inputs, produce or property (1= Yes, 0=No)*							
10. *Have you experienced **unstable prices** or low prices for your produce? (1=Yes, 0=No)*							
11. *Have you experienced low or **unstable demand** for your produce? (1=Yes, 0=No)*							
12. *Have you experienced **removal of subsidies** from your production inputs? (1=Yes, 0= No)*							
13. *Have you experienced unstable or **high interest rates** during cropping season?(1=Yes, 0=No)*							

Management Code: *1=diversify; 2=contract farming/marketing contracts; 3=borrowing; 4=remittance; 5= do nothing, 6=agric. insurance, 7=life insurance, 8=early planting 9=timely spraying of crops 10 =not applicable 11=other ……..*

Q. Household Assets

How many of the following assets are owned by your household? (Estimated values in GH ₵)

Asset	Estimated total Value	Asset	Estimated total Value	Asset	Estimated total Value	Asset	Estimated total Value
Cattle		Guinea fowls		TV		Wheelbarrows	
Goats		Ducks		Chair		Milling machine	

Sheep		Bicycle		Generator		Storage facility	
Pigs		Motorbike		Sewing machine		Fish pond	
Chicken		Car		Water pump		Other imp. asset…….	
Pigeons		Truck		Plough sets			
Turkeys		Tractor		Carts			

R. On Dwelling of Households

Is this house owned? *(1=Yes, 0=No.)*		What is the roofing material? *(1=Grass thatched, 2= Iron sheet, 3=Roofing tile, 4=Wood, 5=Cement/concrete)*	
How old (in years) is this house?		What is the wall material? *(1=Mud, 2=Bricks/stones, 3=Wood, 4=Blocks)*	
If the same house is to be constructed now, what would it cost?		What is the floor material? *(1=Cement, 2=Mud, 3=None)*	

S. Experience of Food Insecurity in the Household in the last 12 Months

	Abundance period	Period of average availability	Lean period
1. On average, how many meals per day does your household have?			
2. If less than 3, what are the reason(s)?			
3. How many days per month did you take only two meals per day because of lack of money/food?			
4. How many days per month did you take only one meal per day because of lack of money/food?			
5. How many days did you go without food because of lack of money/food?			
6. How many months, did you not have enough food to meet your family's needs (cut the size of your meals)?			
7. Whose meals were reduced during these months? (1=Children; 2=Adults; 3=both children & adults)			

Thank you

Appendix 1b: A Questionnaire for the Community level Survey on a Microeconometric Assessment of the Integrated Crop-Livestock Production Systems

A. Community Identification

1. Names of enumerator(s): ……..
2. Date of interview: ……
3. District: …… 4. Community name: ……

B. Community infrastructure

I. Do you have any of the following infrastructures in the community?

If no, provide the distance to the nearest infrastructure. (0=in community; provide the farthest distance possible)

1.	Electricity? ……	Distance to nearest: ……
2.	Market? ……	Distance to nearest: ……
3.	Health post? ……..	Distance to nearest: ……
4.	Agricultural office? ……..	Distance to nearest: ……
5.	Administrative office? ……..	Distance to nearest: ……
6.	Church? ……..	Distance to nearest: ……
7.	Mosque? ……..	Distance to nearest: ……
8.	School? ……..	Distance to nearest: ……
9.	Grain mill? ……..	Distance to nearest: ……
10.	Fuel source? ……	Distance to nearest: ……
11.	Tarred road? …….	Distance to nearest: ……
12.	Feeder road? …….	Distance to nearest: ……
13.	Transport terminal? ……..	Distance to nearest: ……
14.	Input shops? ……	Distance to nearest: ……
15.	Agricultural water source?	Distance to nearest: ……
16.	Domestic water source?	Distance to nearest: ……
17.	Telephone coverage?	Distance to nearest: ……
18.	Information center/ FM radio?	Distance to nearest: ……
19.	Veterinary officer/clinic	Distance to nearest: ……
20.	Good practice livestock Centre	Distance to nearest: ……
21.	Communal land	Distance to nearest: ……
22.	Communal forest reserve	Distance to nearest: ……

II. Details on infrastructure

23. How many vehicles come to the village per day? ……..
24. Where there is less than one vehicle per day, how many come to the village per week? ……

25. Is there a particular day on which these vehicles come? ……..
26. If yes, which one? ……..
27. If yes, how many vehicles come to or pass through the village on that day? ……
28. What is the main sources of water for this village …….
29. Are they all functional?

    ……
30. If no to Q29, how many are functional at the moment……..
31. Do you have GSM coverage in this village?.....
32. If yes to Q31, how many GSM companies have coverage in the village? ……..

A. General crop calendar in the last Land and seasonal use (yes/no)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Main rain season												
Land preparation												
Planting												
1st Fertilizer application												
2nd Fertilizer application												
Herbicide application												
Insecticide application												
1st weeding												
2nd weeding												
Harvesting												
Threshing												
Drying period												
Storage period												
Sales periods												

B. Community structure

28. Describe the population and institutional structure of the community.

What is the name of the name of institution(s) (*cooperatives, associations, organisations etc*)	In what year was it established	What types of activities are they involved?	Status	Benefits

29. List the major crops and livestock produced in this community?

Crops	% of community producing this crop	Livestock	% of community producing this crop

C. Risks factors

Please tell us the how you agree with the following statements as they pertain to the community and production activities?

Statement	Very high	High	Medium	Low	Very low	Not exist
Erratic rainfall is a serious threat to crops production						
Erratic rainfall occurs frequently in this community						
Erratic rainfall result in total yield loss						
Erratic rainfall affects livestock production						
Floods occur is a potential threat to crops and livestock production						
Floods occurs frequently in this community						
If it occurs, it destroys almost all field crops						
Extreme temperatures are potential threats to crop production in this community						
Extreme temperatures occurs frequently in this community						
Strong destructive winds are a serious potential treat to crops production						
Strong destructive winds are serious risks in crop production						
Pests causes major losses to crop yields						
Pests causes major losses to livestock						
Sickness/illness reduces labour availability for crop production						
Sickness/illness reduces labour availability for crop production						
Death of a member of the family or community can bring production to a halt for days						
Death of a member of the family or community can bring production to a halt for weeks						
Death of a member of the family or community can bring production to a halt for months						
Incapacitation can result retirement from crop production						
Incapacitation can result retirement from livestock production						
Production inputs and produce are exposed to theft in this community						
Theft often happens in this community						
Fire and other damages or losses to property do occur in this community						
If it occurs, it is easily managed and put out						
If it occurs, it completely destroys the property						
Prices of crops products have been very low lately						
Low prices reduce the motivation to produce more the following year						
For a particular commodity, low prices this year means high price the next year						
Low demand is the most depressing factor in crop production						
Low demand is the most discouraging factor in livestock production						
Removal of subsidies has resulted in reduced area yield						
There has been increasing interest rate of borrowing						
Increased interest rates has discouraged me from borrowing						

Appendix 1c: A Questionnaire for the Producer-Level Baseline Survey of Integrated Crops-Livestock Production Systems in West Africa

1. Questionnaire ID: …….
2. Name of enumerator: …….
3. Date of enumeration: ……..……

3a. Region: …… 3b. Region Code: …….
4a. District: …… 4b. District Code: …….
5a. Community: …… 5b. Community Code:……
6. Altitude (m): …… 7. Longitude: ……
8. Latitude: ……..

A. General information

1 Household code: …….
2 Name of respondent:
……..……..
3 Sex of respondent: 0=Female1=Male 4 Age of respondent: ……..
5 Highest level of formal education of respondent…… 0=None 1=Basic(Primary/JHS/Middle) 2=Secondary (Secondary/Vocational) 3=Tertiary (Training college/Polytechnic/University)
6 Marital status of respondent: …….. 0=Single 1=Married 2=Divorced/Separated 3=Widowed
7 Years of experience in cereals and legume production ……
8 Is the respondent the head of the household? 1=Yes 0=No
9 If no, provide name of household the head?
…….....
10 Religion Religion 1=Christian 2=Muslim 3= traditional 4= atheist 5 budist 6=other

Distribution of household members	Male	Female	Total
Number of persons in the household			
Number of persons who are <=14 years			
Number of persons who are >=15 and <=60 years			
Number of persons who are >60 years			
Number of persons engaged in animal rearing.			
Number of persons in other activities (specify:……).			

11 What is the main occupation of respondent? …. 1=crop production 2=livestock rearing 3=petty trading 4=craftsmanship 5=labour 6=permanent employment

B. Household Resources

12 Type of dwelling of the household. (Multiple choice) …… 1=Mud hut with thatch roof2=Mud hut with asbestos/iron roof 3=Block house with thatch roof4=Block house with asbestos/iron roof

13 Occupancy status. …… 1=Landlord 2=tenant

14 If tenant what is the monthly rent? Amount…….Currency……

15 Main source of water for drinking and household chores. …… 1=Pipe borne 2=Dam 3=Rain harvest 4=River 5=wells 6=borehole 7=other (specify) ……

16 Main source of lighting? (Multiple choice) …… 1=Kerosene lamps 2=Gas lamps 3=candle 4=torches 5=electricity 6=generator 7=other (specify……)

17 Main source of fuel used for cooking. 1=Bio waste 2=Charcoal 3=firewood 4=Gas 5=Electricity

18 6=kerosene 7=diesel 8=petrol 9=solar power 10=other(specify)……

19 **Land assets** (*Please give information about your land assets*)

Parcel * ID	Parcel Description / Name	Size of this parcel	Unit of land (Code)	Current use (code)	Distance from home (km)	Productivity (code)	Tenure system (Code)	If parcel **is *owned,*** who owns (Code**)**
1								
2								
3								
4								

Unit Of Land	Current Use	Tenure System	Productivity	If Owned, By Who?
1= acre 2= ha 3= sqm2 4= other, specify conversion in metric system	1=Idle/fallow 2=Crops 3=Fodder 4=Natural pasture 5=Other (specify)	1= Title deed 2= Owned but not titled 3= public land 4= Rented-in/ sharecropped 5=Family land 6=Other (specify)	1= Good 2= Average 3= Low	1=Male 2=Female 3=Joint 4=Other relative 5= Other

**parcel is one contiguous plot of land. One parcel can contain more than one plot.*

20 How many of the following assets does the household own?

Asset	Year purchased	Quantity	Estimated current Value (Local Currency)	Asset	Year purchased	Quantity	Estimated current Value (Local Currency)	Asset	Year purchased	Quantity	Estimated current Value (Local Currency)
Motor vehicle				Power tiller				Water pump			
Motor cycle				Combine harvester				Water containers			
Bicycle				Grain storage facility				Generator			
Tractor				Cutlass				Mobile Phones			
Tractor plough				Hoe				Fan			
Tractor harrow				Sickle				Rifles			
Draft animals				Knapsack sprayer				Foam mattress			
Animal plough				Shovel/spade				Utensils			
Animal harrow				Television				Furniture/sofa			
Animal scotch cart				Radio				Sewing machine			
Wheel barrow				Private well				Other			

21 Kindly provide details of your membership of the following associations/cooperatives (crops and livestock).

Association/cooperative	Code 1	Membership 1=Yes 2=No	Years	Rank most important 1=highest; 5=lowest	Rank level of participation 1=highest; 5=lowest	Meetings attended in the 2011	Benefits Code 2	Contributions	
								Cash (local currency	Labour (man-days)

Code 1: 1=Crop specific; 2 = livestock specific; 3=labour; 4=marketing; 5=credit; 6=welfare; 7=other (specify……..)

Code 2: 1=Seed purchases; 2=Seed sales; 4=training; 5=advice; 6=credit; 7=fertilizer purchase; 8=tractor service; 9=produce sales; 10=vet treatments; 11 = improved breeds; 12 = feed and/or mineral lick; 13 = materials and equipment; 14 = watering facility; 15 = donkey and cart; 16 = Other(specify)……..

Livestock asset

Does your household have any livestock (0 = No, 1 = Yes)?

If yes, indicate the numbers of animals for the different species kept by the household. If the household does not own a particular species, mark 0 in the "Total" column and go to the next row (species)

Species	Total		Number owned by males	Number owned by females	Number owned jointly	Estimated cash value (local currency)	Managed but not owned	Owned but managed by others
	Male	Female						
Cattle								
Bulls								
Breeding Cows								
Heifers (<2yo)								
Young males								
Sheep								
Rams								
Breeding ewes								
Young ewes								
Young males								
Goats								
Billies								
Breeding does								
Young does								
Young males								
Other animals								
Chickens								
Pigeons								
Turkeys								
Guinea fowls								
Pigs								
Donkeys								
Other (specify)								

22 Organizations maintaining working relationships with any member of the household

Name	Code1	Benefits (Coded2)	Years of contact	Contacts per year

Code 1: 1=Ministry of Agricculture; 2=Research; 3=NGO (Specify…….); 4=Farmer/Community based organisations; 5=Project

Code 2: 1=Gift of seeds; 2=purchase of seed; 3=sale of seeds; 4=training; 5=advice; 6=credit 7=provide equipment 8=sale of fertilizer 9=gift of fertilizer 10=tractor service; 11= veterinary drugs; 12 = improved breeds; 13 = feed; 14 = mineral lick; 15 = watering facility; 16 = donkey and cart 17 = Other(specify)……

23 Have you ever participated in any cowpea or groundnut development project? 1=Yes 0=No

24 If yes, from which year to which year did you participate in the Project? From _____ to _____

25 Have you ever participated in any sheep and goats development project? 1=Yes 0=No

26 If yes, from which year to which year did you participate in the Project? From _____ to _____

Did you receive any cash and/or input credit in the 2011 crop season for crop production?

Item	Approximate value(local currency)	Source (Code 1)	Timeliness 0=No 1=Yes	Form of repayment (code 2)	Approximate value (local currency)
Cash credit =1					
Seed credit=2					
Grain credit=3					
Fertilizers=4					
Other agro-chemicals=5					
Livestock feed=6					
Veterinary medicines =7					

Code 1: 1=Bank; 2=Money lender; 3=Neighbor; 4=Relative; 5=NGO; 6=Project; 7=Cooperative; 8=company 9=Other (specify: _____)
Code 2: 1=Cash; 2=Produce; 3= Livestock; 4= Other assets

27 Did you receive any cash and/or input credit in 2011 for sheep and goat production?

Item	Approximate value(local currency)	Source (Code 1)	Timeliness 0=No 1=Yes	Form of repayment (code 2)	Approximate value (local currency)
Cash credit =1					
Breeding stock=2					
Improved breed=3					
Housing=4					
Feed=5					
Veterinary service=6					
Other specify					
Other specify					
Other specify					

Code 1: 1=Bank; 2=Money lender; 3=Neighbor; 4=Relative; 5=NGO; 6=Project; 7=Cooperative; 8=Company; 9=Other (specify: _____)
Code 2: 1=Cash; 2=Produce; 3= Livestock; 4= Other assets

28 If you did not receive credit provide **reason(s)**? ……. 0=N/A 1=No facility 2=Did not look for credit 3=No collateral 5=High interest rate 6=other (specify)……

C. Production systems

29 Crop production (please provide information on your crop production activities)

Crop	Land size (acres)	Tenancy(code 1)	Dual purpose (Code 2)	Name of variety planted	Cropping systems (code 3)	Planting arrangements (code 4)	Output (*Grain*)	Output (*Fodder*)
Cowpea								
Groundnut								
Maize								
Rice								
Millet								
Sorghum								
soybean								
Other								

Code1: 1= Own land; 2= Land rented; 3= Sharecropped; 4= Family land; 5= Outright purchase; 6 =Communal 8=other
Code 3: 1=monocrop; 2= intercropping; 3 crop rotation
Code 4: 1= random; 2= row planting *Code 2*:1=yes; 2=No

Costs of crop production/acre

30 Inputs requirements

Item	Quantity	Unit cost	Item	Quantity	Unit cost	Item	Quantity	Unit cost
Cowpea			**Groundnut**			**Soybean**		
Seeds			Seeds			Seeds		
Fertilizer			***Fertilizer***			***Fertilizer***		
NPK			NPK			NPK		
Ammonia			Ammonia			Ammonia		
Urea			Urea			Urea		
Weedicides			Weedicides			Weedicides		
Pesticides			Pesticides			Pesticides		
Fixed cost			***Fixed cost***			***Fixed cost***		
Land (rent/year)			Land (rent/year)			Land (rent/year)		
Hoes			Hoes			Hoes		
Cutlass			Cutlass			Cutlass		
Sacks			Sacks			Sacks		
Other (specify)			Other (specify)			Other (specify)		
Maize/millet			**Rice**			**Sorghum**		
Seeds			Seeds			Seeds		
Fertilizer			***Fertilizer***			***Fertilizer***		
NPK			NPK			NPK		
Ammonia			Ammonia			Ammonia		
Urea			Urea			Urea		
Weedicides			Weedicides			Weedicides		
Pesticides			Pesticides			Pesticides		
Fixed cost			***Fixed cost***			***Fixed cost***		
Land (rent/year)			Land (rent/year)			Land (rent/year)		
Hoes			Hoes			Hoes		
Cutlass			Cutlass			Cutlass		
Sacks			Sacks			Sacks		
Other (specify)			Other (specify)			Other (specify)		

Sheep and goats production

31 Provide Information on your sheep and goats production systems in 2010

Livestock	Number	Husbandry systems Codes 2	Type of feeding Code 4	Feed resource used Code 3	Storage of fodder Code 1	Mineral supplementation Code 1	Type of breed Code 5	Off take
Sheep								
Goats								

Code 1: *1=Yes 2= No* ***Code: 2****=Free range 2=Intensive 3=Semi-intensive*
Code 3: *1=Household waste, 2 = Stored crop residue, 3 = Browse plants*
Code 4*: 1=Free grazing, 2=pasture management, 3=feed purchase 4=Supplementary feeding*
Code 5*: 1=Local, 2=exotic, 3=crossbreed*

32 **Cost of livestock rearing per 10 animals in 2011**

Input	Sheep		Goats	
	Quantity/Number	Unit cost	Quantity/Number	Unit cost
Household waste				
Fodder				
Deworming				
Water				
New stock				
Veterinary fees -cost				
Transport costs				
Herding costs				
Purchased feed				
Purchased supplements e.g salt lick				
Fixed cost				
Land (rent/year)				
Basins				
housing				

Labour Requirements

33 Labour use for **cowpea/groundnut/soybean** cultivation

Activity Code	Family Labour									Communal Labour			Hired Labour			Contract labour
	Adult Male			Adult Female			Children above 15									
	Number	Days	Daily wage if hired	Number	Days	Daily wage if hired	Number	Days	Daily wage if hired	Number	Days	Daily wage if hired	Number	Days	Daily wage if hired	Contract Amount (local currency)

Activity code: 1=Manual ploughing; 2=Manual harrowing; 3=Sowing/Planting; 4=1st weeding (manual); 5=2nd weeding (manual); 6=1st fertilizer application ;7=2nd fertilizer application; 8=herbicides application ;9=insecticides application; 10= fungicides application; 11=harvesting; 12= transportation from farm; 13= Treshing; 14=Drying; 15= other

34 Labour use for **maiz**e cultivation

Activity Code	Family Labour									Communal Labour			Hired Labour			Contract labour
	Adult Male			Adult Female			Children above 15									
	Number	Days	Daily wage if hired	Number	Days	Daily wage if hired	Number	Days	Daily wage if hired	Number	Days	Daily wage if hired	Number	Days	Daily wage if hired	Contract Amount (local currency)

Activity code: 1=Manual ploughing; 2=Manual harrowing; 3=Sowing/Planting; 4=1st weeding (manual); 5=2nd weeding (manual); 6=1st fertilizer application ;7=2nd fertilizer application; 8=Herbicides application ;9=Insecticides application; 10= Fungicides application; 11=Harvesting; 12= Transportation from farm; 13= Treshing; 14=Drying; 15= Other

35 Labour use for **rice** cultivation

Activity Code	Family Labour									Communal Labour			Hired Labour			Contract labour
	Adult Male			Adult Female			Children above 15									
	Number	Days	Daily wage if hired	Number	Days	Daily wage if hired	Number	Days	Daily wage if hired	Number	Days	Daily wage if hired	Number	Days	Daily wage if hired	Contract Amount (local currency)

Activity code: 1=Manual ploughing; 2=Manual harrowing; 3=Sowing/Planting; 4=1st weeding (manual); 5=2nd weeding (manual); 6=1st fertilizer application ;7=2nd fertilizer application; 8=herbicides application ;9=insecticides application; 10= fungicides application; 11=harvesting; 12= transportation from farm; 13= Treshing; 14=Drying; 15= other

36 Labour use for **millet/sorghum** cultivation

Activity Code	Family Labour									Communal Labour			Hired Labour			Contract labour
	Adult Male			Adult Female			Children above 15									
	Number	Days	Daily wage if hired	Number	Days	Daily wage if hired	Number	Days	Daily wage if hired	Number	Days	Daily wage if hired	Number	Days	Daily wage if hired	Contract Amount (local currency)

Activity code: 1=Manual ploughing; 2=Manual harrowing; 3=Sowing/Planting; 4=1st weeding (manual); 5=2nd weeding (manual); 6=1st fertilizer application ;7=2nd fertilizer application; 8=Herbicides application ;9=Insecticides application; 10= Fungicides application; 11=Harvesting; 12= transportation from farm; 13= Treshing; 14=Drying; 15= Other

37 Labour use for **sheep and goats production**

Activity Code	Family Labour									Communal Labour			Hired Labour			Contract labour
	Adult Male			Adult Female			Children above 15									
	Number	Days	Daily wage if hired	Number	Days	Daily wage if hired	Number	Days	Daily wage if hired	Number	Days	Daily wage if hired	Number	Days	Daily wage if hired	Contract Amount (local currency)

Activity code: 1=Herding; 2=Cuts and carry; 3=Pasture establishment; 4=Deworming; 5=Pen construction; 6=dipping; 7=collection of household waste; 8 pasture maintenance; 9 =cleaning of pens 10 =Watering 11=Tethering; 12=Vaccination 13=other

Pests and Diseases Management

38 Provide some additional information on the pests and diseases you identified on the crops cultivated

Pests and diseases	Affected Crop (Code 5)	Stage of attack (Code 1)	Mode of attack (Code 2)	Effect on plant (Code3)	Control strategy (Code4)
Pests					
Disease					

Code 1: 1=immediately after emergence; 2=Vegetative stage; 3=Flowering stage; 4=podding/heading stage; 5=Matured stage.
Code 2: 1= Chew the leaves; 2= Lay eggs on the plant; 3= Destroy the panicle; 4= Feed on the milk; 5= Feed on other insects; 6=Other(specify)……
Code 3:1=stunted growth; 2=yellowing of leaves; 3=defoliation ; 4=die back; 5=wilting; 6=leaf curl; 7=mouldy leaves; 8=shattering of grains; 9=other (specify) ……
Code 4: 1=Neem extract; 2=Insecticide; 3= Cultural practice; 4=plant resistant varieties ; 5=chemical application 6=other (specify)……..
Code 5: 1=cowpea; 2=groundnut ; 3=maize; 4=rice; 5=millet; 6=sorghum

39 *Diseases and pests in sheep and goats production and their management*

Disease/pest	Affected animal (code 1)	Number affected in 2011	Symptoms (Code 2)	Control strategy (code 3)

Code 1: 1=sheep; 2=goats
Code 2: 1=diarrhea; 2=running nose; 3=rough skin coat; 4=loss of weight; 5=bloat 6=rapid breathing 7=Standing hair; 8=Loss of hair; 9=other
Code 3: 1=drenching; 2= call the vert. officer; 3= isolate the affected animal; 4= sells the affected animals; 5= slaughter; 6=local treatment; 7=buy drugs from the vet drug store; 8=buy drugs from the human drugs store 9=other(specify)

Fodder and Manure management

50. How do you store your cereal-legume residues? 1 = Left as standing hay, 2 = Open storage, 3 = Storage in an enclosed area
51. When do you start feeding your stored crop residues? 1 = Just after crop harvest, 2 = in Periods of feed scarcity
52. For how long do you feed your stored haulm? 1 = 1-2 months, 2 = 3-4 months, 3 = 5-6 months
53. Do you sell excess stored feed? 1 = Yes, 2 = No
54. If yes, how much is a kilogram stored residues? Amount ……..currency……..
55. Do you confine/tether your sheep and goats during the rainy season? 1=yes 0=no
56. Do you practice supplementary feeding? 1 = Yes, 2 = No

57. If yes what supplementary feeds do you offer?

Code: 1=Groundnut haulm 2=Cowpea haulm 3=rice straw 4=cowpea chaff 5=soyabean haulm 6=soyabean chaff 7=maize chaff 8=maize stover 9=sorghum head 10=millet stalk 11=household food leftover 12=stylo 13= pitomash 14=other (specify)……..

58. How do you manage animal faeces/ or animal manure? 1 = Compost. 2 = Application on soil 3= thrown away `

59. Quantity of crops harvested in 2011

	Cowpea	Groundnut	Maize	Rice	Millet	Sorghum	Soybean
Quantity							
Unit of measurement							
Equivalent of unit in Kg							
Farm gate price per kg at harvest (local currency)							
Market price per kg at harvest (local currency)							
Current market price per kg (local currency)							

60. Quantity of livestock sold, purchased, lost and consumed in 2011

	Cattle	Goats	Sheep	Other
SOLD				
Number sold				
Type*				
Price (/kg or animal)				
Age of animal (kg)				
Where sold to**				
Reason sold***				
PURCHASED				
Number purchased				
Type*				
Price (/kg)				
Age of animal (kg)				
Where sold to**				
DIED				
Number				
Type*				
Reason (e.g. disease)				
HOME CONSUMPTION				
Number				
Type*				

** e.g. 1=Bull; 2=cow; 3=calf; 4=heifer 5= billy 5= nanny; 6=ram; 7=wither; 8=ewe ; 9= lamb; 10=kid*

*** 1=Other farmer; 2=Local trader; 3=Outside trader; 4=Other*

**** 1=Regular source of income; 2=Special occasion; 3=Necessity; 4=Other*

D. Value chain and market access

61. Value chain and market access issues

Product	Quantity (Kg)/ number sold	Unit price	Major buyers (Code1)	Major markets (Code 2)	Distance to market (Km)	Frequency of visit to the market (code 3)
Sheep						
Goats						
Cowpea						
Soybean						
Groundnut						
Rice						
Maize						
Millet						
Sorghum						

Code1: 1=market women; 2=middlemen; 3=butchers; 4=food vendors; 5=consumers; 6=fresh meat processors; 7= kebab operators

Code 2: 1=Atebubu; 2= Kintampo; 3= Amantin; 4= Walewale; 5= Bolga; 6=Wulugu; 7=Wulugu; 8= Techiman

Code 3: 1=Daily; 2=More than once a week; 3=Weekly; 3=Seasonal; 4=Yearly

E. Production and Marketing Constraints

Rank the major constraints to crop production and marketing

62. Indicate the severity of the following constraints in crop production and marketing

Constraints	Rank	Constraints	Rank
Weeds eg. striga		Distance to fertilizer markets	
Insects		Inadequate labour	
Birds		Labour cost	
Diseases		Unavailability of chemical inputs	
Soil fertility		Cost of chemical inputs	
Droughts		Availability of credit	
Floods		Interest on credit	
Pre-harvest grain loss		Delays in acquiring credit	
Post harvest fodder loss		Difficult to repay credit	
Low prices		Threshing	
Untimely supply of inputs		Winnowing	
Access to get land for renting		Storage problems	
Access to get land for buying		Lack of transport	
Seed quality		Low yield	
Seed available		Low demand for produce	
Fertilizer cost		Availability of extension services	
Fertilizer unavailability		Distance to the extension workers	
Poor fodder yield		Lack of market for fodder	
Difficulty in carting produce and inputs		Interference by Fulani herdsmen	

Code: 1=High; 2=Medium; 3=Low; 0=Not exist; 99=Don't know

50. Indicate the severity of the following constraints in sheep and goats production and marketing

Constraints	Rank	Constraints	Rank
Scarcity of fodder		Pests and diseases	
Unavailability of pasture		Unavailability of extension agents	
Theft		Low prices	
Polythene bag ingestion		High cost of fodder	
Financial difficulty		Lack of improved breeds	
Scarcity of water		Farmer-herder conflict	
Inadequate veterinary service		Restricted livestock mobility	
Poor housing		Labour unavailability	
Other (specify)		Other (specify)	

Code: 1=High; 2=Medium; 3=Low; 0=Not exist; 99=Don't know

F. Indigenous knowledge and options in crops-sheep and goats production

63. Do you undertake any of the following activities in your crops-sheep and goats production?

Indigenous knowledge	Response *1= Yes; 2=No*
Use of pigeon pea to feed animals	
Use of tetracycline to control diseases in sheep and goats	
Use of ash and neem seeds to control insect pests	
Palega Herb (Roots) and dawadawa tree (back) for drenching	
omo and neem extracts and animal feaces to prevent animals from eating the crops	
Broadcasting of seeds during planting	

64. What indigenous plants do you use to feed your livestock……

G. Livelihood Analysis

50. Rank the following sources of livelihoods to your household

Source	Rank	Source	Rank
Sheep rearing		Soybean cultivation	
Goats rearing		Shea butter extraction	
Cattle		Cutting of firewood	
poultry		Burning of charcoal	
Maize cultivation		Petty trading	
Rice cultivation		Artisanship	
Cowpea cultivation		Bambara beans cultivation	
Groundnut cultivation		Sorghum cultivation	
Millet cultivation		Vegetables	
Other			

Rank code: *1=very importan; 2= important; 3=somewhat important; 4=not important; 5=not very important*

51. Gender roles in sheep and goats production

Activity	Responsibility	Activity	Responsibility
Accessing land		Marketing of live animal	
Fattening		Marketing of meat	
Collection of crop residues		Disease control	
Harvesting of browse		Hide marketing	
Taking animals to grazing area		Slaughtering	
Feeding		Deciding when to sell	
Pen cleaning		Tethering	
Watering		Shepherding	
Cut and carry during the dry season		Spending money from the sale of animals	
Cut and carry during the wet season		Milking	
Processing (butchers, kebab operators sausages etc.)		Food preparation (using the meat for household)	
Other			

Codes: 1= all family members; 2= adult male; 3= adult female; 4= male teenager; 5= female teenager; 6= male children ; 7= female children; 8= hired labour

52. Gender roles in cereals and legumes production

Activity	Responsibility	
	Cereals	Legumes
Accessing to land		
Land clearing		
Ploughing and harrowing		
Sowing		
1st weeding		
2nd weeding		
Fertilizer application		
Manure application		
Pesticide application		
Harvesting		
Threshing		
Drying		
Grain marketing		
Fodder marketing		
Purchasing of inputs such as fertilizers and pesticides		
Other		

***Codes:** 1= all family members; 2= adult male; 3= adult female; 4= male teenager; 5= female teenager; 6= male children; 7= female children; 8= hired labour*

H. Income and Expenditure Profile of Household

53. What are the sources of income for your household in 2010?

Category	Quantity	Unit	Unit price	Category	Quantity	Unit	Unit price
Sales of cowpea				Sales pepper			
Sales of groundnut				Shea processing			
Sales of sorghum				Sales garden eggs			
Sales of maize				Sales of livestock			
Sale of rice				Shea fruits collection			
Sale of millet				Dawadawa processing			
Sale of soybean				Food processing			
Sale of Bambara				Petty trading			
Sales of cassava				Craftsmanship			
Sales of yam				Labourer			
Sales of sweet potato				Permanent employment			
Sales onion				Pension			
Sales okra				Remittances			
Sales tomato				Sale of agro inputs			
Sale of charcoal				Sale of cattle			
Sale of firewood				Sale of sheep			
Sale of goats				Sale of fodder			
Sale of poultry				Sale of hide			
Sale of pigs				Other……			

Unit price Code: 1= GH₵*;* 2=CFA 3=Dalasi

54. Approximately how much did you spend on the following in 2010/2011

Expenditure category	Amount (GH¢, CFA, Dalasi)	Expenditure category	Amount (GH¢, CFA, Dalasi)
Staple foods		Water	
Snacks		Electricity	
Tobacco/Alcohol		Remittances to relatives	
School fees		Social contributions	
School uniform		Transport	
School books		Repair of house	
School furniture		Rent	
Medical expenses		Miscellaneous	
Animal protein		Clothing	
Fuel		Other (specify)……	

55. household consumption and food expenditure patterns

Food item	Qty consumed per week	Number of times consumed per week	Amount spent on it per week (local currency)	Food item	Qty consumed per week	Number of times consumed per week	Amount spent on it per week (local currency)
Maize				Sheep meat			
Rice				Goat meat			
millet				Cow meat			
Sorghum				Chicken			
Soybean				Pork			
Yam				Donkey meat			
Cassava				Plantain			
Groundnut				Bush meat			
Cowpea				Guinea fowl			
Vegetables				Eggs			
Oil				Milk products			
Fruits				Cocoyam			
Wheat products (bread, biscuits)							
Other							
Other							

56. Does your household's daily meal contain any of the following food categories?

Food category	Response *(use codes below)*	Food category	Response *(use codes below)*
Carbohydrates (cereals,		Minerals (eg. Salts, spices)	
Proteins (meat, eggs, milk,		Water	
Vegetables (cabbage, carrots, kontomire etc)			
Fats and oils (oils, margarines etc.)			

Response code: 1=always 2= often 3=sometimes 3= rarely 4= never

Thank the farmer

Appendix 7.1a: Probit, Truncated, and Tobit Regression Estimates for Crop Diversification

	Probit		Truncated		Tobit	
	Coefficient	SE	Coefficient	SE	Coefficient	SE
Age	0.065	0.087	0.0070*	0.0037	0.0066	0.0046
Gender	0.22	0.28	0.025**	0.013	0.035**	0.015
Education	0.21	0.26	0.003	0.010	0.016	0.012
Dependency ratio	-0.097**	0.043	-0.0013	0.0020	-0.0035	0.0025
Off-farm income	0.34	0.28	0.008	0.012	0.015	0.015
Land ownership	0.03	0.31	0.005	0.011	-0.002	0.014
Value of farm asset	-0.02	0.12	-0.0013	0.0030	-0.0030	0.0038
Hired labour	2.38***	0.91	-0.0025	0.0062	0.0130*	0.0076
Farm size	-0.07	0.17	-0.0007	0.0095	-0.007	0.011
Share of fam. labour	-0.72*	0.43	0.017	0.016	-0.010	0.020
Credit access	0.01	0.25	-0.007	0.010	-0.014	0.013
Market distance	-0.008	0.059	0.0009	0.0018	0.0010	0.0022
Extension	0.51*	0.26	0.011	0.010	0.027**	0.012
Market information	-0.12	0.29	0.026**	0.012	0.028*	0.014
Stable income	0.09	0.27	0.029***	0.011	0.032**	0.013
District	0.90***	0.32	0.014	0.011	0.048***	0.013
Livestock income	1.64***	0.32	0.073***	0.020	0.237***	0.020
Fertilizer	-0.56*	0.32	-0.216***	0.016	-0.214***	0.019
Fertiliser subsidy	0.88*	0.46	0.0183***	0.0063	0.0259***	0.0079
Constant	1.15**	0.49	0.014	0.011	0.037***	0.014
Number of obs.	-1.10	0.75	0.324***	0.037	0.130***	0.042
Wald/LR χ^2 (19)	606		563		606	
Loglikelihood	177.44***		258.36***		349.47***	
Pseudo R^2	0.5716				-3.2975	
Sigma			0.1157***	0.0035	0.1478	0.0045
Likelihood ratio statistic	247.73					

Note: SE denotes standard error; the asterisks, *, **, and ***, denote significant at the 10%, 5% and 1% levels, respectively.

Appendix 7.1b: Probit, Truncated, and Tobit Regression Estimates for Livestock Diversification

	Probit		Truncated		Tobit	
	Coefficient	SE	Coefficient	SE	Coefficient	SE
Age	-0.006	0.054	-0.0028	0.0063	-0.0032	0.0071
Gender	-0.10	0.18	-0.013	0.021	-0.018	0.024
Education	-0.13	0.15	-0.008	0.017	-0.019	0.019
Dependency ratio	0.040	0.034	-0.0020	0.0034	0.0009	0.0038
Off-farm income	0.03	0.18	0.008	0.021	0.008	0.023
Land ownership	-0.41**	0.17	-0.009	0.019	-0.049**	0.022
Value of farm asset	0.015	0.048	-0.0114*	0.0061	-0.0065	0.0059
Hired labour	-0.154**	0.075	0.005	0.011	-0.012	0.011
Farm size	0.20*	0.12	-0.006	0.014	0.012	0.015
Share of fam. labour	0.20	0.25	0.015	0.028	0.027	0.031
Credit access	0.92***	0.17	0.032*	0.018	0.108***	0.020
Market distance	0.081**	0.033	-0.0057*	0.0032	0.0009	0.0035
Extension	0.15	0.15	-0.019	0.018	0.001	0.020
Market information	0.33*	0.19	-0.052**	0.020	-0.006	0.023
Stable income	0.71***	0.15	0.022	0.019	0.095***	0.020
District	0.04	0.16	0.032*	0.018	0.027	0.020
Road network	-0.51***	0.19	-0.087***	0.029	-0.126***	0.029
Feed crop residue	0.70***	0.17	0.008	0.020	0.082***	0.022
Store crop residue	-0.61***	0.17	0.008	0.021	-0.060***	0.022
Constant	-0.27	0.48	0.416***	0.054	0.204***	0.060
Number of obs.	608		511		608	
Wald/LR χ^2 (19)	143.31***		31.39**		108.6***	
Loglikelihood	-195.20		188.91		-69.73	
Pseudo R^2	0.2685				0.4378	
Sigma			0.181***	0.007	0.2284	0.0074
Likelihood ratio statistic	126.88					

Note: SE denotes standard error; the asterisks, *, **, and ***, denote significant at the 10%, 5% and 1% levels, respectively.

Appendix 7.1c: Probit, Truncated, and Tobit Regression Estimates for Integrated Crop-Livestock Diversification

	Probit		Truncated		Tobit	
	Coefficient	SE	Coefficient	SE	Coefficient	SE
Age	-0.004	0.098	-0.0036	0.0038	-0.0025	0.0046
Gender	0.22	0.30	0.022*	0.013	0.028*	0.016
Education	0.07	0.27	0.010	0.011	0.012	0.013
Dependency ratio	0.034	0.065	0.0017	0.0021	0.0015	0.0025
Off-farm income	0.75***	0.28	-0.004	0.013	0.015	0.023
Land ownership	-0.20	0.32	-0.002	0.012	-0.008	0.014
Value of farm asset	-0.066	0.057	-0.0039	0.0032	-0.0059	0.0038
Hired labour	0.29	0.30	0.0062	0.0061	0.0083	0.0074
Farm size	0.35*	0.20	-0.0015	0.0085	0.009	0.010
Share of fam. labour	-0.08	0.43	0.006	0.017	0.002	0.020
Credit access	0.03	0.28	0.038***	0.011	0.038***	0.013
Market distance	0.055	0.059	0.0018	0.0019	0.0029	0.0023
Extension	0.10	0.27	0.031***	0.011	0.033***	0.013
Market information	0.17	0.36	0.035***	0.012	0.038***	0.015
Stable income	0.03	0.28	0.023***	0.011	0.025*	0.013
District	-0.70**	0.31	-0.013	0.011	-0.029**	0.013
Use of plough tillage	0.79***	0.28	0.115***	0.017	0.157***	0.019
Constant	0.09	0.82	0.441***	0.035	0.341***	0.041
Number of obs.	608		593		608	
Wald/LR χ^2 (22)	34.99***		115.69***		127.88***	
Loglikelihood	-52.849945		390.8832		250.408	
Pseudo R^2	0.2487				-0.3429	
Sigma			0.125***	0.004	0.1518	0.0045
Likelihood ratio statistic	175.25					

Note: SE denotes standard error; the asterisks, *, **, and ***, denote significant at the 10%, 5% and 1% levels, respectively.

Appendix 7.2a: Heckman's model of Crop Diversification

Variable	Stage 1		Stage 2	
	Coeff	SE	Coeff	SE
Age	0.0069*	0.0037	0.065	0.087
Gender	0.025*	0.013	0.22	0.28
Education	0.002	0.010	0.21	0.26
Dependency ratio	-0.0012	0.0021	-0.097**	0.043
Off-farm income	0.007	0.012	0.34	0.28
Land ownership	0.005	0.011	0.03	0.31
Value of farm assets	-0.0013	0.0030	-0.02	0.12
Hired labour	-0.0032	0.0064	2.38***	0.91
Farm size	-0.0002	0.0095	-0.07	0.17
Share of fam. labour	0.018	0.017	-0.72*	0.43
Credit access	-0.006	0.010	0.01	0.25
Market distance	0.0009	0.0018	-0.01	0.06
Extension	0.011	0.010	0.51*	0.26
Market information	0.026**	0.012	-0.12	0.29
Stable income	0.028	0.011	0.09	0.27
District	0.013	0.011	0.90***	0.32
Use tillage equipment	0.066***	0.024	1.64***	0.32
Good road networks	-0.211***	0.016	-0.56*	0.32
Fertilizer	0.0179***	0.0063	0.88*	0.46
Fertilizer subsidy	0.013	0.011	1.15**	0.49
Constant	0.335***	0.041	-1.10	0.75
N	608			
Wald chi^2	229.33***			
Sigma	0.115			
Mills ratio (Lambda)	**-0.017**	0.042		

Note: SE denotes standard error; the asterisks, *, **, and ***, denote significant at the 10%, 5% and 1% levels, respectively.

Appendix 7.2b: Heckman's model of Livestock Diversification

Variable	Stage 1		Stage 2	
	Coeff	SE	Coeff	SE
Age	-0.0050	0.0065	0.024	0.071
Gender	-0.018	0.022	0.26	0.22
Education	-0.019	0.017	0.23	0.20
Dependency ratio	0.0000	0.0036	-0.038	0.032
Off-farm income	-0.004	0.022	0.41**	0.22
Land ownership	-0.038**	0.019	-0.27	0.25
Value of farm asset	-0.0075	0.0051	-0.03	0.10
Hired labour	-0.008	0.010	4.00***	0.87
Farm size	0.006	0.015	0.20	0.14
Share of fam. labour	0.027	0.028	-0.30	0.34
Credit access	0.085***	0.018	-0.28	0.20
Market distance	0.0000	0.0031	0.033	0.042
Extension	-0.008	0.018	0.30	0.21
Market information	-0.023	0.020	-0.04	0.24
Stable income	0.071***	0.018	-0.19	0.22
District	0.029	0.018	0.19	0.22
Road network	-0.096***	0.030	-1.00***	0.24
Feed crop residue	0.069***	0.022	0.57*	0.26
Store crop residue	-0.035*	0.020	-0.16	0.26
Constant	0.279***	0.061	0.12	0.58
N	608			
Wald chi^2	84.75***			
Sigma	0.201			
Mills ratio (Lambda)	**-0.076**	0.074		

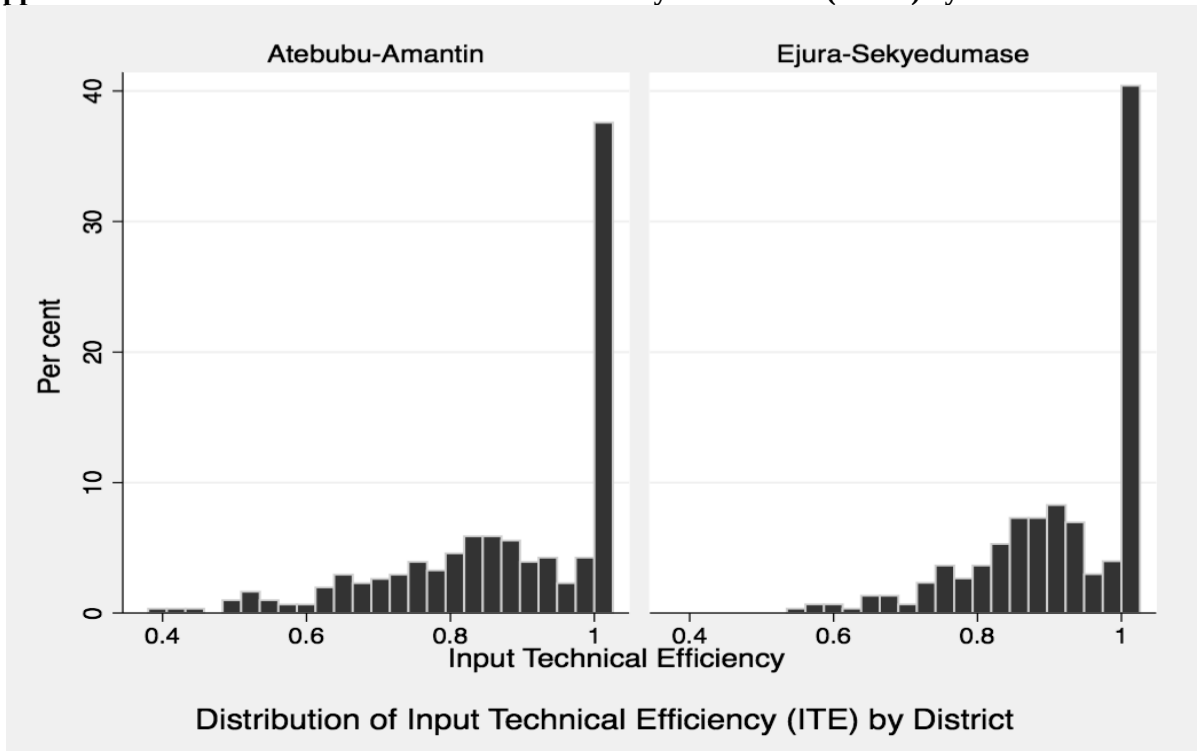
Note: SE denotes standard error; the asterisks, *, **, and ***, denote significant at the 10%, 5% and 1% levels, respectively.

Appendix 7.2c: Heckman's model of integrated crop-livestock Diversification

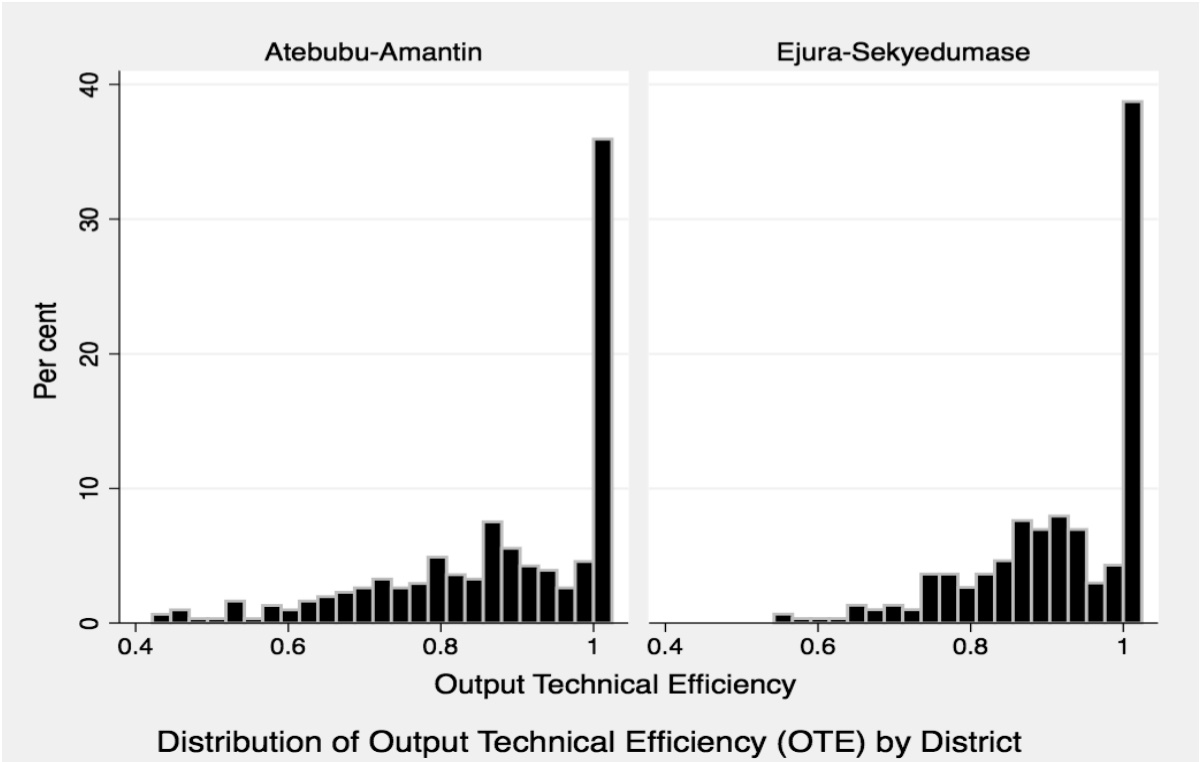
Variable	Stage 1		Stage 2	
	Coeff	SE	Coeff	SE
Age	-0.0038	0.0046	0.054	0.084
Gender	0.021	0.016	0.31	0.25
Education	0.004	0.013	0.42	0.25
Dependency ratio	0.0026	0.0025	-0.043	0.038
Off-farm income	0.001	0.015	0.34	0.25
Land ownership	0.007	0.014	-0.21	0.29
Value of farm asset	-0.0057	0.0037	-0.045	0.074
Hired labour	0.0033	0.0077	2.12***	0.71
Farm size	0.002	0.011	0.13	0.15
Share of fam. labour	0.018	0.021	-0.74*	0.40
Credit access	0.031**	0.013	-0.02	0.23
Market distance	0.0027	0.0022	0.019	0.050
Extension	0.024*	0.013	0.45*	0.24
Market information	0.040***	0.014	-0.16	0.28
Stable income	0.023*	0.013	-0.03	0.25
District	-0.037***	0.014	0.64	0.29
Use of plough tillage	0.077**	0.032	2.19***	0.27
Constant	0.473***	0.053	-1.43**	0.69
N	608			
Wald chi^2	62.56***			
Sigma	0.144			
Mills ratio (Lambda)	**-0.083**	0.051		

Note: SE denotes standard error; the asterisks, *, **, and ***, denote significant at the 10%, 5% and 1% levels, respectively.

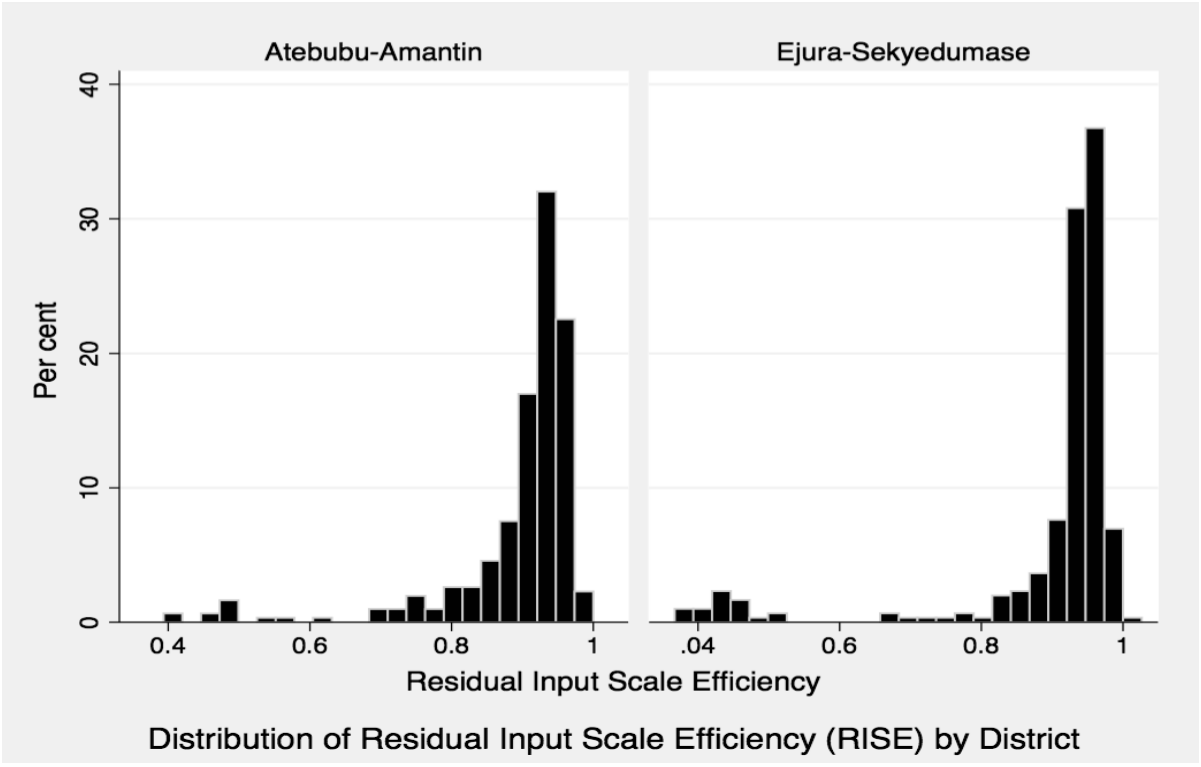
Appendix 8: Distributions of Total Factor Productivity Efficiencies (TFPE) by District



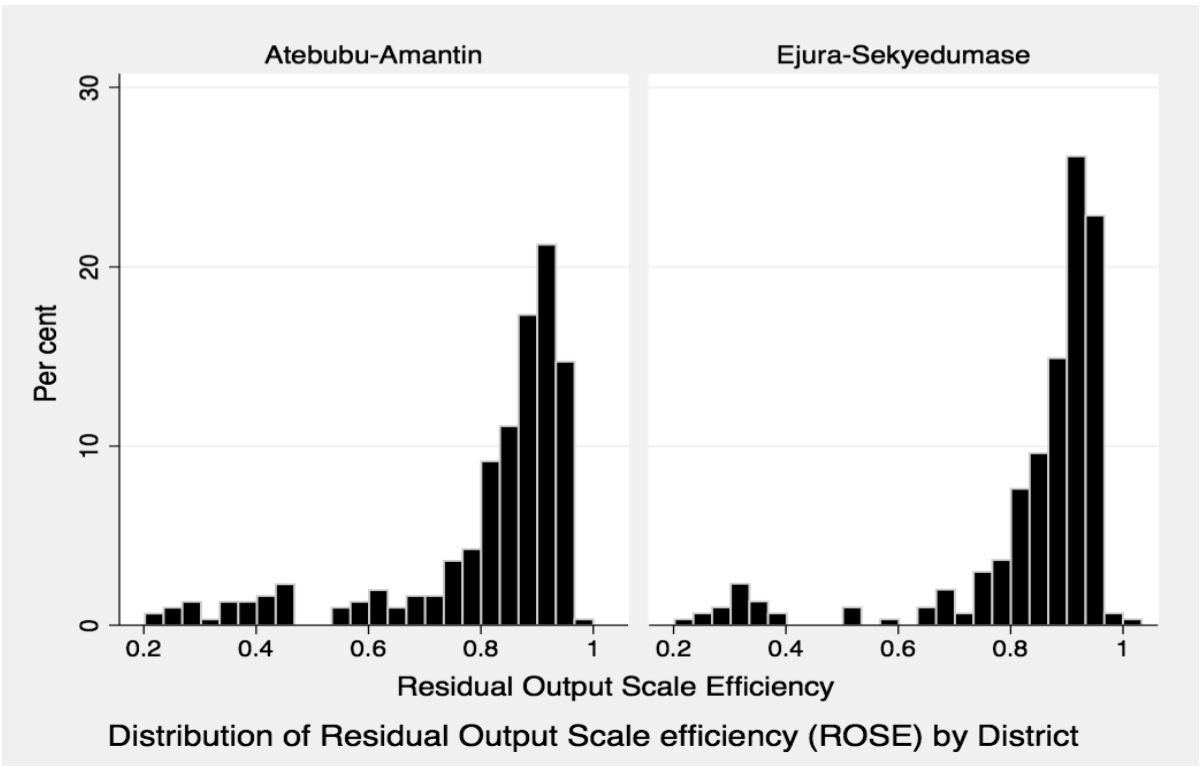
Distribution of Input Technical Efficiency (ITE) by District



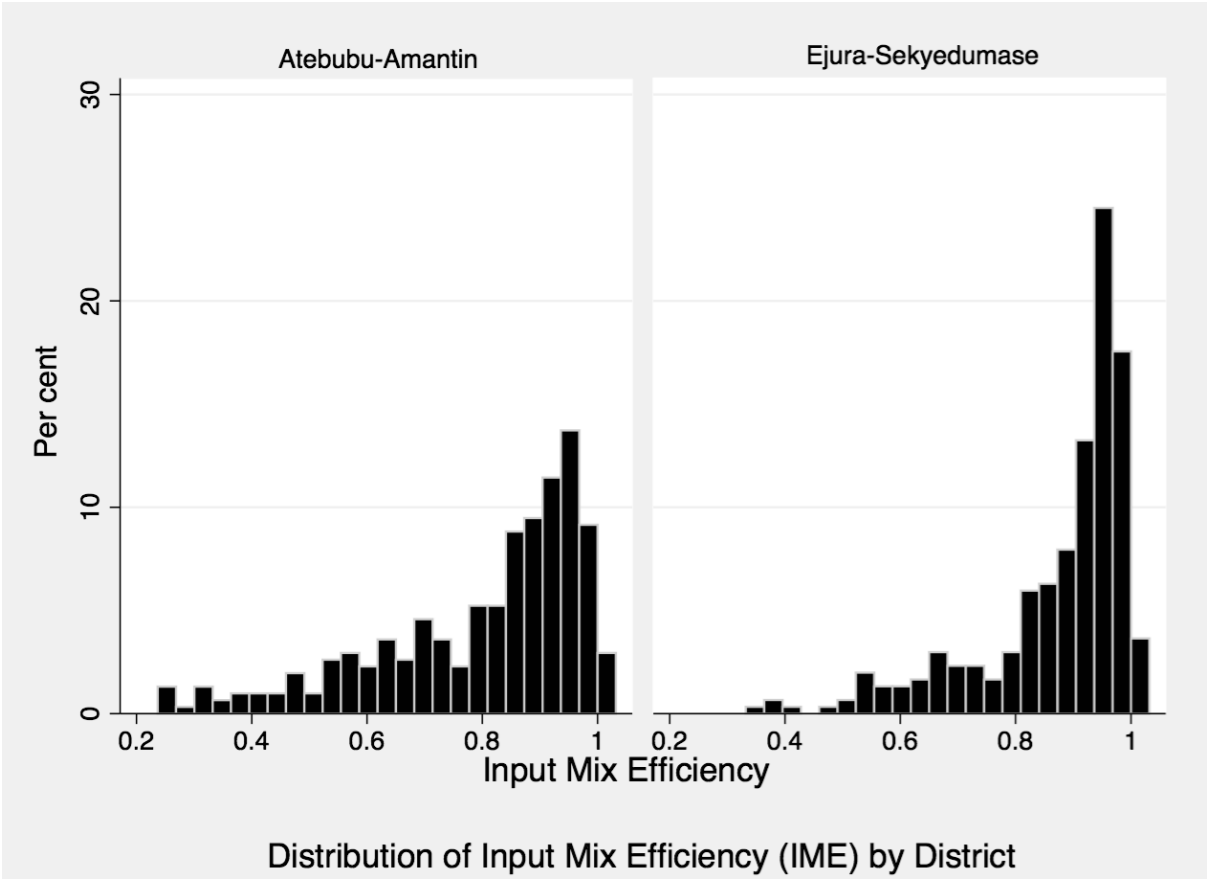
Distribution of Output Technical Efficiency (OTE) by District



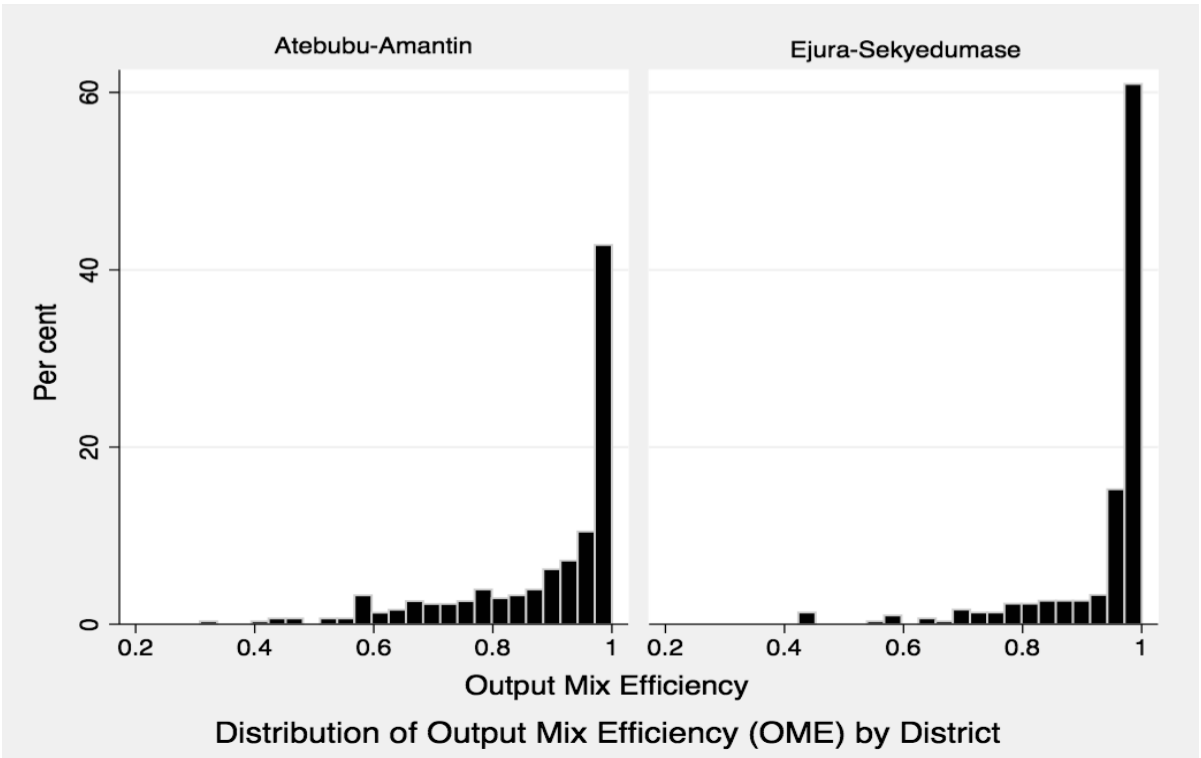
Distribution of Residual Input Scale Efficiency (RISE) by District



Distribution of Residual Output Scale efficiency (ROSE) by District



Distribution of Input Mix Efficiency (IME) by District



Distribution of Output Mix Efficiency (OME) by District

Appendix 9a: Specification Tests for One-part and Two-part Fractional Regression Models for the Input-orientated Mix Efficiency (p-values)[a]

	One-part models				Binary component of two-part models				Fractional components of two-part models			
	Logit	Probit	Loglog	Cloglog	Logit	Probit	Loglog	Cloglog	Logit	Probit	Loglog	Cloglog
RESET test	0.002***	0.036**	0.000***	0.830	0.774	0.989	0.738	0.661	0.000***	0.004***	0.000***	0.452
GOFF-I	0.033**	0.027**	-	0.753	0.974	0.845	-	0.963	0.009***	0.002	-	0.380
GOFF-II	0.003***	0.079*	0.000***	-	0.717	0.971	0.774	-	0.000***	0.015	0.000***	-
GOFF	0.000***	0.000***	0.000***	0.753	0.592	0.704	0.774	0.963	0.000***	0.000	0.000***	0.380
P test												
One-part models												
Logit	-	0.008**	0.001***	0.699								
Probit	0.000***	-	0.000***	0.705								
Loglog	0.159	0.238	-	0.265								
Cloglog	0.000***	0.006**	0.000***	-								
1st component of two-part models												
Logit					-	0.880	0.999	0.999				
Probit					0.363	-	0.999	0.999				
Loglog					0.601	0.987	-	0.999				
Cloglog					0.482	0.957	0.999	-				
2nd component of two-part models												
Logit									-	0.001***	0.000**	0.591
Probit									0.000***	-	0.000***	0.711
Loglog									0.056	0.039*	-	0.788
Cloglog									0.000***	0.001**	0.000***	-

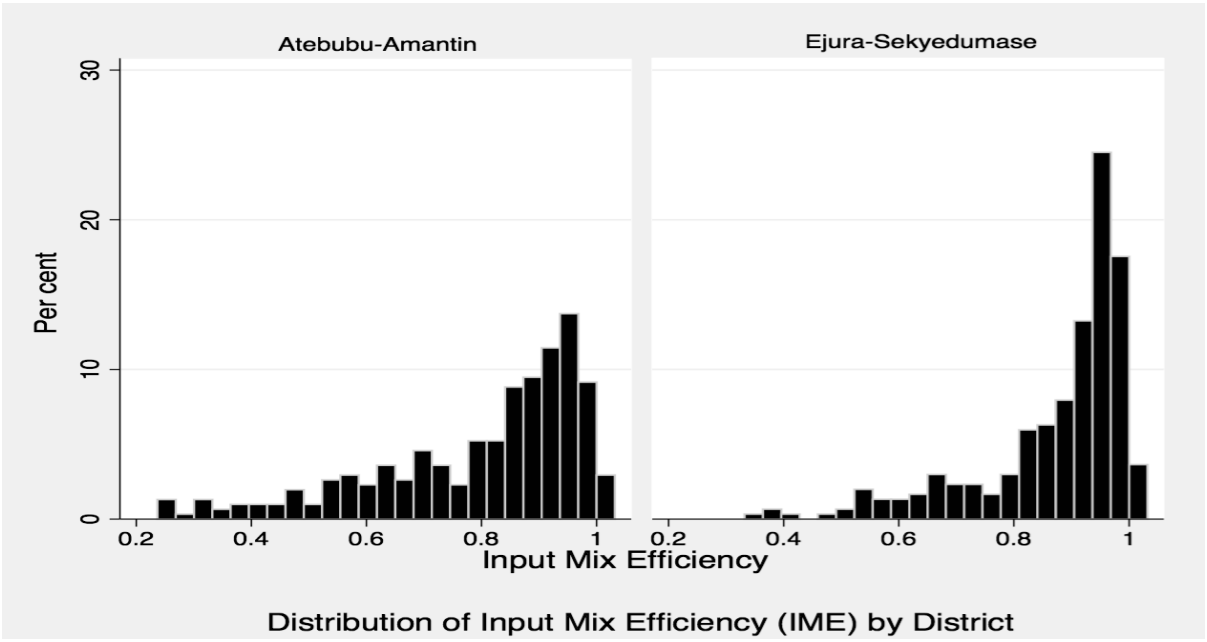
[a] The asterisks, ***,** and * on the test statistics denote test statistics that are significant at 1%, 5% or 10%, respectively.

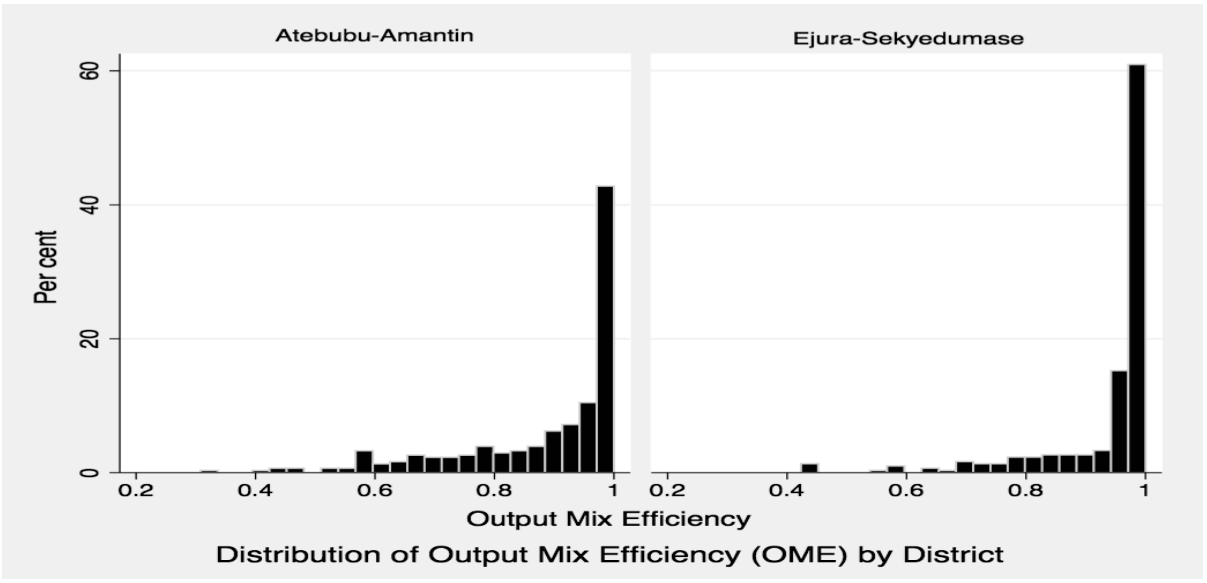
Appendix 9b: Specification Tests for One-part and Two-part Fractional Regression Models for the Output-orientated Mix Efficiency (*p*-values)[a]

	One-part models				Binary component of two-part models				Fractional components of two-part models			
	Logit	Probit	Loglog	Cloglog	Logit	Probit	Loglog	Cloglog	Logit	Probit	Loglog	Cloglog
RESET test	0.554	0.987	0.385	0.529	0.126	0.263	0.916	0.175	0.103	0.455	0.026	0.656
GOFF-I	0.809	0.441	-	0.680	0.161	0.285	-	0.267	0.809	0.441	-	0.680
GOFF-II	0.280	0.722	0.173	-	0.220	0.265	0.925	-	0.280	0.722	0.173	-
GOFF	0.000	0.000	0.173	0.680	0.292	0.516	0.925	0.267	0.000***	0.000***	0.173	0.680
p-value One-part models												
Logit	-	0.936	0.876	0.147								
Probit	0.149	-	0.124	0.228								
Loglog	0.483	0.411	-	0.063*								
Cloglog	0.066*	0.532	0.027**	-								
1st component of two-part models												
Logit						0.035**	0.998	0.482				
Probit					0.541		0.979	0.760				
Loglog					0.290	0.675		0.322				
Cloglog					0.145	0.032**	0.997					
2nd component of two-part models												
Logit									-	0.330	0.367	0.375
Probit									0.009***	-	0.009***	0.404
Loglog									0.918	0.962	-	0.187
Cloglog									0.007***	0.239	0.002***	-

[a] The asterisks, ***, ** and *, on the test statistics denote significance at 1%, 5% or 10% levels, respectively.

Appendix 9c: Distributions of the Estimated Mix Efficiency Scores





Appendix 9d: Significance Tests of Skewness and Kurtosis for Normality of the Distributions

Variable	Skewness	*p-value*	Kurtosis	*p-value*
OME	-1.9	0.000	6.1	0.000
IME	-1.5	0.000	4.7	0.000