HOUSEHOLD SEGMENTATION IN FOOD INSECURITY AND SOIL IMPROVING PRACTICES IN GHANA

A Thesis

by

JIFAR NATA

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Chair of Committee,	James W. Mjelde
Committee Members,	Frederick Boadu
	Urs P. Kreuter
Head of Department,	C. Parr Rosson

August 2013

Major Subject: Agricultural Economics

ABSTRACT

There is a persistent problem of poor agricultural production which leads to household food insecurity problems for farmers in Ghana. Studies show that the adoption of improved agricultural practices and technology may help stabilize production, and lessen food insecurity problems. There, however, is a missing link between food insecurity and adoption of soil improving practices in the literature. The missing link is addressed by investigation whether the food insecurity group differs in adopting the use of soil improving practices. Conversely, the adoption of soil improving practices may influence a household's food security position. With this in mind, the objectives of study are to determine the 1) likelihood of adopting the soil improving practices of Ghanaian households; and 2) determine if and how food insecure agricultural households differ from food secure agricultural households in terms of agricultural practices, household characteristics, and technologies adopted.

A conditional logit model, based on random utility theory, is estimated to determine which factors affect adoption of soil improving practices; whereas, a multinomial logit model is used to examine factors influencing a household's food insecurity position. Positions considered are chronic, seasonal, vulnerable food insecure groups and a food secure group. The positions are differentiated by the length of time a household went without sufficient food. Characteristics of operating under seasonal lease, being a food secure household, and households farming medium quality soil increase the probability of adopting soil improving practices. Application of chemical

fertilizers, commercial seeds, and pesticides, along with operating under a seasonal lease tenure and adoption of improved soil practices are likely to improve the household food security position. Households with medium quality soil have a larger probability of not being a chronic food insecure household. Given the high priority that the government of Ghana has placed on food security, policies that encourage households to adopt soil improving practices may be beneficial to food insecure households.

Household characteristics such as income, age, education level, and household size are not significant in determining the likelihood of a household being in one of food insecurity group. The insignificance may be attributed to the homogeneity of the surveyed household characteristics.

ACKNOWLEDGEMENTS

There are several people who have contributed in one way or another to complete my study. I really owe a debt of gratitude for the support given so far.

I am deeply indebted to my major professor, Dr. James W. Mjelde for his guidance, patience, and encouragement throughout my study. His advice is invaluable and I have learned a lot during the thesis work.

To my committee members, Dr. Urs P. Kreuter and Dr. Frederick Boadu for their encouragement and comments provided. Moreover, I would like to thank Dr Fred Boadu for sharing his knowledge of Ghana agriculture and helping coordinate Ghana survey activities.

I am extremely grateful for Dr. William A. Payne for acquiring funding for my study. Without the financial support, it would have been impossible to pursue my study. I am also grateful for McKnight Foundation for providing funding for my study.

I would like to thank my parents and sister for their moral support, love and encouragement. This is for my father, Tarekegn Nata, my mother, Amsale Tessema, my sister, Sufani Nata, along with her husband, Fantaye Taye.

Finally, I would like to thank colleagues in Norman Borlaug Institute for International Agricultural for administrative support and office space during my study. Moreover, I thank colleagues in Department of Agricultural Economics for sharing knowledge and ideas. Friends are also important in life and I would like to thank friends in College Station and other places giving me joyful moments.

TABLE OF CONTENTS

Page

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION AND LITERATURE REVIEW

Recent census places the population of Ghana at 24.7 million with an annual growth rate of 2.4 percent in 2010 (Ghana Statistical Service (GSS) 2012; Ghana Statistical Research and Information Directorate 2010). Agriculture is the major source of livelihood supporting 46 percent of the total households. Ninety five percent of the agricultural households engage in crop farming and 41 percent raise livestock (GSS 2012). According to the Institute of Statistical, Social, and Economic Research (ISSER), agriculture accounted for 30 percent of Ghana's GDP in 2010 with a 5.3 percent mean annual growth rate (ISSER 2010).

Although agriculture is a growing major sector in Ghana's economy, food insecurity remains an issue. A 2009 study by the World Food Programme (WFP) showed that 1.2 million people in Ghana have limited access to sufficient and nutritious food (WFP 2009). Out of these 1.2 million people, almost 55 percent are from households that are primarily food crops farmers, cash crop farmers, agro-pastoralist, food processors, or unskilled laborers. According to the WFP (2009), the basic underlying factors for food insecure households are high dependency on agriculture, lack of education, lack of access to output markets, and poverty. Other studies such as Mulugeta and Hundie (2009) and World Bank (2008) attribute ineffective production techniques, inadequate extension access, and inadequate input supplies as causes of food insecurity.

To improve food security, Ghana has implemented several programs through accelerated agriculture growth and development strategies (Ghana Ministry of Food and Agriculture (GMOFA) 2011). Ghana's second Food and Agriculture Sector Development Plan (FASDEP II) focuses on reducing food insecurity and poverty (GMOFA 2011). Implementing FASDEP II by improving the extension service to farmers is one of the strategies to raise productivity and reduce food insecurity (GMOFA 2011). Further policy initiatives such as irrigation development, buffer stock management, fertilizer subsidies, and livestock and fisheries development are designed to ensure higher production and national food security (ISSER 2010).

There, however, is a persistent problem in of low agricultural production and household food insecurity for farmers operating under risk. Agricultural production is weather dependent in many Africa countries including Ghana (World Bank 2008). As such, farmers face considerable risks and uncertainties in their farm output, income, and wellbeing (Rosenzwig and Binswanger 1993). Fluctuations in weather patterns and the occurrence of extreme events such as droughts, market crashes, and pest infestations often result in less production than anticipated which may result in food insecurity (World Bank 2008; Christiansen, Hoffman, and Sarris 2007). Because of these events, some households may be forced to go without sufficient food while others face worse than normal food availability for prolonged periods.

Food security is a critical issue. Haggblade and Tembo (2003) argue that conservation farming with minimum till, cover crops and crops, rotation holds promise for stabilizing production and ensuring food security from their experiment in Zambia.

Stabilizing production in a sustainable way through soil improving practices may be one way of ensuring food security for the growing Ghana population.

Increasing food production in a sustainable manner is important for improving farmers' livelihood. There, however, is a missing link between food security and adoption of soil improving practices. To the author's knowledge, no study has investigated the relationship between the two. The objective of this study is to determine the likelihood of adopting soil improving practices of Ghanaian households. Furthermore, the study will determine if and how food insecure agricultural households differ from food secure agricultural households in terms of agricultural practices, household characteristics, and technologies adopted. To achieve these objectives, a survey of agricultural households conducted in Greater Accra Region of Ghana is conducted. Besides descriptive summary statistics, logit models are estimated to determine likelihood of adopting soil improving practices and food insecurity groups.

Literature Review

The World Food Summit in 1996, describes food security as achievement "when all people, at all times, have physical and economic access to sufficient safe and nutritious food to meet their dietary needs and food preference for an active healthy life" (WFP 2009, p. 19). The concept of food security is complex, but can be broken down into three basic elements: availability, access, and utilization (International Fund for Agriculture Development (IFAD) 1992). Availability is the condition where there is physical presence of food in the form of domestic production, commercial imports, and aid (WFP 2009). Access is the ability to acquire food through a combination of home

production and stocks, purchasing, borrowing, personal gifts, and in-kind or food aid (WFP 2009). Utilization is the household's use of acquired food including the ability to absorb and metabolize nutrients (WFP 2009).

How the elements of food security, food availability, access, and utilization are influenced by resource availability, labor productivity, income, and other resources is illustrated in Figure 1 (IFAD 1992). Food insecurity arises from three potential risks: natural, social (illiteracy, illness, malnutrition), and economic. Food security can be improved by enhancing community resilience, livelihood capacity, and human capital which improves the adequacy of food availability and access, as well as, having appropriate food utilization (IFAD 1992).

Studying food security at the household level has received considerable attention because households are the basic economic unit that determines consumption. Individual consumption is determined by each household member's claim on household resources (WFP 2009). Food security at the household level, however, does not necessarily mean that all members of the household are food secure; conversely, a food insecure household may have food secure members (IFAD 1992). Similarly, a country may be food secure, but there can be a considerable number of food insecure households (IFAD 1992).

In analyzing food insecurity, it is not only important to consider the duration of the time that the household did not have sufficient food, but also the intensity / severity of the insecurity (Figure 2). Different scales or categories have been developed to classify different levels of food insecurity. Households' food insecurity can be classified

based on the duration of time a household went without sufficient food: chronic, transitory, and vulnerable (WFP 2006; Deveraux 2006). Chronic food insecurity is characterized by a persistent problem of food shortages; food shortages are an ongoing continuous problem. Causes of chronic food insecurity are most often structural deficiencies in the local food economy manifested by chronic poverty, lack of assets, and low incomes over a protracted period of time (Wiggins et al. 2004). Deveraux (2006) categorized the situation of food insecurity for at least for six months out of a year as a chronic.

In contrast, transitory food insecurity is usually associated with short term or temporary periods of scarcity of food availability and access (Barrett and Sahn 2001). This condition is commonly associated with weather / climate shocks, natural disasters, economic crises, or conflicts. Severe transitory food insecurity can have a form of seasonal or cyclical pattern (Institute of Development Studies (IDS) 2006). Seasonal or cyclical food insecurity arises when there is a pattern of inadequate access to food usually prior to the harvest period (IDS 2006; Deveraux 2006). Prediction of seasonal food insecurity is easier than other forms of transitory food insecurity, because seasonal insecurity arises from a known pattern (Deveraux 2006). Seasonal food shortage that exists for a period of 2-3 months can turn into chronic food insecure if it lasts a total of at least six months a year (Deveraux 2006).

Transitory food insecure households may shift to chronically food insecure level, if the cause for the food insecurity has prolonged effects which force the household to sell their productive assets (Deveraux 2006). By the same token, households that are

chronically food insecure may become worst if they are force to further deplete their assets causing future food insecurity events to be even more severe (Deveraux 2006).

A household is vulnerable to food insecurity if it is border line between food secure and insecure. IDS (2006, p#7) defined vulnerable food insecurity as those "household being at risk to become food transitory or chronically food insecure in future", but currently able to maintain an acceptable food intake.

Poverty, Food Security, and Risks

Household food insecurity is usually associated with poverty. Insecurity has a broader definition than hunger and malnutrition, insecurity usually features a lack of income and ownership of productive assets (United Nations 1995). Moreover, insecurity is usually associated with morbidity and mortality from illness, lack of access to education, and lack of other basic services. Lack of access to food it is an outcome of poverty (European Commission 2000; United Nations 1995). Poverty is a relative term and is set to reflect different consumption sets by families based on their composition (household size and the number of children). Relative poverty measures are based on the average consumption for essential goods such as food, clothing, housing, and housekeeping supplies (WFP 2009). For most developing countries, achieving long term food security is best met by integrating food security into poverty reduction strategies (European Commission 2000).

The association between poverty and food insecurity may also occur in the measurement of poverty line. Food and energy intake is one of the approaches in determining the poverty line (Ravallion 1998). Ravallion (1998) defined the food and

energy intake approach as the sufficient level of consumption expenditures or income level to meet pre-determined food energy requirement. Another way to measure poverty line is the Cost of Basic Needs approach. Ravallion (1998) and Ravallion and Lokshin (2003) defined the Cost of Basic Needs as the estimated cost of the consumption bundle that is an adequate level for basic needs. Hence, households who are not earning above poverty line are considered poor (Ravallion 1992). Given the information of household income, the share of food consumption to total income, the incidence of poverty likely reflects the food insecurity position of the household (Altman, Hart, and Jacobs 2009).

Consumption approach is another alternative to measure poverty. In this measure, the minimum level of food consumption is calculated to draw the poverty line. World Health Organization recommends 2100 calorie energy per day per person, which is often used as the minimum benchmark (Pradhan and Ravallion 1999; Abele, Twine, and Legg 2007).

Risk is another important feature of household food insecurity that makes households vulnerable. Siegel and Alwang (1999) describe risk as a stochastic event with a known probability distribution. Risks such as drought, commodity price fluctuations, and conflicts can affect food access and availability at the household level. As shown in the Figure 3, exposure to risk comes in the form of geography (urban vs. rural), ecological (natural hazards and environmental damages), economic (occupation, income fluctuation, and production loss), demographic (family size, gender, and children), conflicts (breakdown of the rule of law), and policy changes (property rights, tax imposition, and subsidy removal) (IFAD 1992). How risks are featured from

different sources such as natural, state, and market which affect productive, non-productive, and human capital is shown in Figure 3 (IFAD 1992; Christiansen, Hoffman, and Sarris 2007; Siegel and Alwang 1999).

The presence of risks has caused food insecure households to adopt coping methods. Households smooth consumption by making conservative production decisions or employment choices, and/or diversifying economic activities. By using such coping strategies, households protect themselves from adverse income losses before they occur (Deaton 1992). Other coping strategies for a food insecure household are reducing the number and size of meals, eating less preferred foods, skipping meals, and taking children out of school (Quaye 2008; IDS 2006).

Food Insecurity and Adoption of Agricultural Innovation

Sociologist Everett Roger's (1962) seminal work of diffusion of innovations cited in Meade and Islam (2006) is widely accepted as popularizing the innovation-diffusion model. Innovation is defined as an idea, practice, or object that is perceived as new by individuals or other units of adoption (Rogers 2003). Diffusion is the process which an innovation is communicated overtime among members in a social system (Rogers 2003).

The innovation-diffusion model suggests a sigmoid adoption curve with five types of adopters depending on the when they adopt (Rubas 2008). Rogers (1962) cited in Ayodele (2012) classified adopters are innovators, early adopters, early majority, late majority, and laggards. The Sigmoid adoption curve reflects sequential adoption where innovators adopt technology first. Innovators, which are willing to take risks, are

commonly younger in age, higher in social status and financial liquidity than their peer. Early adopters have the highest degree of opinion leadership; they are younger in age and more discrete in adoption choice than innovators. Early majority adopters tend to be slower in adoption process and the time to adoption is significantly longer than innovators and early adopters. Late majority are typically skeptical on innovations and tend to adopt after the majority of society members have adopted. Laggards are last group to adopt and are typically averse to change and older in age than their peers (Rogers 1962 cited in Ayodele 2012).

There are two types of approaches that explain why potential adopters adopt at once when multiple innovations taken place (Rubas 2008; Diederen et al. 2003). In the epidemic or disequilibrium approach, access to information is key to diffusion. Information has a bandwagon effect, if the given innovation is profitable and others are using technology, people will jump on the bandwagon and adopt the innovation (Rubas 2008). In other words, the number of adopters' increases as the information is spread among potential adopters. Markets for new technologies, however, are is not transparent and usually prone to imperfect information. Hence for non-adopters, it takes time to see the effect of new technologies that benefited adopter (Diederen et al. 2003). In contrast, the equilibrium or Bayesian approach emphasizes that the gradual diffusion is not because of market imperfection, but arises because of variation in benefits of the innovation over all potential adopters (Diedersen et al. 2003). According to this approach, the s-shape adoption curve arises because adopters adjust the intensity of using new technology through learning and modifying expectations (Rubas 2008).

Feder, Just, and Zilberman (1985) review the literature on adoption of agricultural innovation in developing countries. Their review emphasizes the pattern of farmers' adoption behavior for agriculture technologies. Empirical studies reviewed in the article concentrate on the analyses of observed adoption patterns in relation to key factors that might influence adoption behavior. Farm size, risk and uncertainty, human capital, labor availability, credit, and tenure are key factors influencing adoption. Most of the research reviewed analyze adoption as a dichotomous case (adopt or not adopt). Rubas (2008) summarized those factors that are strongly related to the profiles of adopter. Literacy, income, open attitude toward change, group participation, interpersonal communication, opinion leadership, and group participation are among the prime characteristic that fits into socio-economic profile of adopters.

Adesina and Baidu-Forsou (1995) and Thirtle and Ruttan (1987) studied adoption of agricultural innovations with respect to the level of education and credit availability, income level, access to extension service, and farming inputs. These factors show significant influences on increasing agricultural technology adoption. Factors that are negatively correlated with adoption are high level of poverty and vulnerability to shocks. To a lesser extent, factors such as farm size, ownership of land, and access to commodity markets influence adoption of agricultural innovations.

The effect of adoption of agricultural innovation may translate into better farm income and food insecurity. Adoption of agricultural innovation influences the level of agricultural productivity which in turn helps determine farm income and household food insecurity. Studies show there is statistical significant positive relationship between

agricultural technology adoption and poverty reduction and household food security. Minten and Barrett (2008) show that Madagascar farmers regard productivity enhancing innovations, such as improved access to agricultural equipment, irrigation, and cattle, as key elements to increase their rice productivity, food security, and income. Moyo et al. (2007) analyze the impact of agricultural research on peanuts on poverty in Uganda. Benefits from research leading to the adoption of rosette resistant peanut varieties are estimated at $62 million over 15 years which provides a modest reduction in poverty.

As a result of using improved chickpea varieties, smallholder farmers in Ethiopia and Tanzania farmers are able to produce more and create a market surplus in their locality (Asfaw and Shiferaw 2010). Food security for these farmers improved after adoption. Further, Asfaw and Shiferaw (2010) show that adoption of improved chick pea varieties has a significant and positive impact on crop income and consumption expenditures. Adekambi et al. (2009) estimate the impact of NERICA (a new rice variety) adoption on poverty in Benin by analyzing household expenditures for 268 households. They observe that productivity and households' income increase for NERICA adopting households relative to non-adopting households. Similarly, in analyzing data from 927 Ugandan households, Kassie, Shiferaw, and Muricho (2011) find farmers who adopted the use of improved groundnut varieties had higher groundnut surpluses compared to non-adopters. Adopters also had significantly higher crop incomes and lower poverty levels. Results from these studies suggest agricultural technology adoption can play a role in increasing incomes, lowering poverty rates, and improving household welfare.

Land Management and Food Security

Links between food security, population pressure, and environment degradation have also received attention. Pender and Gebremedhin (2006) argue that because of population pressure, more land is being cultivated causing arable land to become increasingly scarce. Landholdings per household may become smaller, reducing per farm production and subsequently smaller investments in the land. As a result of these issues, a vicious circle of low productivity, inadequate investment capacity, and continued degradation exert further pressure on the existing cultivated land (Pender and Gebremedhin 2006). Solutions to this cycle call for the need to apply sustainable land practices to resolve the long term impact of degradation on productivity and food production.

Kristjanson et al. (2012) explore the link between changes in farming practices made to cope with changes in economic and ecological conditions over the last 10 years and household food security. Their study considered different agro-ecology and farming with wide range of livelihood practices in crops, fishing, and livestock management. Based on data from 700 households in Tanzania, Uganda, Kenya, and Ethiopia, Kristjanson et al. (2012) show farmers behavioral response is to change agricultural practices in adapting to climate change. Changes in climate triggered practices such as planting earlier or late planting depending on rainfall patterns. There are considerable differences between study sites in changes in agricultural practices in the last 10 years because of climate change. Moreover, it is found that the changes in agricultural

practices are negatively related with the number of months without food. However, the direction of causation was not firmly established based on the information collected.

The application of improved agricultural practices has also become an important part in the development agenda (Opang-Anane 2006). Kassie, Shiferaw, and Muricho (2011) note sustainable agriculture has the potential to conserve and enhance natural resources by increasing soil fertility and soil organic manner while at the same time not hampering yields. Wollini, Lee, and Theis (2010) note the use of improved agricultural practices can have a positive effect on food security and biodiversity through crop rotation and intercropping. Farmers may be able to grow crops that can be harvested at different times and have different climate and environmental stress response characteristics. Such practices are a way of hedging the risks of drought, irregular temperatures, and rainfall variability. Smallholder farmers may be unable to cope with climate variability partly because there is lack of capital to invest into new adaptive practices (Wollini, Lee, and Theis 2010).

Diao and Sarpong (2007) examine the economic impact of degradation on productivity and poverty. They examine bio-physical and socio-economic factors that limit productivity growth in Ghana using an economy wide multimarket model. The aggregate economic cost of soil loss on economic growth and poverty is estimated by taking into account linkages between production and consumption. Soil fertility depletion is identified as the main bio-physical factor that deters improvements in productivity and per capita food production. Using 2003 as the base, Diao and Sarpong (2007) find that agricultural soil loss will lower maize and sorghum yields by 33 and 50

percent by 2015. With the application of sustainable land management practices there is still soil loss, but maize and sorghum yields decrease only by 12 and 15 percent.

Norris and Batie (1987), Ervin and Ervin (1982), and Lee and Stewart (1984) analyze determinants of adoptions of improved practices. Norris and Batie (1987) find that older farmers are less likely to use soil conservation practice because of a shorter planning horizon. Ervin and Ervin (1982) find education has a positive influence on conservation behavior. Lee and Stewart (1984) show income is an influential factor in adoption of erosion control practices. Moreover, renters rather than the owner of the land have more inclination to adopt conservation measures.

2. STUDY AREA, SURVEY, AND DESCRIPTIVE STATISTICS

Study Area

The study area is the Greater Accra Region of Ghana located in West Africa. Ghana's total land area is estimated at 23 million hectares of which 57 percent is area under cultivation (GMOFA 2010). There are 13 agro-ecological zones (Figure 4) and categorized into rain forest, deciduous forest, savannas, transitional zones, and range (GMOFA 2010). These agro ecological zones have growing periods that varying from 100-200 days in the southern coastal area to 200-220 days in the transitional zone (GMOFA 2010). Agriculture is generally rain-fed with production dependent on the amount and distribution of rainfall (Stumpf 1998; GMOFA 2010). Farming is predominately small landholdings; 90 percent of the holdings are less than 2 hectares (GMOFA 2010). Cultivation is primarily based on traditional farming methods with hoe and cutlass as the main farming tools (GMOFA 2010).

As noted earlier, the Ghana agricultural sector is growing. This growth is attributed to percentage increase in the production of common food staples: cassava (10 percent), rice (25 percent), and maize (5 percent) (ISSER 2010). Maize, cassava, and yam are the major crops (GMOFA 2010). Though there have been increases in production, Ghana still imports rice to cover increasing demand (ISSER 2010). For instance in 2010, total domestic production of rice available for human consumption was 190,000 metric tons, while the estimated national quantity demanded were 529,200 metric tons. A total of 341,200 metric tons were met through imports (ISSER 2010)

Similar to Ghana as a whole, the main livelihood in Greater Accra is agriculture. Approximately 70 percent of the population in this region depends on agriculture and agriculture related activities (Ghana Ministry of Local Government and Rural Development (GMoLGRD) 2006). Primary sources of livelihood are crop farming, livestock, fisheries, and distribution of farm produce (GMoLGRD 2006). Six districts comprise the Greater Accra region (Figure 5). Total land area in this region is 324,000 km^2, comprising 1.5 percent of the country. Ninety-five percent of the land holdings are small scale (GMOFA 2010). The remaining approximate five percent are large scale commercial based farms which grow nontraditional export crops such as chili pepper, pawpaw, tinda, and marrow (GMoLGRD 2006). Management of an area can be passed to the households' children through inheritance (GMoLGRD 2006). Lease share cropping between households in a community is another type of land tenure arrangement (GMoLGRD 2006).

Agricultural production in the Greater Accra region is primarily maize, rice, and cassava. Maize covers one-fourth of the cropping area, while cassava and rice comprise approximately one-half and one-fourth of the cropping area in 2010 (GMOFA 2010). In 2010, production of rice was 12,741 tons, while cassava and maize production were 68,170 tons and 3,584 tons (GMOFA 2010).

Survey

Data for this study is from the Ghana's Household Segmentation in Food insecurity and Technological Access Survey conducted in the fall of 2012. The survey questionnaire was pretested using 10 households. Using face-to-face interviews,

information on food insecurity, farming technology, socio-economic characteristics, consumption, asset ownership, extension service, soil improving practices, and income data for approximately 100 households were collected. The households were from 14 rural villages in the Greater Accra West District. Villages were chosen to account for diversity in farming systems in the region. Household respondents were identified with the help of the data collectors based on household lists for each community. Four data collectors who have knowledge about the specific localities agriculture and livelihood conducted the interviews. Data collectors are professional agricultural officers working in the survey area. The data was collected in collaboration with the local Extension Bureau of the Ministry of Food and Agriculture of Ghana. The survey questionnaire was composed of five sections (see Appendix):

Section 1 - household characteristics including age, gender, education, occupation, principal source of electricity, water, and source of cooking fuels of the households;

Section 2 - food insecurity and household welfare including perceived household food insecurity levels, causes of food shortage, number of meals per day, condition of farming, and distance to closest fuel sources and markets;

Section 3 - consumption and expenditures covering types, sources, and sales of most important crops, food and nonfood expenditures, shocks, and percentage of income spent on purchasing food;

Section 4 - farming practices and livelihood covering land holding size, use of agricultural inputs, use of conservation agriculture techniques, bio-physical characteristics, use of extensions services, asset ownership, and post-harvest storage facilities; and

Section 5 - personal information including income, and prevalence and productivity losses because of malaria, and other infectious diseases.

Descriptive Statistics

Data from 117 households were collected over approximately three weeks. For analysis, one household was dropped because of incomplete information on production and costs. Of the entire survey questions, only selected variables are presented here.

Socio-economic Characteristics

The main occupation of the households is farming with a few other activities including off farm, masonry, and petty trading (Table 1). Seventy-eight percent of the households' head main occupation was farming, while 22 percent of the household heads' main occupations were off-farm. The compositions of spouse activities included household chores and going to school. The most common activity for spouse, however, was farming at 53 percent.

Junior high is the most common level of education completed by the household heads with 40 percent of the respondents completing junior high (Table 2). Only nine percent of the household heads had a senior school or college level education. A sizable (35 percent) portion of households' head have no formal schooling. The spouses' education level is similar to the household heads education levels with 35 percent of spouses having no formal schooling and only five percent achieving senior school or college.

Household size varies from two to 12 members (Table 3). The average household size is five. Sixty-nine percent of the households have five or less members. Approximately fourteen percent of the households have more than eight members. The

composition of the households includes all people living in the house including grandparents, grandchildren, and in-laws.

Food Insecurity Group

An important dimension is categorizing food insecurity according to relative time period that a household was without sufficient food to examine differences in innovativeness and socio-economic characteristics influencing food insecurity. Three food insecure groups along with a food secure category are identified. These four food insecurity groups are defined based on the time that a household is without sufficient food. The distinction between food secure and food insecure household is based on the framework adopted by WFP (2009), Deveraux (2006), and Department Fund for International Development (2004). Accordingly, food insecure households are divided into three different categories. Survey questions based on the respondents' recollection of the past 12 months and five years are used to distinguish households between food insecure groups:

Chronic food insecure - occurs if the household was persistently unable to meet the minimum daily requirement over the past 12 months (Department Fund for International Development 2004);

Seasonal food insecure - occurs if there was a cyclical pattern of inadequate access to food over the past 12 months. Typically, the period of food shortage is between planting and harvesting (Deveraux 2006);

Vulnerable food insecure - occurs if the household is at risk of transitory or chronically food insecure, but currently has a minimum acceptable food intake (IDS 2006). Respondents whose food intake over the past 12 months has been adequate and but the respondent's household experienced food shortages in the past five years will be considered vulnerable; and

Food secure household - is a household where all members have not lived in hunger over the past five years (U.S. Department of Agriculture 2000).

Only17 percent of the household are food secure; the remaining 83 percent fall in to one of the three food insecurity groups (Table 4). Seasonal food insecure is the largest group with 57 percent of the households experiencing seasonal insecurity. Chronic and vulnerable food insecurity groups make up 10 and 16 percent of the households. For the seasonal and chronic food insecure households, the average numbers of days with insufficient food are 39 and 61 days. The severity of food insecurity ranges from 18 days to 110 days for the chronic food insecure groups and 11 to 78 days for the seasonal food insecure group.

One potential cause for food insecurity is shocks to the household that affect its ability to produce crops. Respondents were asked whether the household experienced shocks in the past 12 months in the form of drought, inflation, crop pest infestations, animal disease, unregulated sand mining, or conflict. Drought is the most common shock experienced with 78 percent (91 households) of households experiencing drought. Given the large number of farmers in the survey and regional nature of drought, such a large percentage is not unexpected. Other shocks such as conflict and crop infestation are rare. Although not a shock, sand mining is another activity that disrupts farming activities in the areas. Mining sand from agricultural lands is becoming a source of livelihood. Because of construction demand for sand, sands are mined from farm and fallow land. Approximately 78 percent of the households believe that unregulated sand mining affected their ability to produce (Table 5).

Income and Food Insecurity

The average income of the households over the past 12 months is 3,612 cedi (or U.S. $1,829 at a current exchange rate of one U.S. dollar = 1.932 cedi). The largest household income is 18,340 cedi, while the smallest income is 1,200 cedi. Higher incomes may not necessarily translate into food insecurity position; 86 percent of largest income group (25 out of 29 households) are food insecure (Table 6). A follow up question on income asks for the portion of income generated from farming. Income from agriculture is on average 73 percent of the total household income, but ranges from approximately 10 percent to 90 percent.

Agricultural Innovation and Food Insecurity

Households were asked about the application of improved inputs (technology), such as commercial fertilizers, seeds, herbicides, and pesticides. As shown in table 7, there is a relatively high application of commercial seeds (80 percent) by the food secure households compared to 67 percent for chronic food insecure households. However, it is a mixed result for application of fertilizer. Approximately, 67 percent of chronic food insecure household apply commercial fertilizer as compared to 40 percent of food secure households. Food secure households tend to apply less fertilizer compared to food insecure categories. This result may be because of the small sample size for chronic food insecure households. There is relatively higher application of herbicides as compared with fertilizer and seeds by all food insecurity categories with almost all food secure household applying herbicides to their farm.

Application of soil improving practices of no-till, crop rotation, mulching, minimum tillage, and / or cover crops is another dimension to describe farmer's innovativeness (Table 8). Household were asked whether they used any of these practices. Minimum till has higher application than other practices. Most of the chronic (9 out of 12) and seasonal (36 out of 66) households are using minimum till as a soil improving practices. No-till is preferred among food secure households where 65 percent (13 out 20) apply it. Though most of the vulnerable food insecure do not apply any of the practices (8 out 18), 22 percent of this group uses no-till.

Land Ownership and Bio-physical Characteristics

Land holding arrangements differ among households. Sixty-seven percent of the households rent farming land on a seasonal basis and it is a common type of access to land. Land arrangements which include both long term lease and ownership are collectively called long term proprietorship. There are only eight farmers (seven percent) that own the land they farm. Share cropping accounts for 15 percent of the household land access. Sharecropper's average size is 0.7 ha, while long term proprietorship relatively has larger average land size of 0.9ha. The maximum land size holding is registered under seasonal lease arrangement is 4.8 ha while in long term proprietorship is 4 ha (Table 9).

Bio-physical factors determine the productivity of the land holdings. Households were asked their perception on the condition on soil, slope, rainfall, and fertility of the land farmed (Table 10). Almost all respondents stated their land slope is gentle instead steep or medium. Further, almost all respondents felt their land productivity is

degrading rather than improving. Only one respondent felt their foil fertility was good. The most common perception of soil fertility is medium fertility at 59 percent with 41 percent of respondents feeling their land is of poor fertility. One other important factor that is an indicator of agricultural land productivity is access to water. Only 25 households (22 percent) have access to small scale irrigation or micro dam. About half of the respondent (53 percent) perception about the rainfall for the past 12 months was inadequate. However, 41 percent of the household do not know whether the rainfall is adequate or not for the same period.

3. METHODOLODY

To obtain the objectives of this study, two logit models are estimated. First, a conditional logit model, based on random utility theory, examines the adoption of soil improving practices. Second, factors influencing the food insecurity of the households are then examined using a multinomial logit model.

Random Utility Theory and Conditional Logit for Adoption Choice

The use of discrete choice models in economics is based on random utility theory (Train 2007). Individual or decision makers face alternative choices and constraints. Decision makers in this model are assumed to be utility maximizers faced having to choose among j alternatives (Train 2007). Each alternative is associated with a different level of utility. Among the alternatives, individual i chooses the bundle with highest utility taking into account constraints they face including their budget constraint (Mas-Colell, Whinston, and Green 1995).

Indirect utility is the basis for analysis. Indirect utility measures the maximum utility that a decision maker achieves given the price level and constraints (Mas-Colell, Whinston, and Greene 1995). According to random utility theory, indirect utility has both a deterministic component and a random (unobservable) component:

(1) $U_{ij} = V_{ij} + \varepsilon_{ij,}$ where $V_{ij}=XB_{ij}$

where V_{ij} is the deterministic utility associated with individual i and alternative j, X is a matrix of explanatory variables with the corresponding parameter vector β, and ε_{ij} is the random component. The exogenous variables, X, describe individual characteristics and

are identical across alternatives for an individual but vary between individuals. The probability that individual i prefers alternative j over n because it provides higher utility is:

$$(2) \qquad \Pr_{ij}(U_{ij} > U_{in}, \forall j \neq n) = \Pr[(V_{ij} - V_{in}) > (\varepsilon_{in} - \varepsilon_{ij}) \text{ for } \forall j \neq n].$$

If the error terms are independently and identically extreme value distributed with Gumbel (type 1 extreme value) distribution

$$(3) \qquad F(\varepsilon_{ij}) = e^{-e^{-\varepsilon_{ij}}}.$$

Then probability that an individual i choses alternative j is

$$(4) \quad \Pr(y = j|X) = \exp(X\beta) / \left[\sum_{i=1}^{j} \exp(X\beta) \text{ for } j = 0,1\right]$$

which is the conditional logit model (Greene 2012).

The choice of the individual is described by the variable y* for two alternatives:

$$(5) \quad y* = XB_{ij} + \varepsilon_{ij}, \; y = \begin{cases} 1 \text{ if } U_{ij} \geq U_{in} \\ 0 \text{ otherwise} \end{cases}.$$

In this model estimated, y = 1 is designated as an individual choosing to adopt soil improving practices and y = 0 describes an individual who does not adopt soil improving practices.

Equation (4) is estimated using maximum likelihood technologies to determine how various factors affect the likelihood of adopting soil improving practices. Given the variables in X are similar to the variables in the food insecurity group model, a description of the variables is presented after the presentation of the food insecurity model.

Multinomial Logit for Food Insecurity Group

A multinomial logit model is estimated to investigate the factors influencing a household's food insecurity position including the adoption of technology. An unordered multinomial logit model is used to determine the probability of specific households being in one of the four food insecurity categories. The dependent variable represents the food insecurity category of the household and includes four food insecurity positions (food secure, vulnerable insecure, seasonal insecure, and chronic insecure) in order of best to worse food insecurity level.

It is assumed that food insecurity depends on individual characteristics of each household. Let y represent the food insecurity of the household by taking on the values of 0, 1, 2, or 3 and X be a matrix of explanatory variables. Chronic food insecure households, (j = 0), are assumed to be the base in the estimation. The probabilities a household will be in one of the four food secure categories (Wooldridge 2010) are:

$$(6)\quad \Pr(y = j|X) = \exp(x\beta) \Big/ \left[1 + \sum_{i=1}^{j} \exp(X\beta) \text{ for } j = 1,2,3 \right]$$

$$(7)\quad \Pr(y = 0|X) = 1 \Big/ \left[1 + \sum_{i=1}^{j} \exp(X\beta) \text{ for } j = 0 \right]$$

where β is a vector of parameters to be estimated. Equations six and seven are estimated using maximum likelihood techniques.

Dependent and Independent Variables

The first model investigates the likelihood of the household to be innovative in terms of adopting soil improving practices. As previously noted, the dependent variable can take on one of two values. The household is categorized as *adopter* if they adopt one or more of the five soil improving practices and *non-adopters* are households that do not adopt any of the practices. The five practices are no-till, minimum till, applying mulch, planting cover crops, and using crop rotation. For estimation propose, the base group is *non-adopter*. The second model assesses the likelihood of being in specific food insecurity category given household characteristics. Estimated coefficients are interpreted relative to base of chronic food insecure.

There are 16 variables used in estimating the two models. Some variables are categorical and others are continuous. The definition of variables, expected signs with respect to base independent variables are given in Table 11. Independent variables in the adoption of soil improving practices model are long term proprietorship (dropped as the base), sharecropping, and seasonal lease, off-farm income activities (carpentry, masonry and petty trading), access to extension service, food insecurity category, household head's education, medium quality soil, income, household head's age, and household size. The food insecurity model uses most of the variables for previous model. However, it includes application of fertilizer, seeds, herbicides, and pesticides, and adoption of soil improving practices variables.

Although the equations are most likely a system, to the author's knowledge there is not a logistic distribution that would allow such an approach. Estimating as a system

may gain efficiency in the parameter standard deviation estimates, but the parameter estimates are consistent with single equation estimation if the model is correctly specified. Household food insecurity group and are also adoption of soil improving practices are the two dependent variables and are also independent variables in the different models. In adoption model, the adoption of soil improving practices is dependent variable and food insecurity categories are independent factors. In the food insecurity categorization model, the four security groups are the dependent variables and adoption of soil improving practices is an independent variable.

Soil conditions may be important for adoption of soil improving practices and production which would ensure food security. Soil quality is assessed by the farmer's subjective opinion as to the current quality of the soil, either medium (medium and the one observation of good soil quality) or poor soil quality. Poorer quality soils may benefit the most from soil improving practices. Hence, households with poor quality soil may be expected to adopt those practices.

The type of land holding may have an important role in motivating farmers to adopt soil improving agricultural practices. Most of the farmers are using seasonal leases and few are share cropping. There are also owners of land and long term lease holders. As mentioned in the previous chapters land ownership and long lease are collectively called long term proprietorship.

Socio-economic characteristics of the household may influence adoption behavior for soil improving practices and the households' food insecurity category. For some of the characteristics prior beliefs as to the influence in a particular model are

discussed. If there is no prior expectation for a variable in a particular model, that variable is not discussed. This case of no prior expectation is given by a "?" in Table 11. Planning horizons are different for younger and older household heads. It is expected that younger household heads are more likely to adopt the soil improving practices, because the potential benefits of adoption may be realized longer.

Household head's education status is divided into two categories schooling and no schooling. Education may help farmers learn new techniques and open their minds to the use of technology. It is expected that having some schooling is likely to be associated with increased adoption of soil improving practices. Moreover, household heads with education are more likely to be in an improved food insecurity position. Education may be associated with increased yields.

It is expected that income is positively associated with adopting soil improving practices. Higher income households may be: 1) more likely to afford soil improving practices; and 2) able to wait longer for the benefits generated from adopting soil improving practices. In a similar fashion, food secure households may be able to afford the short-run costs of adoption of soil improving practices to realize the longer term gains. Higher income households are likely to be able to buy more food or produce more output for sale which can improve their food insecurity position.

All households in the survey are farmers, but some farmers have off-farm activities. It is expected that those households with off-farm activities are likely to be more food secure than those without non-farm through extra income. Extension service access supports farmers including those facing problems of low productivity, land

degradation, and marketing issues. In this way, access to extension services should positively influence the adoption of soil improving practices and improve the food security of the household. Application of fertilizer and commercial seeds may help increase or maintain the yield levels which should improve the food insecurity position of the household.

4. RESULTS AND DISCUSSION

Adoption of Soil Improving Practices Model

As mentioned in the methodology section, the first model determines the likelihood that a respondent will adopt soil improving practices. In this model, the dependent variable categorizes those households adopting any of the five soil improving / conservation (minimum till, no-till, cover crop, crop rotation, and mulching) practices as *adopters* and those respondents not using any of the practices as *non-adopters*. Conditional logit regression estimation results are given in Table 12.

The base group is *non-adopters*; signs of the independent variables are interpreted with respect to this base. The likelihood ratio test p-value is 0.000, indicating that the coefficients of independent variables are not jointly equal to zero. Moreover, the model fit is within the range expected for cross-sectional data with a pseudo R^2 of 0.28.

The effects of seasonal lease, food security (whether the household is food secure or not), and soil quality (medium quality soil) are significant at the ten percent level or less. The other explanatory variables, extension service, school (whether the household head attended junior and above or not), sharecropping, off-farm activities, age of household head, household size, and income are insignificant (15 percent or less).

Seasonal leases tend to increase the probability of adoption over long-term proprietorship. Food secure households are more likely to adopt conserving practices than food insecure households. Soil quality is categorized as either poor or medium quality according to the subjective opinion of the respondent. This coefficient is

negative indicating respondents with higher quality soil are less likely to adopting soil improving practices than those farming poorer quality soil.

Discussion – Adoption of Soil Improving Practices

Results imply that seasonal lease arrangements increase the probability of adopting soil improving practices relative to the long-term proprietorship. Given the nature of the survey questions, one can only speculate as to why this is the case. Adoption may be because of the short-term lease arrangements. Landowners may require producers to use conserving practices or leaseholders may be afraid of losing their leases if they do not use conserving practices. It may be the case that the lessee has an incentive to take care of the land to be able to obtain a contract for next season.

Households with better quality soil may have less of an incentive to adopt land conserving practices than those households with poorer soils. Households may be adopting soil improving practices as their soil quality deteriorates. As the soil deteriorates and yields decrease, households may only then perceive the benefits of adopting soil improving practices.

Food secure households are more likely to adopt soil improving practices than food insecure households. Food secure households may be willing to sacrifice some production for increased soil quality because they are not hungry. Another possible explanation is that food secure households have adopted soil conservation in previous years and now reaping the benefits of adoption through increased production. Kristjanson et al. (2012) found a similar relationship between farming practices and number of months with deficit food for five African countries. Their study observed that

households that experience a larger number of months with a food deficit per year make less changes to their farming practices (such as introducing micro-catchments, ridges, rotations, improved pastures, and trees) compared to households with fewer months with food deficits.

Presented in table 13 are the marginal effects associated with the independent factors on the adoption of soil improving practices. Marginal effects show the how an unit increase in a continuous variables, or a change from 0 to 1 for categorical variables lead to a change in the probability that a household adopts soil improving practices at the mean values for the other variables.

Household characteristics such as age, income, household size, education are not significant to determine the likelihood of soil improving practices. It implies that the household characteristics do not matter in adoption of soil improving practices despite priori information predicts that these factors may have influence in adoption behavior.

Food Insecurity Categorization Model

The food insecurity model analyses the likelihood of that a household is in one of the four food insecurity groups. Within the multinomial logit model, the food insecurity groups are relative terms, as such the independent variables coefficients are interpreted relative to the base group, chronic food insecurity (Table 13). The likelihood ratio test p-value is 0.000, indicating that the coefficients of independent variables are not jointly equal to zero. Moreover, the model fit is within the range commonly seen using cross-sectional survey data with pseudo R^2 of 0.30.

For the seasonal insecurity category, only medium quality soil is significant at the 10 percent level or less. Having medium soil quality increases the probability that a household is in the seasonal food insecure group relative to being chronic food insecure. All other explanatory variables are not significant (15 percent level or less) implying these variables do not influence the likelihood of household being in seasonal food insecurity group relative to the chronic insecurity group.

In the vulnerable food insecure equation, medium quality soil and seasonal lease are significant at the 10 percent level, whereas, use of commercial seeds and off-farm activities are significant at the 15 percent level. Similar to the chronic food insecurity equation, a household with medium quality soil is more likely to be in vulnerable category relative to chronic food insecure. As compared to long-term proprietorship, seasonal lease tenure increases the likelihood relative to long-term proprietorship of being in the vulnerable group relative to the chronic group. Application of commercial seeds increases the likelihood that a household is in the food vulnerable group relative to the chronic food insecure group. Households with a source of off-farm income are more likely to be in vulnerable group relative to chronic group.

Four factors are significant at 15 percent level in the food secure equation. Adoption of soil improving practices, farming medium quality soil, and applying chemical fertilizers increase the likelihood that a household is food secure relative to the chronic food insecure group. The use of pesticides, however, decreases the probability of being food secure relative to chronic food insecurity. Medium quality soil is the only variable significant in all three equations. Household characteristics such as education

level of the household, age of the household head and household size; income, sharecropping, herbicide applications, and extension service do not significantly influence the probability of households improving their food insecurity position relative to chronic food secure. This is also another finding that household characteristics do not make difference in determining food insecurity position of the households.

Discussion – Food Insecurity Groups

Households using commercial seeds are more likely to be with vulnerable food insecure group relative to the chronic food insecure group. The use of commercial seeds may be one way of improving food security of Ghanaian households. Commercial seeds may increase production. If households are net buyers of food, increased production through the use of commercial seeds will most likely improve the households' food security.

Household engaging in off-farm activities are more likely to be in the vulnerable food Insecurity group relative to the chronic food insecure group. Off-farm activities may provide extra income that the household can use to purchase food, which improves the households' food security. This may be especially true during the off agricultural production season. Households may engage in off-farm activities to meet the food requirements of the households. Omotesho et al. (2006) showed that off farm income has a significant and positive effect in improving food security in rural Nigeria.

Application of soil improving practices increases the likelihood that a household is in the food secure group relative to chronic food insecure category. According to Thurow and Kilman (2009) there has been widespread application of soil improving

practices such as no-till and mulching in some parts of Ghana. No-till plots may have larger yields with less labor, while use mulching helps to retain water (Thurow and Kilman 2009). There may be an association between soil improving practices and food secure household because of increased productivity. This association may increase farmers' production levels and income, which leads to improved household food security.

In all food insecurity equations, medium quality soil is positive and significant. Better quality soil generally means larger production which leads to an improvement in food insecurity position of the household. Land degradation and soil erosion may be one of the main causes of food insecurity through a reduction in yields in Ghana. Diao (2007) finds that land degradation reduced agriculture income by $4.2 billion during in 2006-2015 in Ghana. More importantly, Diao (2007) showed that soil loss has a significant and positive effect on poverty (food security is one component of poverty reduction). Her study calculated the effect of soil loss on poverty at the national level. Comparing the case of soil loss with no soil loss scenario, there will be 5.4 percent increase in the poverty rate with soil loss compared to a no soil loss scenario.

The use of chemical fertilizers increases the probability of being a food secure household over chronic food insecurity. Kassie, Ndiritu and Shiferaw (2012) found similar results for rural Kenya where application of chemical fertilizers significantly increases the likelihood of being food secure for male headed households. Application of pesticides however, decreases the probability of being a food secure household relative to chronic food insecure. Pesticides use may be an indicator that there is a pest

attack on the crop. Hence, households that experienced pest attacks may have decreased production and reduced their food security.

Household characteristics such as education level and age of household are insignificant. The insignificance may be because of the households in the survey area are relatively homogenous in those factors.

5. CONCLUSIONS AND RECOMMENDATIONS

Agriculture in Ghana accounts for 30 percent of the GDP and provides a means of support for 46 percent of the population (ISSER 2010; GSS 2012). Agriculture in Ghana, however, is characterized by low productivity and the inability to meet the food requirements of 1.2 million of food insecure people (WFP 2009). Underlying causes of low productivity are increased land degradation, rainfall dependency, and raising input prices (Diao 2010). Differences exist among farmers in terms of adopting soil improving practices to reduce land degradation. Moreover, differences in the scale and severity of households' food shortages exist.

With the above in mind, this study has two objectives: 1) determine the likelihood of a household to adopt soil improving practices; and 2) determine the likelihood that specific households to be in one of the four food category given agricultural practices and household characteristics. To achieve these objectives, survey data from 116 households from Ghana's Greater Accra West District (14 villages) were collected using face-to-face interviews. Information on household characteristics, food insecurity and adoption of improvement practices are analyzed using logit models to provide information on adoption and food insecurity of the households.

Respondents are divided into *adopters* and *non-adopters* of soil improving practices; 80 households have adopted soil improvement practices. With regard to food insecurity, the largest category is seasonal food insecure comprising 66 households (56 percent). Food secure households make up the second largest category with 20

households. Eighteen households are categorized as belong vulnerable. Only 12 households are categorized as chronic food insecure households.

A logit model, based on random utility theory, is used to determine factors affecting the adoption soil improving practices. Operating under a seasonal lease type of land tenure, being a household that is food secure, and farming medium quality soil are significant and likely to increase the probability of adopting soil improving practices. A second model is a multinomial logit model of the factors that influence a household's food insecurity position. Medium quality soil is significant in the three food insecurity equations (seasonal food insecurity, vulnerable food insecurity, and food secure with chronic food insecure households being the base).

Use of chemical fertilizers, commercial seeds, and pesticides, along with operating under a seasonal lease tenure and adoption of improved soil practices are significant in at least one of the three food insecurity equations. For the food secure category equation, medium soil quality, adoption of soil improving practices, and the use of chemical fertilizer may contribute for improvement of household food security. However, pesticide uses decreases the probability for a household to be food secure relative to chronic food insecure.

Soil quality should be the center of the focus in addressing the issues of adopting soil improving practices and food insecurity in Ghana. Respondents with higher quality soil are more likely to adopt soil improving practices and are more likely to be in an improved food insecure category. Because food security influences adoption of soil improving practices and adoption influence food security, these two issues should not be

examined independently, but as a system for policy and other purposes. Given the high priority the government of Ghana has placed on food security, policies that encourage the application of soil improving practices may be beneficial to farm households.

Priorities may differ between food secure and food insecure households in terms of applying soil improving practices. It is estimated that food secure households are more likely to adopt soil improving practices than food insecure households. Food insecure households may be weighing the immediate need for increased production from the limited land they farm against longer term needs. Food secure households may be able to afford to adopt soil improving practices even if there is temporary drop in yields. Policies may have to be customized for the different categories of food secure households to increase adoption of soil improving practices.

Household characteristics such as income, age, education level, and household size emerge as not influential in improving household food security or influencing the adoption decision in all food insecurity groups. Further research into why households appear to differ little between the categories should be conducted or is it entirely related to soil quality.

Three sets of recommendations from improving the extension services and technology use, food security policy possibly enhance adoption of soil improving practices. First, given that soil quality is important for adoption of soil improving practices and food security, interventions and policies that enhance the quality may be important. Information on improving soil quality from research may need to be delivered to farmers in a way that is understandable and easy to use be it through

extension or other means. Second, the use of commercial seeds and chemical fertilizer is likely to improve food insecurity positions of farmers. Increased affordability and accessibility to fertilizer and commercial seeds may help increase their use by farmers. Institutions and infrastructure that would ensure the efficiency of input markets may be important. Third, food insecurity is critical issue in the survey areas given the fact that chronic and seasonal food insecure households do not have sufficient food. These households are crop producers, but their production or income from the sale of crops is not being large enough to support the family food requirements. The government of Ghana has policies for food security such as buffer stock management and fertilizer subsidy. These policies may have contributed to reduce food insecurity. However, policies that have direct impact for food insecure households may be needed.

Contrary to a priori expectations both access to agricultural extension services and education are insignificant in both adoption of soil improving practices and food insecurity categorization. A priori it was felt these factors should increase adoption and improve the food insecurity position of the household. Further, research is necessary to better understand the relationship between these variables. Are respondent using extension services correctly? Does the extension service need to re-evaluate how they deliver their services? Would better education levels beyond junior high provide increased adoption and food security?

Study Limitations and Future Research

This study tries to improve our understanding of the adoption of soil improving practices and household food insecurity. However, there are three main limitations that

if addressed in future studies would improve the quality of the study. First, the sample size is small. Given there are four different categories of food insecurity groups, increasing the sample size would have helped to characterize group and possibly identify other significant factors influencing food insecurity. Second, along the lines of small sample, time-series data may help refine the study. The dynamics of adoption and food security may be important. Time series data would allow for examining these dynamics. Third, bio-physical soil information is based on the subjective evaluation of respondents. More specific measurements of soil quality and topography may generate improved results.

Further research that focuses on adoption of soil improving practices and household food security beyond additional data is necessary. First, this research should take into account farmers' attitude toward risk. Because new or improved soil practices have uncertain outcomes, risk preferences of the farmer may help explain for adopting or not adopting. Second, assessing the returns and costs from investment from applying soil improving practices is important to analyze the net benefits of the practices. Information on the prices of labor, capital, equipment, and output price are necessary to undertaking this type of study. Third, household size relative to their income may more important than just their income. Using per capita income instead of total household income may better explain the food insecurity position of the household.

REFERENCES

Abele, S., E. Twine, and C. Legg. 2007. "Food Security in Eastern Africa and the Great Lakes." Final report USAID 15 Oct. 2012. http://c3project.iita.org/Doc/Final%20report%20C3P%20small.pdf

Adekambi, S.A., A. Diagne, F.Simtowe, and G. Biaou. 2009. "The Impact of Agricultural Technology Adoption on Poverty: The Case of NERICA Rice Varieties in Benin." Paper Presented at International Association of Agricultural Economists conference, Beijing, 16-22 August. 20 Oct. 2012. http://ageconsearch.umn.edu/bitstream/51645/2/473.pdf

Adesina, A.A., and J. Baidu-Forson. 1995. "Farmers' Perceptions and Adoption of New Agricultural Technology: Evidence from Analysis in Burkina Faso and Guinea, West Africa." *Journal of Agricultural Economics* 13:1-9.

Altman, M., T. Hart, and P. Jacobs. 2009. "Household Food Security Status in South Africa." *Agrekon* 48(4):345-361.

Asfaw, S., and B. Shiferaw. 2010. "Agricultural Technology Adoption and Rural Poverty: Application of Endogenous Switching Regression for Selected East African Countries." Poster Presented at the joint 3rd African Association of Agricultural Economists (AAAE) 19-23 September. 2 Dec. 2012. http://ageconsearch.umn.edu/handle/97049

Ayodele, A.E. 2012. "A Critical Analysis of Diffusion of Innovation Theory." Odinakadotnet, A Site for All. 20 Nov. 2012. http://odinakadotnet.wordpress.com/2012/09/22/a-critical-analysis-of-diffusion-of-innovation-theory/

Barrett, C.B. and D.E. Sahn. 2001. "Food Policy in Crisis Management." Unpublished, Cornell University. 20 Nov. 2012. http://aem.cornell.edu/faculty_sites/cbb2/Papers/worldbankpaper.pdf

Christiansen, L., V. Hoffman, and A. Sarris. 2007. "Gauging the Welfare Effects of Shock in Rural Tanzania." World Bank Policy Research Working Series. 2 Dec 2012. http://elibrary.worldbank.org/content/workingpaper/10.1596/1813-9450-4406

Deaton, A. 1992. "Saving and Income Smoothing in Cote D Ivoire." *Journal of African Economies* 1(1): 1-23.

Department Fund for International Development. 2004. *Scoping Study towards DFID-SA's Hunger and Vulnerability Programme*. Unpublished, Southern African Regional Poverty Network, South Africa. August.

Devereux, S. 2006. "Desk Review: Distinguishing Between Chronic and Transitory Food Insecurity in Emergency Needs Assessments." Unpublished, World Food Programme. 20 Oct 2012. http://www.livestock-emergency.net/userfiles/file/assessment-review/Institue-Development-Studies-2006.pdf

Diao, X. and D. Sarpong. 2007. "Cost Implication of Agricultural Land Degradation in Ghana: An Economy Wide Multimarket Model Assessment." Discussion Paper 698, International Food Policy Research Institute, Washington DC. 2 Nov. 2012. http://www.ifpri.org/publication/cost-implications-agricultural-land-degradation-ghana

Diao, X. 2010. "Economic Importance of Agriculture for Sustainable Development and Poverty Reduction: Findings from a Case Study of Ghana." Paper presented at Global Forum on Agriculture, Policies for Agricultural Development, Poverty Reduction and Food Security, Paris 29-30 November. 2 Nov. 2012. http://www.oecd.org/tad/agriculturalpoliciesandsupport/46341169.pdf

Diederen, P., H. van Meijl., A. Wolters., and K. Bijak. 2003. "Innovation Adoption in Agriculture: Innovators, Early Adopters and Laggards", Cahiers d'économie et sociologie rurales, no 67, 20 Oct. 2012 http://www.inra.fr/sae2/publications/cahiers/pdf/diederen.pdf

Ervin, C.A., and D.E. Ervin. 1982. "Factors Affecting the Use of Soil Conservation Practices: Evidence, Hypothesis and Policy Implication." *Land Economics* 58 272-292.

European Commission. 2000. "Integration of Food Security Objectives Within Poverty Reduction Framework: Concept Paper." Unpublished, Brussels, 19 Sep. 2012. http://agri-alim.redev.info/Doc/docs/integration_foodsecurity_ue.pdf

Feder, G., E.R. Just, and R.E. Zliberman. 1985. "Adoption of Agricultural Innovations in Developing Countries: A Survey." *Economic Development and Cultural Change* 33:255-298

Ghana Ministry of Food and Agriculture. 2010. *Northern Region Agriculture Development Unit*. Tamale. 19 Sep. 2012. http://mofafoodsecurity.wordpress.com/district-networks/

Ghana Ministry of Food and Agriculture. 2011. "*Food and Agricultural Sector Development Policy.*" August 2007. Accra. 19 Sep 2012. http://mofa.gov.gh/site/?page_id=598

Ghana Ministry of Local and Rural Development. 2006. "Greater Accra West." 19 Sep. 2012. http://gawest.ghanadistricts.gov.gh/?arrow=atd&_=1&sa=1140

Ghana Statistical, Research and Information Directorate. 2010. "*Agriculture in Ghana: Facts and Figures."May 2011*. Accra.

Ghana Statistical Service. 2012. **"**2010 Population and Housing Census, Summary Report of Final Results." Accra. 5 Feb 2012. http://www.statsghana.gov.gh/docfiles/2010phc/Census2010_Summary_report_of_final_results.pdf

Greene, W. H. 2012. *Econometric Analysis*, Seventh Edition, Pearson Education Limited: Prentice Hall.

Haggblade, S., and G. Tembo. 2003. "Development, Diffusion and Impacts of Conservation Farming in Zambia." International Food Policy Research Institute, EPTD Discussion Paper 108. http://ageconsearch.umn.edu/handle/54464

Institute of Development Studies. 2006. "Desk review: Distinguish Between Chronic and Transitory Food Insecurity in Emergency Needs Assessment." Unpublished, Rome. 19 Sep. 2012. http://www.livestock-emergency.net/userfiles/file/assessment-review/Institue-Development-Studies-2006.pdf

Institute of Statistical, Social, and Economic Research. 2010. *The State of the Ghanaian Economy in 2010.* Lagon, University of Ghana.

International Fund for Agricultural Development. 1992. Household Food Security: Concepts, Indicators, and Measurements, A Technical Review. Rome. 12 Sep. 2012. http://www.ifad.org/hfs/tools/hfs/hfspub/hfs_toc.pdf

Kassie, M., B. Shiferaw and G. Muricho. 2011. "Agricultural Technology, Crop Income, and Poverty Alleviation in Uganda." *World Development* 39 (10): 1784–1795.

Kassie, M., S.W. Ndiritu, and B. Shiferaw. 2012. "Determinants of Food Security in Kenya, A Gender Perspective, Paper Presented at the 86th Annual Conference, Warwick University, Coventry, April 16-18. 2 May 2013. http://ageconsearch.umn.edu/handle/135124

Kristjanson, P., H. Neufeldt, A. Gassner, J. Mango, F.B. Kyasse, S. Desta, G. Sayula, B.Thiede, W. Furch, P.K. Thornton, and R. Coe. 2012. "Are Food Insecure Smallholder Households Making Changes in their Farming Practices: Evidence from East Africa." *Food Security* 4: 381-397.

Lee, L.K., and W.H. Stewart. 1983. "Land Ownership and Adoption of Minimum Tillage." *American Journal of Agricultural Economics* 65 (2): 256-264.

Mas-Colell, A., M.D. Whinston, and J.R. Green. 1995. *Microeconomic Theory*. New York: Oxford University Press.

Meade, N., and T. Islam. 2006. "Modeling and Forecasting the Diffusion of Innovation: A 25-Year Review." *International Journal of Forecasting* 22: 519– 545.

Minten, B., and Barrett, C. B. 2008. "Agricultural Technology, Productivity, and Poverty in Madagascar." *World Development* 36(5): 797–822.

Moyo, S., G.W.Norton, J. Alwang, I. Rhinehart, and M.C. Demo. 2007. "Peanut Research and Poverty Reduction: Impacts of Variety Improvement to Control Peanut Viruses in Uganda."*American Journal of Agricultural Economics* 89(2): 448–460.

Mulugeta, T and B. Hundie. 2009. "Impacts of Adoption of Improved Wheat Technologies on Households' Food Consumption in Southeastern Ethiopia." Prepared for Presentation at the International Association of Agricultural Economists (IAAE) triennial conference, Foz do Iguaçu Brazil, 18-24 August. 29 Nov. 2012. http://ageconsearch.umn.edu/bitstream/126766/2/Mulugeta.pdf

Norris, P.E. and P.E. Batie. 1987. "Virginia Farmers Soil Conservation Decision: An Application of TOB Analysis." *Southern Journal of Agricultural Economics* 19: 79-87.

Omotesho, O. A., M. O. Adewumi, A. Muhammad-Lawal, and O. E. Ayinde. 2006. "Determinants of Food Security among The Rural Farming Households In Kwara State, Nigeria." *African Journal of General Agriculture* 2(1): 7-14.

Opang-Anane, K. 2006. "Forage and Pasture Resource Profile of Ghana." Unpublished, Food and Agriculture Organization. 19 Sep. 2012. http://www.fao.org/ag/AGP/AGPC/doc/Counprof/PDF%20files/Ghana-English.pdf

Pender, J and B. Gebremedhin. 2006. "Determinants of Agricultural and Land Management Practices and Impacts in Crop Production and Household Income in Highlands of Tigray, Ethiopia." *Journal of African Economies* 17: 395-450.

Pradhan, M., and M. Ravallion. 1999. "Demand for Public Safety." Policy Research Working Paper series 2043, World Bank. 23 Oct. 2012. http://elibrary.worldbank.org/content/workingpaper/10.1596/1813-9450-2043

Quaye, W. 2008. "Food Security Situation in Northern Ghana, Coping Strategies and Related Constraints."*African Journal of Agricultural Research* 3(5): 334-342.

Ravallion, M. 1992. "On 'Hunger and Public Action': A Review Article on the Book by Jean Drize and Amtrya Sen." *World Bank Research Observer* 7: 1-16. http://wbro.oxfordjournals.org/content/7/1/1.abstract

Ravallion, M. 1998. "Poverty Lines in Theory and Practice Living Standards Measurement Study." Policy Research Working Paper Series 133, World Bank. 23 Oct. 2012 http://www.eric.ed.gov/ERICWebPortal/search/detailmini.jsp?_nfpb=true&_&ERICExtSearch_SearchValue_0=ED422144&ERICExtSearch_SearchType_0=no&accno=ED422144

Ravallion, M., and M. Lokshin. 2003. "On the Utility Consistency poverty Lines." Policy Research Working Paper Series 3157, World Bank. 23 Oct. 2012.

Rogers, E. M. 1962. *Diffusion of Innovations,* 1st ed. New York: Free Press.

Rogers, E. M. 2003. *Diffusion of Innovations,* 5th ed. New York: Free Press.

Rosenzweig, M. and H. Binswagner 1993. "Wealth, Weather Risk and the Composition of Profitability of Agricultural Investment." *Economics Journal* 103(416): 56-78.

Rubas, D. 2008. "Technological Adoption: Who is Likely to Adopt and How Does the Timing Affects the Benefits?" Ph.D. Dissertation, Texas A&M University, College Station.

Siegel G., and A. Alwang. 1999. "An Asset Based Approach to Social Risk Management: a Conceptual Framework", Social Protection Discussion Paper Series 9926, World Bank 2 Dec 2012. http://siteresources.worldbank.org/SOCIALPROTECTION/Resources/SP-Discussion-papers/Social-Risk-Management-DP/9926.pdf

Stumpf, E. 1998. "Post-harvest Loss Due To Pests in Dried Cassava Chips and Comparative Methods for its Assessment: A Case Study on Small-Scale Farm

Households in Ghana." Ph.D. Dissertation. Deutsche Gesellschaft fuer Technische Zusammenarbeit (GTZ) GmbH.

Thirtle, C. and V.W. Ruttan, 1987. "The Role of Demand and Supply in the Generation and Diffusion of Technological Change." In F.M. Scherer, ed. *Fundamentals of Pure and Applied Economics*. London, UK: 21 Hardwood Academic Publishers, pp 1-21.

Thurow, R., and S. Kilman. 2009. Enough: Why the Poorest Starve in an Age of Plenty, New York, Public Affairs

Train, K.E. 2007. *Discrete Choice Models with Simulation*. New York: Cambridge University Press.

United Nations. 1995. *World Summit for Social Development, 1995. Copenhagen*. 29 Oct. 2012. http://www.un.org/esa/socdev/wssd/text-version/index.html

U.S. Department of Agriculture. 2000. *Guide to Measure Household Food Security.* Office of Analysis, Nutrition, and Evaluation, Washington DC.

Wiggins, S.E. Anderson, H. Chaplin, E. Cromwell, E. Clay, J. Farrington, P. Harvey and R. Tripp. 2004. "Can Africa Feed Itself in 2025 Under the Impact of HIV/AIDS?" A Report to the United Nations AIDS Programme (UNAIDS), Overseas Development Institute, London.

Wollini D., R. Lee. and J.E. Thies. 2008. "Effects of Participation in Organic Markets and Farmer-based Organizations on the Adoption of Soil Conservation Practices Among Small-scale Farmers in Honduras." Paper presented at the American Agricultural Economics Association annual meeting, Orlando FL, 27-29 July. 20 Oct 2012. http://ideas.repec.org/p/ags/aaea08/6423.html

Wooldridge, J. 2010. *Econometric Analysis of Cross Section and Panel Data.* Cambridge/USA: MIT Press.

World Bank. 2008. *Agriculture for Development, World Development Report 2008.* Washington DC.

World Food Programme. 2009. *Comprehensive Food Security and Vulnerability Analysis, Republic of Ghana*. VAM food security analysis, May 2009. 26 Aug. 2012. http://documents.wfp.org/stellent/groups/public/documents/ena/wfp201820.pdf

APPENDIX A

Farmer Segmentation in Food Security Survey 2012
Household Questionnaire
Texas A&M University

Interview Time: Beginning _____Ending _____

Interviewed by: _____

Data entered by:_____

General Background Information

Country: _____

Region:_____

District:_____

Village:_____

Ethnic Group:_____

Religion:_____

Respondent head of the household (check one that apply)

Yes

No

If no, what is your relationship to the household:_____

Gender of the head of the household:_____

1. Household roster

In this section we seek information about your household structure, labor on your farm, water, cooking fuel and electricity.

1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	1.10	1.11	1.12
Household member starting head of household	Age	Gender	Relation to head of household	Marital status	Education status	Main occupation	Secondary occupation	% contribution to own-farm labour	Principal Source of drinking water	Principal source of cooking fuel	Principal source of electricity
	Years	**M or F**	**Code A**	**Code B**	**Code C**	**Code D**	**Code D**	**Code E**	**Code F**	**Code G**	**Code H**
1			1								
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
			Code A 1=house head 2=spouse 3=son/daughter 4=parent 5=in-laws 6=grand child 7=other	**Code B** 1=married 2=single 3=widowed 4=divorced	**Code C** 1=no school 2=pre-school 3=junior high 4=senior high 5=college 6=university 7=Other__	**Code D** 1=Farming 2=off farm labor 3=masonry 4=household chore 5=school 6=petty trading 7=other_____		**Code E** 1=100% 2=50% 3=25% 4=0%	**Code F** 1=Bore hole 2=well 3=tap 4=pond 5=river 6=Other	**Code G** 1=Wood 2=charcoal 3=gas 4=electricity 5=solar 6=dung 7=other	**Code H** 1=None 2=grid 3=generator 4=other__

2. Food Security and Household Welfare

In this section we seek information about access to food and the welfare of your household.

	Yes	No
2.01. At any time during the last 5 years, did you or your family have insufficient food (not having enough food or cash to buy food) to eat? If Yes – go to Q 2.02 If No – go to Q 2.06	☐	☐
2.02. During the last 12 months did you or your family not have enough food to eat in between planting and harvesting? If yes, approximately how many days did you not have enough food? _____	☐	☐
2.03. During the last 12 months did you or your family not have enough food to eat on several occasions throughout the year? If yes, approximately how many days did you not have enough food? _____	☐	☐
2.04. During the last 12 months, was there ever no food to eat in your household? If yes, on about how many days did this happen? _____	☐	☐
2.05. During the past 5 years, was there ever no food to eat in your household? If yes, on about how may days did this happen? _____	☐	☐
2.06. Do you have a bank account with funds to buy food during lean times?	☐	☐

2.07. During which months is food normally most scarce (insufficient amount of food to feed your household) period?_____

2.08. During normal seasons (enough amount of food to eat), how many meals per day do you consume?_____

2.09. During scarce times, about how many meals per day do you consume?_____

2.10. Compared to normal times, how do your diet and your family's diet change during lean times? **Check all that apply**.

2.11. Which of the following have caused food short fall in the household? **Check all that apply**.

☐ Drought	☐ Crop Failure	☐ Insufficient labor
☐ Flood	☐ No funds for seeds	☐ Loss of jobs
☐ Diseases	☐ No funds for fertilizer	☐ Political unrest

For this next 8 questions, check the box with the most suitable response on the right.	Much more	Somewhat more	About the same	Somewhat less	Much less
2.12. How does the amount of crop production per hectare from your land compare to other farmers in the area?	☐	☐	☐	☐	☐
2.13. After post harvest harvesting, how does the loss of crops harvested from your land compare to other farmers in the area?	☐	☐	☐	☐	☐
2.14. Compared to other farmers in your area, how much land do you farm?	☐	☐	☐	☐	☐
2.15. Compared to other farmers in your area, how do you rate your level of use of machinery to plant, irrigate, harvest, etc?	☐	☐	☐	☐	☐
2.16. Compared to other farmers in your area, how much manure do you use on your land?	☐	☐	☐	☐	☐
2.17. Compared to other farmers in your area, how much man made fertilizer do you use on your land?	☐	☐	☐	☐	☐
2.18. Compared to other farmers in your area, how much labor do you hire to assist with crop production on your land?	☐	☐	☐	☐	☐
2.19. Compared to other farmers in your area, how do you rate your level of farming-related income from farming?	☐	☐	☐	☐	☐

2.20. How difficult is it to manage your basic family need (food, education and health expense) at present income levels? **Check only one**.

☐ Very difficult ☐ Somewhat difficult ☐ Not difficult

☐ Difficult ☐ Not so difficult ☐ Not at all difficult

2.21. How often do you obtain fuel for your household _____ times per month

2.22. How often do you go the market?_____ times per month

2.23. How far away is the primary source of fuel for household use? Distance _____ kms

or Walking time_____ min

2.24. How far is the nearest market from your home? Distance _____walking time_____ min

3. **Food Consumption and expenditure**

In this section we seek information about the food types you eat and how you obtain them.

3.01. About how much each week do you consume the following **GRAIN CROPS** in your household and what percentage of these is homegrown, purchased, or otherwise obtained?

	Times eaten each week	% homegrown	% purchased	% in-kind, food aid, gift
Maize (corn)				
Rice				
Millet				
Sorghum				
Wheat				
Barley				
Other (specify) _____				

3.02. About how much each week do you consume the following STARCH **ROOT CROPS** in your household and what percentage of these is homegrown, purchased, or otherwise obtained?

	Times eaten each week	% homegrown	% purchased	% in-kind, food aid, gift
Cassava				
Potato				
Sweet potato				
Other (specify) _____				

3.03. About how much each week do you consume the following **VEGETABLE CROPS** in your household and what percentage of these is homegrown, purchased, or otherwise obtained?

	Times eaten each week	% homegrown	% purchased	% in-kind, food aid, gift
Tomato				
Onion				
Okra				
Pepper				
Spinach				
Carrot				
Garlic				
Cabbage				
Other (specify) _____				

3.04. About how much each week do you consume the following **LEGUMES** in your household and what percentage of these is homegrown, purchased or otherwise obtained?

	Times eaten each week	% homegrown	% purchased	% in-kind, food aid, gift
Cowpea				
Lentil				
Faba bean				
Soybean				
Green beans				
Pigeonpea				
Grass pea				
Chickpea				
Field pea				
Other (specify) _____				

3.05. About how much each week do you consume the following **OIL CROPS** in your household and what percentage of these is homegrown, purchased or otherwise obtained?

	Times eaten each week	% homegrown	% purchased	% in-kind, food aid, gift
Groundnuts				
Oil palm fruits				
Sesame seed				
Nigerseed				
Rapeseed				
Groundnuts				
Other (specify) _____				

3.06. About how much each week do you consume the following **FRUITS** or **TREE CROPS** in your household and what percentage of these is homegrown, purchased or otherwise obtained?

	Times eaten each week	% homegrown	% purchased	% in-kind, food aid, gift
Banana				
Orange				
Mango				
Papaya				
Coconut				
Hop				
Other (specify) _____				

3.07. About how often each week do you consume each of the following **PROTEIN FOODS** in your household what percentage of these is homegrown, purchased or otherwise obtained?

	Times eaten each week	% homegrown	% purchased	% in-kind, food aid, gift
Beef				
Mutton/lamb				
Goat				
Pork				
Milk				
Chicken				
Fish				
Bush meat				
Other (specify) _____				

3.08. During the last 12 months, what are the main foods purchased by your household, what is the average amount bought each week and how much do you spend on average each week consume?

	Average purchased each week (kg)	Price per kg	Total cost per week
Grains (specify) _____			
Root crops (specify) _____			
Veggie (specify) _____			
Fruit(specify) _____			
Legume (specify) _____			
Oil crops(specify) _____			
Proteins foods (specify) _____			
Other (specify) _____			

3.09. During the last 12 months did you experience any shock (natural/ manmade event which is unusual or undesirable) that reduces the ability to acquire food?

☐ Yes ☐ No; if No – go to Q3.11

3.10 What was the cause for shock? **Check all that apply**

☐ drought ☐ inflation ☐ unregulated sand wining

☐ conflict ☐ animal disease

☐ crop pest

3.11. Did the shock create drastic decrease in income or sale of asset (eg farming tools, electronics, and furniture) on the last 12 months?

☐ Yes ☐ No

3.12. Did the shock create difficult situation for the ability to have enough food to eat?

☐ Yes ☐ No

3.13. Did the household recover from this shock now?

☐ Yes ☐ No

3.14 In the past 6 months how much did you spend on the following non-food items?

	Expenditure in cash	Expenditure in credit (borrow)
Medical expense		
Clothing/shoe		
Farming equipment/tools		
School fee		
Celebration, social events		
Funerals		
Others _____		

4. Farming practices and livelihoods

In this section we ask for information about farming practices and your basic livelihood.

4.01. Do you have access to land for agricultural production or cultivation?

☐ Yes ☐ No; if No – go to Q4.04

4.02. What is the size of land holding that you farmed during the past 12 months__(ha)

4.03. How do you have access to land for agriculture? **Check all that apply.**

☐ Own the land myself ☐ Community land

☐ Share cropping[1] ☐ Seasonal lease

☐ Long term lease ☐ Permission from chief

[1] Sharing output in return to land use

4.04. Did you produce any crops during the last 12 months?

☐ Yes ☐ No; if No – go to Q4.20

In questions 4.05 through 4.23, indicate which crops you produced and sold **during the last 12 months**, how much money you obtained for them and what losses you incurred, and what crop storage and cultivation practices you use.

4.05. What crops did you produce and how much of each crop did you harvest?

	Harvest 1		Harvest 2	
	Amount produced	Unit	Amount produced	Unit
Crop 1 _____				
Crop 2 _____				
Crop 3 _____				
Crop 4 _____				
Crop 5 _____				
Crop 6 _____				
Crop 7 _____				

4.06. How much of the crops that you produced did you sell?

	Harvest 1			Harvest 2		
	Amount sold amount	unit	Money obtained	Amount sold Amount	unit	Money obtained
Crop 1_____						
Crop 2_____						
Crop 3_____						
Crop 4 _____						
Crop 5_____						
Crop 6 _____						
Crop 7 _____						

4.07. By your estimate, what percentage of the crops harvested was lost?

	Harvest 1 % loss	Harvest 2 % loss	Total % loss
Crop 1 _____			
Crop 2 _____			
Crop 3 _____			
Crop 4 _____			
Crop 5 _____			
Crop 6 _____			
Crop 7 _____			

4.08. What were the primary causes of crop post harvest losses? **Check all that apply**.

☐ Rodents ☐ Wild animals ☐ Inadequate store

☐ Diseases ☐ Insect attack ☐ Water damage

	Yes	No
4.09. Do you use traditional storages for the harvested crops?	☐	☐
4.10. Do you use improved (manufactured) storages for the harvested crops?	☐	☐
4.11. Do you save and re-use seeds for future planting your crops?	☐	☐
4.12. Do you use commercial seeds for planting?	☐	☐
4.13. Do you use animal manure to fertilize your crops?	☐	☐
4.14. Do you apply inorganic chemical fertilizers to your crops?	☐	☐
4.15. Do you use paid labor to remove weeds from your crops?	☐	☐
4.16. Do you apply herbicides to reduce competition of weeds in your crops?	☐	☐
4.17. Do you use hand labor to kill insects that damage your crops?	☐	☐
4.18. Do you apply pesticides to reduce insect damage to your crops?	☐	☐
4.19. Do you apply fire after harvesting to control pathogens in your crops?	☐	☐

4.20. During the last 12 months on a single harvest time, what was the total number of paid family labor work when you produced crops? _____ (people)

4.21. During the last 12 months on a single harvest time, what was the average number of days that hired labor work when your produce crops? _____ (days)

4.22. During the past 12 months, what quantity of inputs did you use to produce crops on your land and how much did you pay for them?

	Harvest 1			Harvest 2		
	#	unit	Total cost	#	Unit	Total cost
Hired labor						
Seeds						
Chemical fertilizer						
Herbicides						
Pesticides						
Other (specify) _____						

4.23. Do you raise any animals for living?

☐ Yes ☐ No; if No – go to Q4.28

In questions 4.24 through 4.26, indicate which animals you raised and sold **during the last 12 months**, how much money you obtained by selling them and what losses you incurred.

4.24. What animals did you own and how many of each did you produce what number of percentage did you sell and lose through death, theft etc?

	Total owned	# produced	# sold	# lost
Cattle				
Sheep				
Goats				
Chickens/turkey/ostrich				
Ducks				
Other (specify) _____				

4.25. How much income did you make from the sale of live animals and from animal products (e.g., milk, eggs, meat, etc)

	Income from sale of live animals	Income from sale of animal products
Cattle		
Sheep		
Goat		
Chickens		
Ducks		
Other (specify) _____		

4.26. What were the primary causes of animal losses? **Check all that apply**.

☐ Wild predators ☐ Theft ☐ Diseases

☐ Drought ☐ Flood ☐ Others (Specify)

4.27 Do you own these types of equipment in your household? **Check all that apply**

☐ Hoe ☐ Axe

☐ Sickle ☐ Grinding mill

☐ Plough ☐ Sprayer

☐ Pump

4.27. Have you received training or information on any extension service in recent times?

☐ Yes ☐ No; if No – go to Q4.29

4.28. About which of the following land management practices did you receive information/training from an extension service? **Check all that apply**.

☐ Conservation agriculture[2] ☐ Marketing

☐ Soil and water management ☐ Livestock Production

☐ Irrigation

☐ Others (specify)_____

☐ New Variety Seed

[2] Includes cultivating with minimum disturbance (minimum till) mulching, and cover rotation

4.29. During the past 5 years have you made changes in way of production (different type of varieties, fertilizers, tools) and land improvement practices (new farm management technique)?

☐ Yes ☐ No

4.30. During the last five years, which of the following practices have you adopted or used more intensively if previously adopted? **Check all that apply**.

☐ No-till
☐ Crop rotation
☐ Use of cover crops
☐ Minimum tillage
☐ Mulching
☐ Applying organic fertilizer
☐ Applying herbicide
☐ Applying pesticides
☐ Use of new variety seeds
☐ Mechanization
☐ Applying irrigation
☐ Herd improvement
☐ Use new breeds of livestock
☐ Veterinary science
☐ Others (Specify)_____

4.32 What were the reasons for the improvements in adoption or intensification of the preceding land management practices? **Check all that apply.**

☐ Extension training
☐ Training from friends
☐ Purchase of new tools
☐ Able to pay cost
☐ Better access to information
☐ Other (specify) _____

4.33 Does your household have access to the small scale irrigation or micro-dam on the farm?

☐ Yes ☐ No

4.34. How do you rate the steepness of the farmland you cultivating

☐ Gentle ☐ Medium ☐ Steep

4.35 What is the condition of the soil today compared to condition 5 years ago

☐ Improving ☐ Degrading ☐ same

4.36 How adequate the rainfall volume in the past 5 year?

☐ adequate ☐ inadequate ☐ difficult to tell

4.37 What is the level of soil fertility of the farm land?

☐ good ☐ medium ☐ poor

5. Personal Information

In order to better understand some of the responses that you have given, we ask for some personal information. This information will be treated as confidential and will NOT be shared with anyone outside of the research team and will only be used as background information to analyze the information that we have received.

5.01. During the last 12 months, how many household members over age 12 were affected by serious illness? _____ (people)

5.02. During the last 12 months, is the illness affected member of household unable to work on their farming?

☐ Yes ☐ No

5.03. During the last 12 months, how much saving the household lost due to illness (cost of medical bills)? _____ (monetary loss)

5.04. During the past 12 months, which of the following illnesses affected members of your family? **Check all that apply.**

☐ Malaria ☐ Persistent diarrhea ☐ Kwashiorkor

☐ Swollen abdomen

5.05. During the last 12 months, about what portion (%) of your household income was obtained from agriculture?_____ (%)

5.06. During the last 5 years, about what portion of your household income was obtained from agriculture?_____ (%)

5.07. During the last 12months, about what was your total annual household income?

_____ (monetary value)

5.08. How do you rate the last 12 months income as compared with the previous five year yearly income? **Check only one**

☐ Much better ☐ Slightly better ☐ Same

☐ Slightly worse ☐ Much worse

THANK YOU VERY MUCH FOR THE TIME SPENT PROVIDING INFORMATION FOR THIS SURVEY

APPENDIX B-TABLES

Table 1. Occupation of Household Head and Spouse

Occupation	Household head	Percent	Spouse	Percent
Farming	90	77.6	57	52.8
Off-farm	26	22.4	38	12.0
Household chores	0	0.0	1	0.9
School	0	0.0	12	11.1

Based on question 1.7 from the questionnaire.

Table 2. Education Level of Household Head and Spouse

Level of education	Household head	Percent	Spouse	Percent
No school	40	34.5	40	35.1
Preschool	20	17.2	33	28.9
Junior high	46	39.7	36	31.6
Senior high	7	6.0	4	3.7
College/university	3	2.6	1	0.9
Total	116	100	114	100

Based on question 1.6 from the questionnaire.

Table 3. Household Size Category

Household size	Frequency	Percent
2-3	28	24.1
4-5	52	44.8
6-7	20	17.6
8-9	12	10.4
>10	4	3.4
Average	5	

Based on question 1.1 from the questionnaire.

Table 4. Food Insecurity Group and Average Days of Insufficient Food

	Number of Households		Number of Days With Insufficient Food		
Food Insecure Category	Frequency	Percent	Average	Minimum	Maximum
Chronic food insecure	12	10.3	61.54	18	110
Seasonal food insecure	66	57.0	38.71	11	78
Vulnerable food insecure	18	15.5			
Food secure	20	17.2			
Total	116	100.0			

Based on questions 1.1, 2.01, 2.02, and 2.03 from the questionnaire.

Table 5. Shocks Experienced by Households

Shocks	Frequency	Percentage
Drought	91	78.4
Sand Mining	90	77.6
Conflict	9	7.9
Crop Infestation	15	13.0

Based on question 2.11 from the questionnaire.

Table 6. Frequency of Households by Food Insecurity and Income Group

	Income group (29 households/group)				
Food insecurity group	Bottom 25 Percent	Below 50 Percent	Above 75 Percent	Top 25 Percent	Total
Chronic	3	4	2	3	12
Seasonal	14	18	15	19	66
Vulnerable	7	4	4	3	18
Food secure	5	3	8	4	20
Income Group (in cedi)	1200-2489	2490-3220	3225-3800	3820-18340	
Average Income	2053	2903	3467	6025	

Based on questions 2.01, 2.02, 2.03, and 5.05 from the questionnaire.

Table 7. Number of Households by Food Insecurity Group and Technology Use

Food insecurity	Fertilizer	Percent	Seed	Percent	Herbicide	Percent	Pesticide	Percent	Total
Chronic	10	83.3	11	66.7	10	83.3	8	66.7	12
Seasonal	48	72.8	41	75.8	54	81.8	26	39.4	66
Vulnerable	14	77.7	12	77.8	14	77.8	7	38.9	18
Food Secure	19	95.0	12	80.0	19	95.0	7	35.0	20

Based on questions 4.12, 4.14, 4.16, 2.01, 2.02, and 2.03 from the questionnaire.

Table 8. Improved Agricultural Practices and Food Insecurity Group

Food Insecurity Groups	No-till		Crop rotation		Cover crops		Minimum till		Mulching		Total
	Freq.	Percent	Freq.	Percent	Freq.	Percent	Freq.	Percent	Freq.	Percent	
Chronic	1	8.3	2	16.7	1	8.3	9	75.0	5	41.7	12
Seasonal	9	13.6	9	13.6	4	6.1	36	54.5	12	18.2	66
Vulnerable	4	22.2	0	0.0	0	0.0	1	5.6	3	16.7	18
Food secure	13	65.0	2	10.0	0	0.0	1	5.0	2	10.0	20

Based on questions 4.30, 2.01, 2.02, and 2.03 from the questionnaire.

Table 9. Types of Land Ownership by Percentage, Average, and Range

Land ownership/access	Number of households	Percent	Average Land size	Min. land size	Max. land size
Long term proprietorship	21	18.1	0.91	0.2	4.0
Sharecropping	17	14.7	0.75	0.12	2.4
Seasonal lease	78	67.2	1.12	0.2	4.8

Based on questions 4.02, and 4.03 from the questionnaire.

Table 10. Household Perception on Bio-physical Condition

Bio-physical factors	Conditions	Frequency	Percent
Slope	Gentle	111	95.7
	Medium	4	3.5
	Steep	1	0.9
Soil condition	Improving	1	0.9
	Degrading	114	98.3
	Same	1	0.9
Rainfall	Adequate	8	7.0
	Inadequate	61	52.6
	Do not know	47	40.5
Soil fertility	Good	1	0.9
	Medium	68	58.7
	Poor	47	40.5
Micro dam	Yes	25	21.6
	No	91	78.5

Based on questions 4.34, 4.35, 4.36 and 4.37 from the questionnaire.

Table 11. Description of Variable, Expected Sign, and Variable Type Used

Variables	Expected sign		Values	Details
	Soil improving practice model	Food insecurity model		
Application of soil improving practices	-	positive	no adoption=0 adoption = 1	Mulching, cover crops, crop rotation, no-till, and minimum till
Food insecurity groups		-	chronic = 1 seasonal = 2 vulnerable = 3 food secure = 4	
Food insecure and food secure	positive	?	food insecure = 1 food secure = 2	
Income	positive	positive	continuous	In cedi currency/annum
Chemical Fertilizer application	-	positive	no application = 0 apply = 1	12 month time frame
Commercial seed application	-	positive	no application = 0 apply = 1	12 month time frame
Pesticide application	-	?	no application = 0 apply = 1	12 month time frame
Herbicide application	-		no application = 1 apply = 1	12 month time frame
Household head age	positive	?		continuous
Household head education level	positive	positive	no or pre-school = 0 junior & above school = 1	
Household size	?	?		continuous
Medium quality	?	positive	poor = 0 medium = 1	
Seasonal lease	?	?	no seasonal lease = 0 seasonal lease = 1	12 month time frame
Long term proprietorship	positive	?	no long lease = 0 long lease = 1	12 month time frame
Sharecropping	?	?	no sharecropping = 0 share cropping = 1	12 month time frame
Access to extension services	positive	positive	no access = 0 access = 1	

Table 12. Estimated Coefficients for Adoption of Soil Improving Practices Model

Variable	Coefficient	Standard error	z	p> |z|	[95 % confidence Interval]	
Intercept	-0.61	1.60	-0.38	0.70	-3.75	2.53
Tenure						
Share cropping	-0.50	0.81	-0.62	0.53	-2.08	1.07
Seasonal lease	2.21	0.63	3.49	0.00	0.96	3.44
Off-farm	0.19	0.66	0.29	0.77	-1.10	1.48
Extension service	0.31	0.58	0.53	0.59	-0.83	1.46
Food secure	1.27	0.71	1.78	0.08	-0.12	2.66
Level of education	-0.11	0.54	-0.21	0.83	-1.18	0.95
Medium quality soil	-0.99	0.60	-1.65	0.09	-2.18	0.19
Income	0.00	0.00	0.37	0.71	-0.00	0.00
Age of household head	0.00	0.02	0.43	0.67	-0.03	0.05
Household size	-0.03	0.13	-0.23	0.81	-0.29	0.23

Base group: *non-adopters*

Number of observation = 116
LR chi ^{2} (10)=39.90
Prob>chi2=0.0000
Pseudo R^2=0.28
Log likelihood=-51.9

Table 13. Marginal Effects for Adoption of Soil Improving Practices Model

Variable	dy/dx	Standard error	z	p> |z|	[95 % confidence Interval]	
Tenure	0.09	0.15	0.62	0.54	-0.21	0.40
Share cropping	-0.42	0.12	-3.54	0.00	-0.65	-0.19
Seasonal lease	-0.03	0.12	-0.29	0.77	-0.28	0.21
Off-farm	-0.05	0.11	-0.53	0.06	-0.28	0.16
Extension service	-0.06	0.11	-0.53	0.69	-0.28	0.16
Food secure	-0.24	0.13	-1.79	0.07	-0.50	0.02
Level of education	0.02	0.10	0.21	0.03	-0.18	0.22
Medium quality soil	0.19	0.11	1.69	0.09	-0.03	0.41
Income	-0.00	0.00	-0.37	0.71	-0.00	0.00
Age of household head	-0.00	0.00	-0.43	0.67	-0.01	0.01
Household size	-0.01	0.03	0.23	0.82	-0.04	0.06

Number of observation = 116

Conditional marginal effect at mean
Share cropping=0.15
Seasonal lease=0.67
Off-farm =0.22
Extension service=0.76
Food secure=0.17
School=0 .66
Medium quality soil= 0.6
Income=3612.28
Age of household head=48.14
Household size=5.00

Table 14. Multinomial Regression Result for Food Insecurity Model

Independent variables	Coefficient	Std.err	z	p> |z|	[95% Confidence Interval]	
Seasonal food insecure						
Intercept	-2.94	3.24	-0.91	0.36	-9.29	3.39
Adoption of soil imp.	1.14	1.21	0.95	0.34	-1.22	3.51
Chemical fertilizer	0.27	1.10	0.25	0.81	-1.89	2.44
Commercial seed	-0.31	1.56	-0.20	0.84	-3.37	2.74
Herbicides	0.44	1.14	0.39	0.70	-1.78	2.66
Pesticide	-0.94	0.88	-1.07	0.28	-2.67	0.78
Medium quality soil	3.22	1.53	2.10	0.04	0.22	6.23
Off-farm activity	0.51	0.93	0.55	0.58	-1.30	2.32
Seasonal lease	1.57	1.15	1.36	0.17	-0.70	3.83
Share cropping	15.11	946.20	0.02	0.99	1839.6	1869.8
Income	0.00	0.00	0.47	0.64	-0.00	0.00
Education level	0.80	0.84	0.95	0.34	-0.85	2.45
Household size	-0.09	0.18	-0.49	0.63	-0.44	0.26
Age of house head	0.01	0.03	0.24	0.81	-0.05	0.07
Extension service	0.75	1.53	0.49	0.62	-2.24	3.74
Vulnerable food insecure						
Intercept	-8.61	4.02	-2.02	0.04	-16.01	-0.24
Adoption of soil imp.	-1.88	1.39	-1.35	0.17	-4.61	0.85
Chemical fertilizer	0.23	1.40	0.17	0.87	-2.51	2.98
Commercial seed	2.72	1.86	1.46	0.14	-0.92	6.36
Herbicides	0.30	1.35	0.22	0.83	-2.35	2.94
Pesticide	-1.04	1.16	-0.89	0.37	-3.31	1.24
Medium quality soil	5.24	1.71	3.07	0.00	1.89	8.58
Off-farm activity	1.70	1.16	1.47	0.14	-0.57	3.98
Seasonal lease	3.29	1.51	2.18	0.03	0.33	6.25
Share cropping	14.08	946.30	0.01	0.99	-1840.6	-1868.8
Income	0.00	0.00	0.71	0.48	-0.00	0.00
Education level	1.46	1.08	1.36	0.18	-0.65	3.58
Household size	-0.01	0.24	-0.06	0.95	-0.49	0.46
Age of house head	0.05	0.04	1.16	0.25	-0.03	0.12
Extension service	-2.04	1.72	-1.19	0.24	-5.40	1.33
Food secure						
Intercept	-11.64	4.29	-2.60	0.09	-19.28	-2.79
Adoption of soil imp.	2.27	1.42	1.60	0.11	-0.52	5.06
Chemical fertilizer	3.04	1.61	1.89	0.05	-0.10	6.19
Commercial seed	0.82	1.75	0.47	0.64	-2.60	4.24
Herbicides	1.71	1.46	1.17	0.24	-1.15	4.56
Pesticide	-2.32	1.13	-2.06	0.04	-4.55	-0.10
Medium quality soil	5.71	1.73	3.29	0.00	2.31	9.11
Off-farm activity	-0.15	1.29	-0.12	0.91	-2.67	2.38
Seasonal lease	-0.07	1.36	-0.05	0.96	-2.73	2.58
Share cropping	13.75	946.30	0.01	0.98	1840.9	-1868.46
Income	0.00	0.00	1.10	0.27	-0.00	0.00
Education level	1.36	1.06	1.28	0.20	-0.72	3.44
Household size	-0.04	0.23	-0.17	0.87	-0.50	0.41
Age of house head	0.03	0.04	0.73	0.47	-0.05	0.11
Extension service	0.21	1.68	0.13	0.90	-3.08	3.49

Base group: chronic food insecure
Number of observation = 116
LR chi ^{2} (10)=78.89
Prob>chi2=0.0005
Pseudo R^2=0.3
Log likelihood=-93.69

APPENDIX C-FIGURES

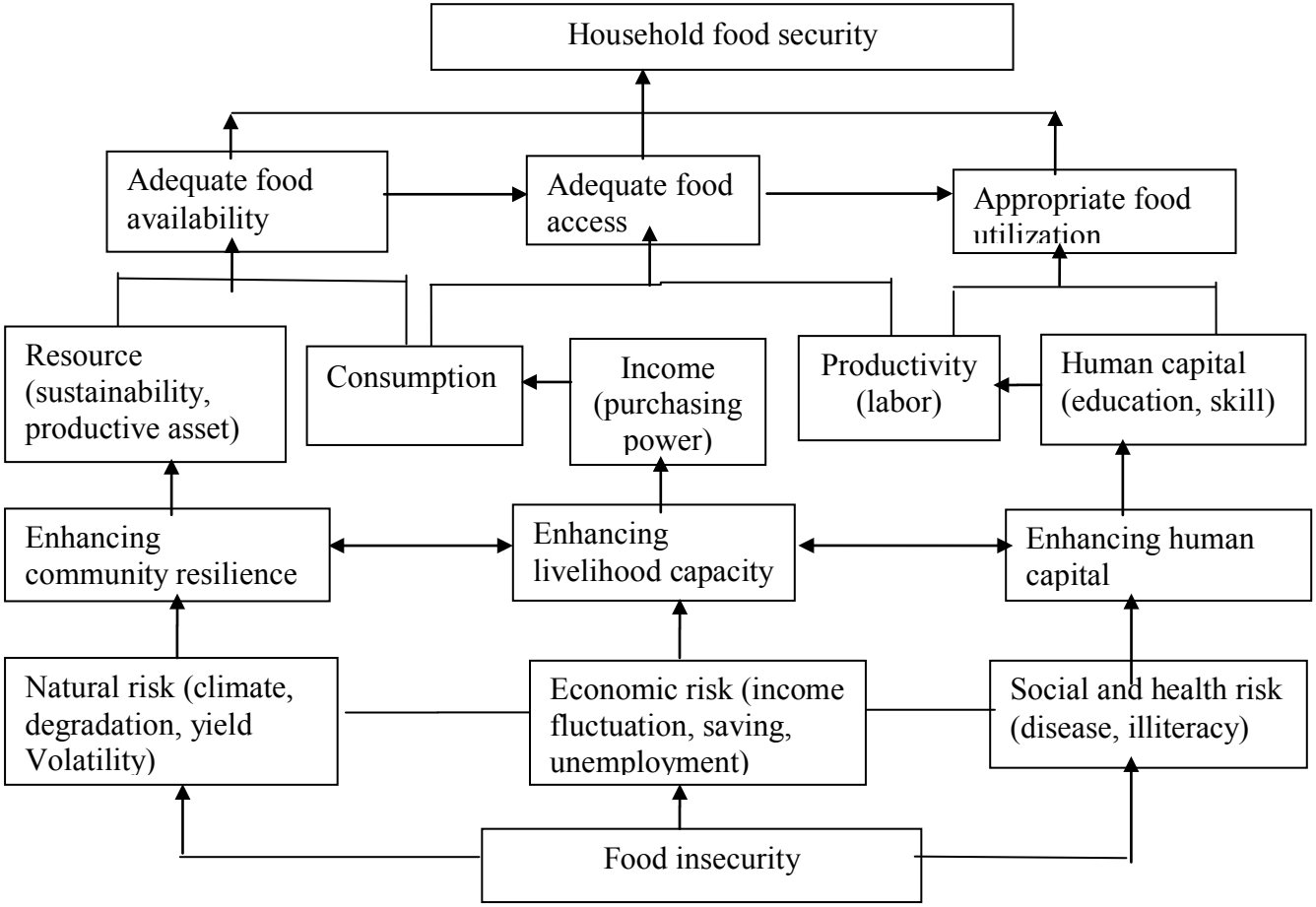

Figure 1. Household exposure to food insecurity
Source: IFAD 1992

		Temporal dimension High food insecure→ less food insecure		
	Intensity	chronic	seasonal	vulnerable
↓ Severity Dimension	Moderate	Moderate chronic food insecure e.g Chronic hunger	Moderate seasonal food insecure e.g seasonality	Moderate vulnerable food insecure e.g borrowing to cover food expense
	Severe	Severe chronic food insecure e.g high infant mortality	Severe seasonal food insecure e.g emergencies	Severe food insecure e.g selling possession to buy food

Figure 2. Categorization of food insecurity
Source: Extended from Deveraux (2006) and Altman Hart and Jacob (2009)

Temporal dimension refers to the time period that a household gone without sufficient food before getting into sufficient level. It can seasonal, long-term or persistent, short-term. While the severity in the temporal dimension is defined as the extent time period that household gone without food (Altman, Hart, and Jacob 2009).

Severity dimension focus on the magnitude of the food gap (measured in energy intake). Usually severity is more visible for intervention in food assistance because of its criticalness of the condition at the time of shock (Altman, Hart, and Jacob 2009).

Source of entitlement	Natural risk	State risk	Market risk	Community risk	Other risks
Productive capital	Drought	Land redistribution		Loss of access to finance	Loss of land due to conflict
Non-productive capital	Pests and animal disease	Compulsory procurement	Price shock, rapid inflation	Breakdown of sharing mechanisms	Loss of asset due to theft
Human capital (power, education)	Disease, epidemics	Declining public expenditures	Lack of jobs	Breakdown of labor reciprocity	Forced labor Mobility restriction
Income (crops, non-agricultural	Pests	Tax increases	Food price shocks		Marketing channel disrupted by war
Claims (social contracts, loans)		Reduction in school feeding programs			Communities disrupted by war

Figure 3. Source of risk to household food insecurity
Source: IFAD 1992

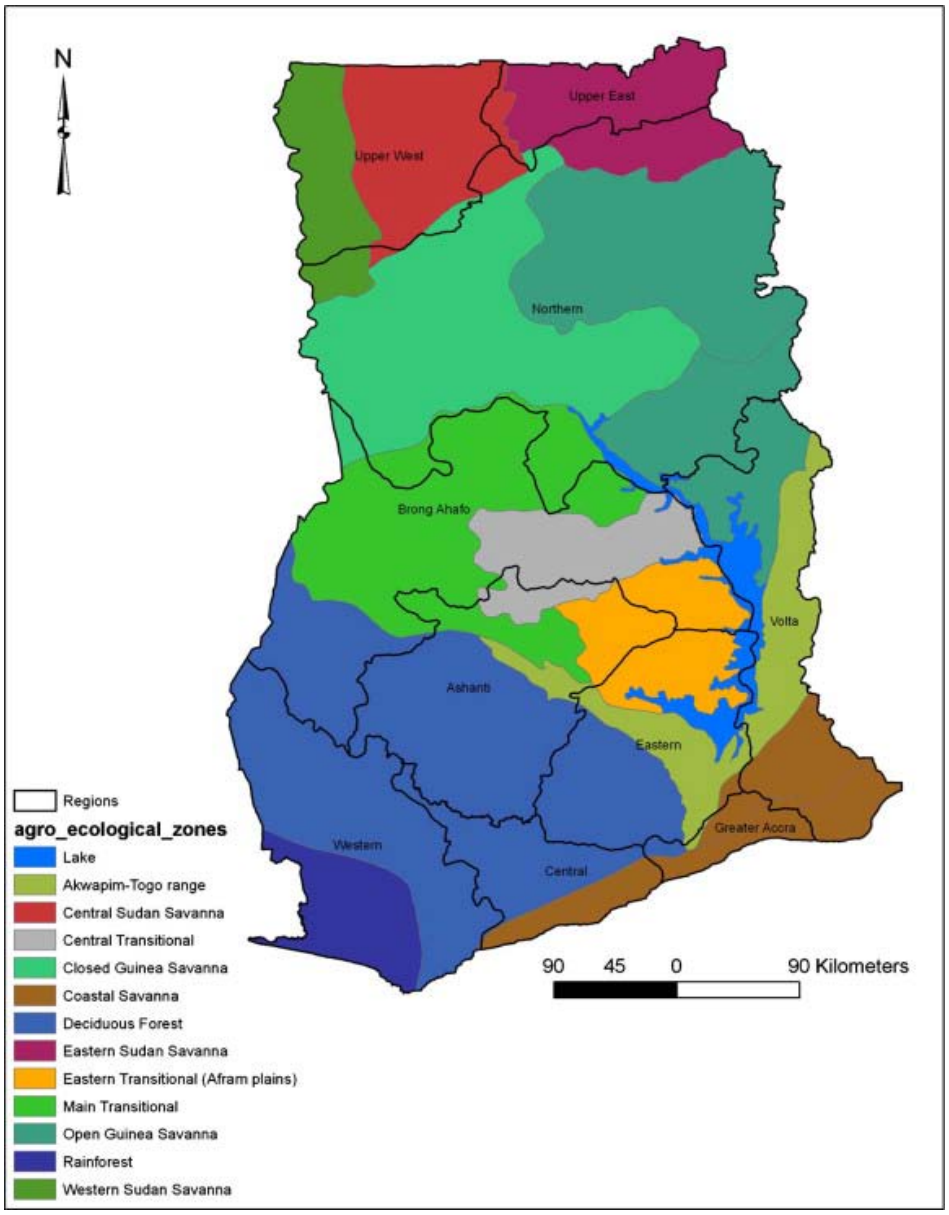

Figure 4. Map of Ghana by region and agro-ecological zones
Source: http://www.sciencedirect.com/science/article/pii/S0306919210000266

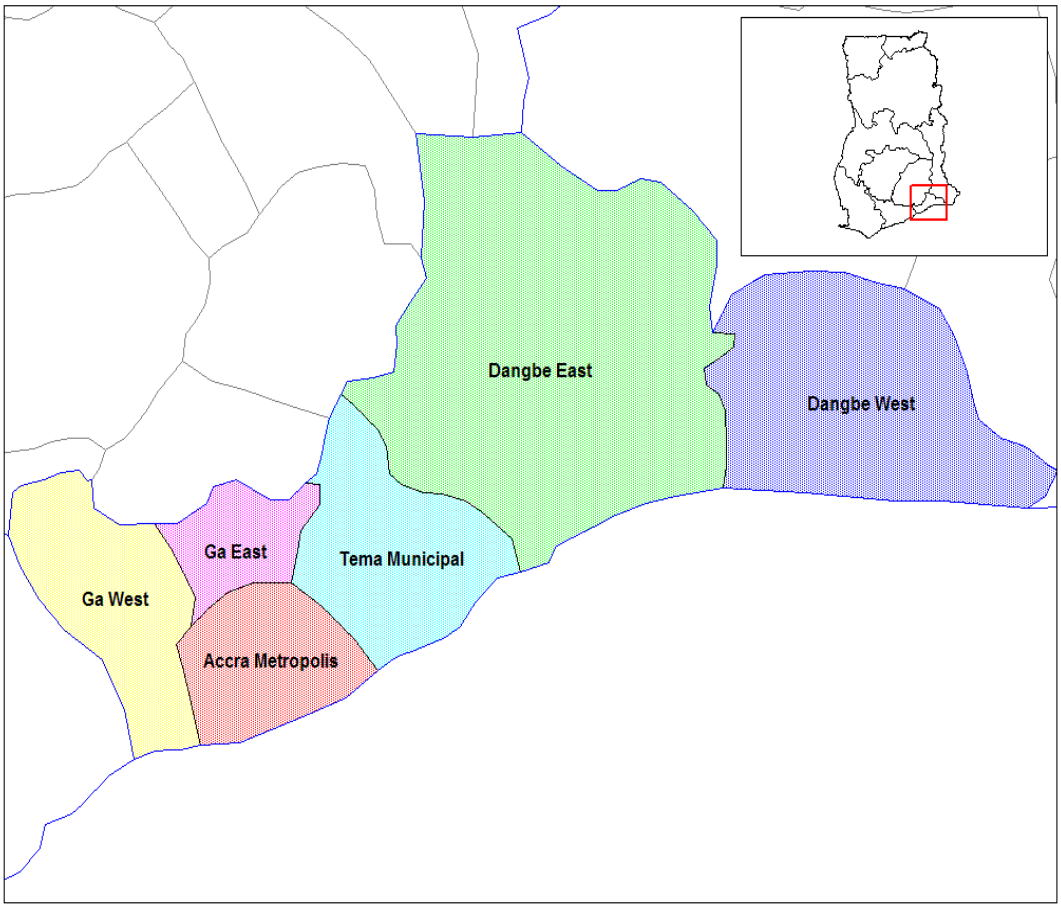

Figure 5. Map of Greater Accra Region by district
Source: http://pt.wikipedia.org/wiki/Ficheiro:Greater_Accra_districts.png