FACTORS AFFECTING FERTILIZER USE
THE EVIDENCE FROM NORTHERN GHANA

by

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A THESIS

submitted in partial fulfillment of the requirements for the degree

MASTER OF SCIENCE

Department of Agricultural Economics
College of Agriculture

KANSAS STATE UNIVERSITY
Manhattan, Kansas

2015

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Abstract

Ghana is the first Sub-Saharan African country to meet the Millennium Development Goals (MDG) of halving extreme poverty by 2015 and has made great improvement in four of the total eight MDG. Supporting by several aid programs, Ghana is right in the middle of an economic boom through agriculture with the stock exchange listing of the Ghanaian Agricultural Development Bank the 3rd of July 2015. However, many Ghanaian producers, specifically in the northern part, cannot take full advantage of this “boom” as they are dealing with poor soil quality and suboptimal levels fertilizer use. By increasing fertilizer use, producers can improve their field’s soil quality and achieve higher crop yields. The purpose of this study is to gain a better understanding of factors influencing the fertilizer use decision among smallholder producers in northern Ghana. A two-part model is estimated and takes into account number of important demographic, production and marking factors affecting producer’s decision on fertilizer adoption and amount used. Findings from this study have implication for designing private initiatives and public policies on improving smallholder producers’ agricultural productivity through the adoption of fertilizer.

Keywords: fertilizer use, decision making, agriculture, Ghana, double-hurdle

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Acknowledgements

I thank Kansas State University for all I have learnt and its warm welcoming. I especially thank Dr. Vincent who welcomed me in this project and guided me during my work on the surveys' interpretation. I also thank all his team, and in particular: Dr. Kara Ross, I'm grateful to her for the regular meetings that encouraged me in that work; Dr. Yacob Zereyesus who was always there to answer to my questions and help me in the difficulties I sometimes faced with the STATA software; and Dr. Aleksan Shanoyan who took a big part in the framing of my research work.

Still, I want to thank all the persons I worked with since I arrived at KSU. They all taught me a lot, both on a professional and human level.

Chapter 1 - Introduction

1.1 The importance of agricultural productivity for smallholder producers

By looking to different countries having experienced an “agricultural revolution”, such as China, Brazil or Thailand, different situations exist to an exponential economic development. First, in China, in the last twenty years, the rural population decreased from 80% to 55% in 2003 (Collier and Dercon, 2014). The development of urban area attracted a lot of people and gave the opportunity to famers to increase their size of land and their productivity. Then, in Brazil or in Thailand, the creation of centers of commercial agriculture ran by private companies have contributed to the successful economic development of these countries.

The majority of agricultural producers in Africa are smallholder producers, and they represent the best structure in the current context. In fact, a recent study led by Larson in 2013 based on large datasets, more than 80,000 households surveyed in twelve Sub-Saharan African countries including Ghana, shows the “inverse-yield relationship” for maize. In fact, the theory of inverse-yield relationship demonstrated in this study is that the cereal yield decreases as the production scale increases (Larson et al., 2013). Therefore, they shown that the small scale of production that exist in those countries is for now the most adapted to face the lack of infrastructure, e.g., storage facilities, and irrigation systems, and the poor soil quality.

Collier and Dercon (2014) view the smallholder producers as a central component in the development of the African economy. These producers should not be pushed to become “mega-farms”, instead they should be supported by new institutional and policy frameworks. By creating an environment that promotes increases in the agricultural productivity of smallholder producers, it will naturally lead to an increase in yield. As a consequence, there will be a reduction of smallholder farmers are some will elect to sell their land and migrate to urban areas. This is a way to initiate a fast development in some Sub-Saharan African countries, starting with the most important sector, agriculture, which is the driver of economic growth in most of the advanced developing countries. This is why, the agricultural productivity is essential for economic growth in Sub-Saharan Africa, however smallholder producers will invest in advanced agricultural technologies only if they come better off. Indeed, the increase on the cereal production should meet an increase of the market demand. According to Drafor et al. (2000), who studied the social welfare of cereal and cocoa producers in Ghana, these smallholder producers are both producers and consumers, so their behavior is conditioned by the market price. If the cereal price increase, they will be likely to keep their production for their own consumption instead of selling it. Therefore, Drafor et al. recommend to keep motivating smallholder producers, with a stabilization of income, to increase their production in order to have more foreign exchanges and create value by exporting cereals. This approach will enable a better life condition for smallholder producers and ensure the food security in Ghana.

1.2 Method to Increase Agricultural Productivity

In Africa, the agricultural productivity is limited by the poor soil quality. The quality of soil is perceived as the main barrier to practice traditional agriculture even with use of organic inputs such as crop residues or manure for example (Crawford et al., 2006). According to Giller from Wageningen University, there is not enough arable land available to produce sufficient quantity of organic fertilizers in Africa given this quality of soil (Theguardian.com, 2014). That is why, the chemical fertilizers are viewed as a good solution because they can provide the necessary nutrients to support optimal productivity. But different alternatives can be used in order to increase the soil fertility and optimize the quantity of fertilizer use. For instance, by using chemical fertilizer, it will produce more output and consequently more crop residues. These crop residues can increase the soil cover and contribute to the maintenance and enhancement of the soil nutrient stock (Vanlauwe et al., 2014). The vegetal residues contribute to the nitrogen input and enable producers to focus their efforts on increasing phosphate, which is mostly mineral fertilizer based (Sanchez et al., 1997). The chemical fertilizers represent an investment for smallholder producers, and if used effectively, it can increase the agricultural productivity of smallholder producers. This increase in productivity can lead to the reduction of poverty by increasing incomes and also ensure the food security in Africa.

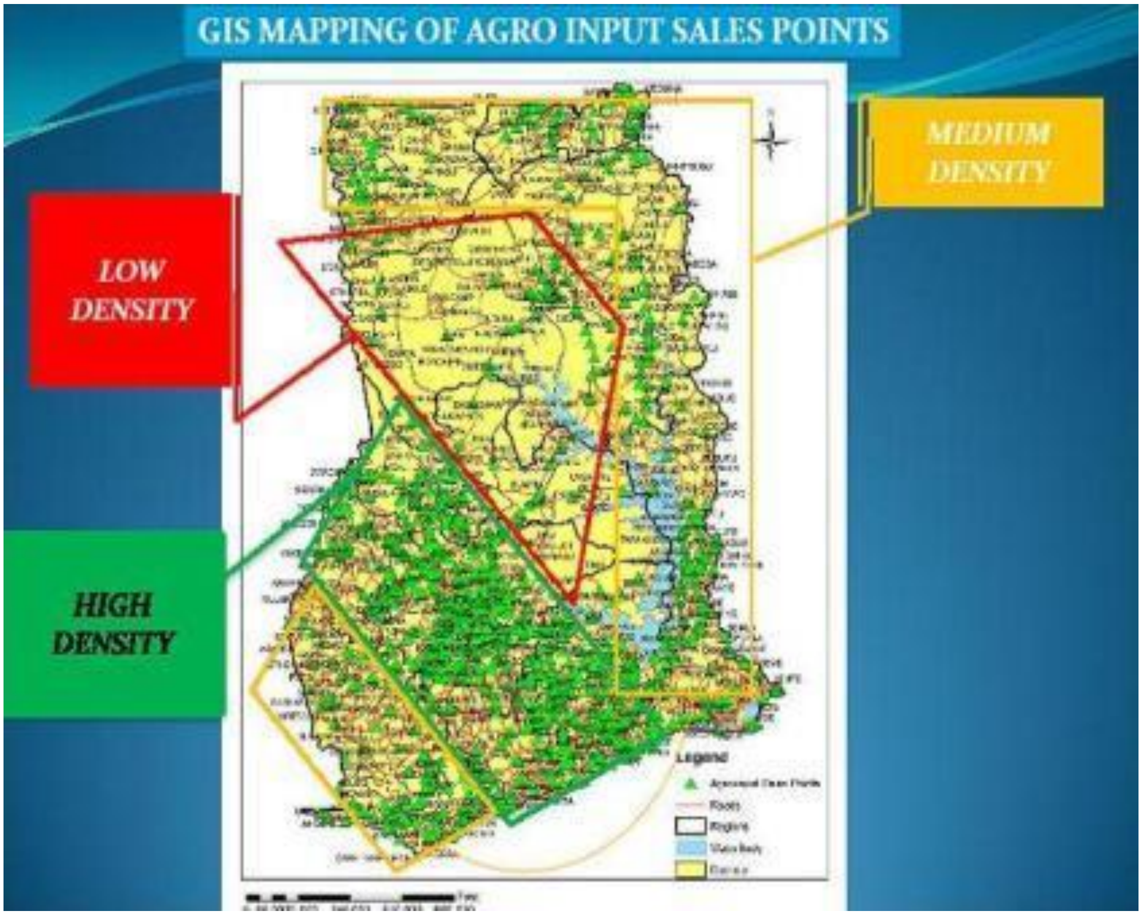
In Ghana (Figure 1), fertilizers are usually distributed through small familial agricultural shops located throughout the country (Krausova and Banful, 2009). But supplying these shops with a consistent supply of quality fertilizer is sometimes difficult because of loses due to packaging damage in transporting or humidity when storing the product. As a result, the quality of the product varies and so does its price. To improve the accessibility to fertilizers, the government has implemented fertilizer subsidy programs in which the government pays for part of the selling price where it pays for a part of the price to the supplier and offers a product more affordable for smallholder producers.

1.3 Chemical fertilizer use

1.3.1 Chemical Use in Africa

In Africa, the chemical fertilizer use is the lowest in the world with 14.7 kg of NPK (Nitrogen, Phosphorous, and Potassium) fertilizer per hectare of arable land in 2012 which is far behind Latin America and Caribbean with 125.9 kg, United States with 131.1 kg and European Union with 149.4 kg per hectare of arable land (The World Bank, 2015). Chemical fertilizers are

Figure 1: Agro-input Sale Points in Ghana



Source: Agricinghana, 2013

key inputs in agriculture because they can increase agricultural productivity when properly and efficiently used. However, the incorrect usage of chemical fertilizer can have a more negative effect on productivity than the effect of no chemical fertilizer use at all. An excessive dose of chemical fertilizer can create a lodging, which means the plant stem is too long and the crop lies down. Therefore, smallholder producers would benefit from technical support and specific guidance to increase their crop yields.

In the early 2000's, there was a movement for Sub-Saharan African countries to improve their own countries' development through different initiatives. In 2001, two important initiatives were developed: the Millennium Africa Recovery Plan (MAP) led by South African government and the Omega Plan led by Senegal. These two plans were combined to create the New Partnership for Africa's Development (NEPAD), which coordinates the Fertilizer Support Program. This program has an objective to create a stable fertilizer market in Africa and to improve the fertilizer access and information to millions west and east African producers by 2015. This will to build development decisions in union with African countries has led to "the largest and most comprehensive effort ever to address Africa's soil fertility crisis" (Africafertilizer.com, 2013; Wanzala, 2015). During the African Fertilizer Summit in 2006, African politicians developed strategies to boost fertilizer use such as eliminating all taxes on chemical fertilizers, improving access to chemicals and providing producers with access to better information on fertilizer use and application (Africafertilizer.com, 2013). Subsequent projects have been launched by international organizations to support these strategies. Two initiatives, the Millennium Villages project created by the Earth Institute of Columbia University in 2005 and the Alliance for Green Revolution in Africa launched in partnership between the Rockefeller and the Bill & Melinda Gates Foundations in 2006, encourage Sub-Saharan African governments to boost fertilizer use with economic leverages such as subsidies (Minot and Benson, 2009; AGRA, 2014).

All those projects are characterized by time-limited programs and they can fit in two main categories. The first category is the market development programs, which offers trainings and certifications for agro-dealers expanding their network to private agro-input dealers and the second one is the programs offering input vouchers allowing smallholder producers to use inputs at a lower price or for free like in Malawi in the 1990's (Minot and Benson, 2009). The main goal for the projects was to reach a fertilizer application rate of 50 kg per hectare by 2015 (African Union, 2006). Despite the fact that the current chemical fertilizer application rate is still well below 50 kg of NPK per hectare (14.7 kg), fertilizer usage has increased by 30% over the past ten years (The World Bank, 2015).

1.3.2 Chemical Use in Ghana

The chemical fertilizer use rate has increased from more than 13 kg per hectare in 2011 to nearly 35 kg of NPK applied per hectare in 2012. In one year (2012) the usage increased by more than 160% with mainly the Fertilizer Support Program (The World Bank, 2015). Recently, there has been an increasing number of policy initiatives and assistance programs in Ghana and other West African countries focused on lessening the supply-side constraints and increasing the accessibility and availability of more reliable, affordable fertilizer supply (Fuentes et al., 2012). Some of these initiatives involve expanding the agro-dealer networks, which would improve smallholder producers' access to fertilizer and decrease the transportation costs from the dealers to smallholder producers (Fuentes et al., 2012). On April 16, 2015, Ghana's Ministry of Food and Agriculture announced the return of a fertilizer subsidy program for the 2015 cropping season involving three main companies: Yara Ghana Limited, Chemico Limited and AFcolt Ghana Limited. This initiative to improve fertilizer affordability and access for the smallholder producers is based on the success of a five year fertilizer subsidy program launched in 2008 (Ghanaweb.com, 2014). The fertilizer subsidy program was not continued in 2014 because of the Ghanaian government defaulting on payments to suppliers.

During the five year subsidy program (2008-2013), 724,055 metric tons (MT) of compound fertilizer and Urea were subsided by the government for only, on average, 20.7% of the selling price. In this 2015 subsidy program, 180,000 MT of granular fertilizers, including compound fertilizer and Urea, will be distributed to the smallholder producers cultivating maize, rice, sorghum and millet. The governmental subsidies will improve the accessibility of chemical fertilizers in Ghana and these fertilizers will be available at a fraction of the selling price. The subsidized price will be, on average, 21% of the selling price (Government of Ghana, 2015).

1.4 Ghana country profile

Ghana is located in Sub-Saharan western Africa, along the Gulf of Guinea, just a few degrees north of the equator. Figure 2 gives an overview of this country which is surrounded by three countries: Ivory Coast to the west; Burkina Faso to the north; and Togo to the east. To the south, Ghana is bordered by the Atlantic Ocean with a 350 mile coastline. It has also an opening on the Atlantic Ocean with a 350 miles coast. The total area of Ghana is 92,099 square miles, which is slightly largely than the state of Kansas (82,277 square miles). In 2014, the estimated population was 26.22 million people with almost 40% of the population under the age of 15 years and had a population growth rate of 2.19 % (IMF, 2014; CIA 2014).

1.4.1 Overview of the economic situation

Of the Sub-Saharan African countries with more than five million residents, Ghana has the third highest Gross Domestic Product (GDP) based on purchasing power parity (PPP) per capita after Angola and Nigeria. In 2014, Ghana's GDP was $4,172.68. GDP is an economic indicator representing the value of all the goods and services produced in a country divided by its population. Table 1 represents Ghana's business sectors based on their GDP share. The agriculture sector contributes the largest share to the GDP in 2013 (22.8%), followed by such the transport, storage and communication sector (14.3%). In 2012, the top three agricultural crops in terms of value were yams, cassava and cocoa beans (FAO, 2015a).

Figure 2: General Map of Ghana

Source: www.wordtravels.com/Travelguide/Countries/Ghana/Map

Ghana is the first country in Sub-Saharan Africa to meet its Millennium Development Goal (MDG) of halving extreme poverty by 2015, and one of the first African countries to have made great improvements in at least four of the eight MDGs (Appendix B).

Table 1: Business Sector's contribution to GDP in Ghana

Business Sector	GDP (%)
Agriculture, hunting, forestry, fishing	22.8
Mining	14.0
Manufacturing	6.3
Electricity, gas and water	1.4
Construction	12.6
Wholesale and retail trade, hotels and restaurants	10.7
Transport, storage and communication	14.3
Finance, real estate and business services	9.9
Public administration, education, health and social work, community, social and personal services	6.6
Other services	9.0
Gross domestic product at basic prices / factor cost	100.0

Source: Okudzeto et al., 2014

The MDGs are targeted goals set by United Nation members to reduce the global poverty by 2015. These eight goals have been approved and adopted via the United Nation Millennium Declaration in September 2000 with the world leaders at the United Nation Headquarter. Ghana is ranked third among Sub-Saharan Africa countries on the Global Hunger Index. The percentage of people suffering from food insecurity has decreased from 21.4% in 1990 to 8.9% in 2012 (United Nation, 2013). Ghana's ability to act quickly and to make some significant changes to improve its development along with its stable democratic political status has made it a hopeful country for leading African development.

1.4.2 Inequality between North and South Ghana

There are some significant differences between north and south Ghana. First, the tropical climate is different in the north with a dry season from November to March and a wet season reaching a peak in August – September, compared to the four seasons experienced in the southern part of the country. Also, the population distribution is unbalanced with less than 20% of the total population located in northern Ghana. Another characteristic of Ghana is the asymmetry in development process. Figure 3 illustrates maps very simply the resources distribution within Ghana. The resources are mostly concentrated in the south while the north looks more barren. In fact, this map illustrates the huge inequality currently present between northern and southern Ghana. By extension, the northern Ghana or Zone of Influence (ZOI) refer to the northern savannah ecological zone in Ghana that encompasses three main regions: Northern, Upper West and Upper East (MOFA, 2015).

Figure 3: Map with Resources in Ghana

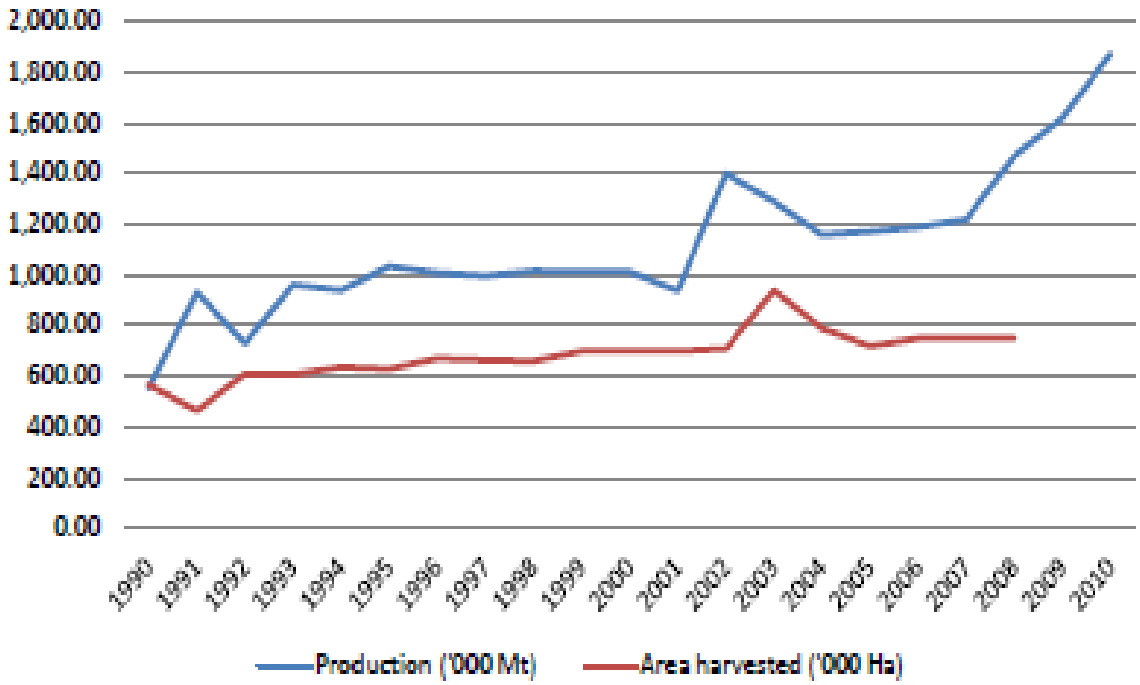
Source: Time For Kids, 2015

Although overall Ghanaian population has a low food insecurity rate, with 5% of people suffering from food insecurity, this rate varies from 10% to 34% in northern Ghana. The food insecurity affects mainly children and is due to availability, access, utilization and stability in availability of food (USAID|Ghana, 2012a).

1.4.3 Importance of maize production

According to Angelucci (2012), maize production represents 55% of the total grain production in 2010 and it has been positively affected by the fertilizer incentive programs launched in 2008. Since this year (2008), a strong increase has been recorded in the production, from 1.2 to 1.8 million of ton (Figure 4). Table 2 is interesting to understand the purpose of this initiative based on maize yield. Ghana's increase in maize production and its reduction in maize imports (decrease from 34,230 Mt in 2009 to 890 Mt in 2010) suggests that it is becoming more selfsufficient in needing its nation's maize demand. Also, Ghana's maize exports are starting to increase from 10 Mt in 2009 to 50 Mt in 2010 (Table 2).

Figure 4: Maize Production and Area Harvested per year in Ghana



Source: Angelucci, 2012

Table 2: Maize Production Import and Export in Ghana

	2005	2006	2007	2008	2009	2010
Production ('000Mt)	1,171.40	1,188.80	1,219.60	1,470.08	1,619.59	1,871.70
Imports ('000 Mt)	73.95	6.55	0.6	63.87	34.23	0.89
Exports ('000 Mt)	0.02	0.01	0.02	0.11	0.01	0.05
Exports share on production	0.00%	0.00%	0.00%	0.01%	0.00%	0.00%
Trade intensity (X+M)/P	0.06	0.01	0	0.04	0.02	0
Food Aid Imports ('000 Mt)	1.7	2.17	n.a.	2.06	1.13	0.95

Source: Angelucci, 2012

This present study will be focus on smallholder producers in northern Ghana who are producing maize as their main crop[1] in order to capture factors affecting their fertilizer use decision.

1.4.4 Soil quality issue

Northern Ghana is the focus area for development aid programs such as the Feed the Future Initiative launched for Ghana in 2011 by the USAID. In this area, there is a high prevalence of poverty and malnutrition in spite of the yield improvements on three main cereal crop produced - maize, rice, and soybeans - due to the adoption of improved technologies, e.g., tractors, improved seeds, chemical fertilizers, by smallholder producers. In Ghana, the consumption of NPK fertilizer has increased by 162% in a single year between 2011 and 2012 with an average application rate of 34.9 kg/ha in 2012 (The World Bank, 2015). However, the current yields are still far below Ghana's full potential. During the 2002 to 2004 cropping seasons, a study was conducted in Africa to evaluate the soil nutrients losses. For those cropping seasons, Ghana appeared to have lost 58 kg/ha of nutrients (NPK) in the soil every year because of deforestation, disappearance of fallows and usage of mono-cropping that expose the soils to erosion (Henao and Baanante, 2006; Braimoh and Vlek, 2006).

1.4.5 Prevalence of poverty

In Ghana, the north appears barren with 4.93 million residents against 19.73 million residents in the south (Ghana Statistical Service, 2012). In addition to this difference in the population distribution, over a twelve year period the number of impoverished people has reduced by 2.5 million in southern Ghana whereas the number of people living in poverty has increased by 0.9 million in northern Ghana. Based on the World Bank poverty threshold of $1.25

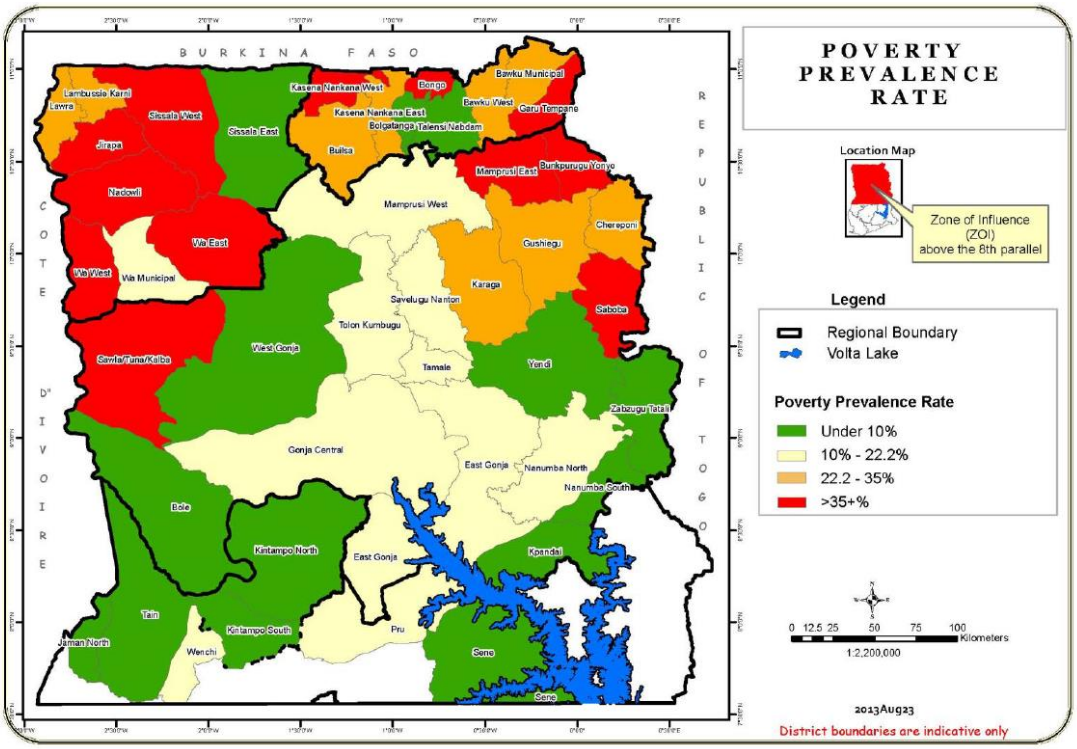
[1] The main crop is defined as the crop with the largest area cultivated for each smallholder producer.

daily expenditure per capita, Dr. Zereyesus et al. in 2014 estimate the average poverty prevalence rate to be 22.2% in northern Ghana. This statistics indicates that approximately 1.2 million people are living under the poverty threshold; mainly in the north-east and north-west of northern Ghana (Figure 5). Northern Ghana, or the area above the 8^{th} parallel line, is referred to the Zone of Influence (ZOI) for USAID's Feed the Future initiative (Figure 4). Since the last poverty prevalence rate available was estimated in 2006, it is difficult to compare the poverty prevalence rate calculated in 2013 on the north with the 2006 estimation on the south. However, in 2006 the northern Ghana poverty rate was nearly twice that of the south.

1.4.6 Importance of agriculture in northern Ghana

Because of a lack of natural resources in northern Ghana, agriculture is very important, with 70% of northern Ghana's economically active population aged 15 to 49 years involved in agricultural activities compared to 40% in the south (Ghana Statistical Service, 2012). Furthermore, 90% of smallholder producers in northern Ghana cultivate less than two hectares (Ghana Statistical Service, 2012). Yet this difference in agricultural involvement between north and south is kind of logical. Indeed, as mentioned earlier, the south own much more resources, especially mining resources and with the sea opening to the international market, it has contributed to the development of better infrastructures. The climate is different and so it is more appropriate for tropical production such as cocoa, oil palm or coffee. This type of agriculture involves producers owning on average 7.5 ha in 2004 (Vigneri and Santos, 2007). Therefore, the smallholder producer profile in southern and northern Ghana is different, the north is mainly focused on agriculture activities with a majority of smallholder producers (less than 2 ha) cultivating annual crops whereas in the south other industries are important and smallholder producers are mainly specialized in perennial productions.

Figure 5: Poverty Prevalence Rate by District in the Zone of Influence (2012)



Source: Amanor-Boadu et al., 2013

1.5 Motivation and thesis structure

The motivation to focus this thesis on chemical fertilizers is that its impact on agricultural productivity is quickly observable and it is a solution to deal with the poor soil condition in northern Ghana. This research study identifies the factors that influence smallholder producers' decision to use the chemical fertilizers. Additional questions addressed in this thesis are (1) what is the current profile of a smallholder producer using chemical fertilizer? (2) Who are the smallholder producer who want to use chemical fertilizer but for some reasons do not?

To answer to these questions, this present study examines a dataset that is developed from two United States funded surveys conducted in northern Ghana during the 2013 – 2014 cropping season and in July – August of 2012. A statistical double-hurdle model is estimated to determine the significant factors that affect the fertilizer use. Based on this study's results, recommendations will be given to increase the adoption rate of fertilizer usage and promote the effective fertilizer application rate in northern Ghana.

The remainder of the thesis will be divided into the following six chapters. Chapter 2 will provide a brief literature review of the effects of fertilizer on crop yield and the subsidy programs that have made fertilizers affordable to smallholder producers. A description of the method used to identify the factors impacting the fertilizer use decision of smallholder producers in the study follows in Chapter 3. Chapter 4 describes the selected variables examined in the study that are hypothesized to influence the fertilizer use decision. Chapter 5 provides a discussion on the estimation results with the focus on the significant factors. Finally, findings from this study providing insights into the situation or interventions that can be designed and implemented to improve smallholder producers' agricultural productivity through the adoption of fertilizer will be presented in Chapter 6.

Chapter 2 - Literature review

Africa has the lowest fertilizer use percentage in the world with 14.7Kg/ha (The World Bank, 2015). The limited use of fertilizer in Sub-Saharan Africa compared to the rest of the world has been the focus of a number of studies in recent years. Crawford et al. (2006) studied the optimal method to implement fertilizer subsidy programs in Sub-Saharan Africa by identifying and reviewing the major elements from the large amount of literature. This paper points out the critical low quality of soil in this region and the need for adapting aid programs to achieve an “African Green Revolution” in reference to the Asian Green Revolution. The key points of a Green Revolution are the simultaneous investment in irrigation, improved seed varieties and fertilizer use. An advantage of this paper, they first select papers from different authors about agricultural development and soil fertility in order to extract the major elements from the literature. This initiative has been commissioned by the World Bank to give to analysts the various arguments needed to know for decision making concerning fertilizer subsidies. The limit of this study is the missing elements about the coordination of a good fertilizer distribution among smallholder producers. Having a good understanding of the social and the marketing factors influencing producers to use fertilizer will help coordinate the fertilizer distribution in Sub-Saharan Africa.

Since some authors think that fertilizer use has an important role in Sub-Saharan African development, some others are claiming the use of good agricultural practices (tillage, mulching, rotations, etc.) as a solution to improve the agricultural development (See Landers, 1999; Roose and Barthes, 2001; Gupta and Sayre, 2007; all cited in Vanlauwe et al., 2014). However, Vanlauwe et al. (2014) states that the soil fertility issue has to be resolved first before a Conservation Agriculture implementation. Conservation Agriculture consists of the practice of minimum tillage, mulching and intercropping or rotation with a legume. Vanlauwe et al. (2014) also believe that a fourth principle is necessary to be included in the Conservation Agriculture definition: the appropriate use of chemical fertilizer.

The coordination of sustainable agriculture practices and fertilizer use is made by producers. Vanlauwe et al., 2014 underscored that most of the smallholder producers in Sub-Saharan Africa are smallholder producers, who are farming, on average, less than two hectares. Akpan et al. (2012) used a double-hurdle model to examine the factors affecting fertilizer adoption and use among agricultural producers in southern Nigeria. The advantage of the double-hurdle model is its ability to identify the factors that influence the two separate but related decisions: adoption of fertilizer and intensity of fertilizer use. A producer's decision to adopt fertilizer use was found to be influenced by size of the household, size of land used, price of fertilizer, years of farming, output value, technical assistance, number of domestic animal on the farm, i.e., goat and sheep, and whether the producer had poultry. Significant relationships between the quantity of fertilizer use and the following variables were discovered: age, gender, size of land used, crops grown for commercial sale, price of fertilizer, output value, number of domestic animal, poultry production and distance to fertilizer selling point. The small sample size, 150 producers, was a limitation of the study. Another limitation is Akpan et al. (2012) only measured the marginal effect of the adoption decision and did not measure the marginal effect of the intensity decision.

Chapoto and Ragasa (2013) studied the factors affecting the decision of fertilizer use in Ghana. They used cross-sectional data collected from a survey of 630 maize smallholder producers to examine the responsiveness of maize yield to chemical fertilizer application and to understand the economics of fertilizer use with or without subsidies. They used a number of different models

- trivariate probit model, double-hurdle model and quadratic functional form- to show the impact of fertilizer use on maize yield.

They examined the factors affecting the decision of fertilizer use but also the factors related to the decisions to use specific types of seed. The results indicated that fertilizer price is not the only variable involved in when deciding to use fertilizer or not. Distance to agro shop, price of certified seeds, intercropping and soil perceived very fertile have a significant negative effect on fertilizer use. Whereas plowing in row, use of tractor for plowing, plots burnt before planting, hired labor hours per hectare and the location (northern or southern Ghana) are positively impacting the intensity of using fertilizer in Ghana. This present study contributes to the literature by investigating the effect of additional variables on fertilizer use, e.g., use of irrigation, the household size or the income accessed by smallholder producers, and it focuses on smallholder producers in northern Ghana, those who could benefit greatly from fertilizer use.

Martey et al. (2013) conducted a recent study in northern Ghana using survey data from 330 smallholder producers. They also used a double-hurdle to identify the factors influencing fertilizer adoption and quantity used. Factors that had a significant impact on the decision to adopt fertilizer were age, nativity (Ghanaian citizenship), size of land used, access to credit, and distance to fertilizer selling point. The significant variables affecting the intensity of fertilizer use were household income, agricultural group membership, distance to an agricultural office, access to fertilizer selling point, income from participation in projects promoting the Integrated Soil Fertility Management practices and income-earning male-headed household. A major drawback of the article is the absence of average partial effects. The measure of the unconditional average partial effect, specific to the double hurdle approach, would have been a valuable addition to the article as these average partial effects estimate the impact of each significant factor on the intensity decision for fertilizer users or non-users. This present study contributes to the literature by computing the unconditional average partial effect.

There are a number of studies examining factors affecting the fertilizer use decision among smallholder producers in Sub-Saharan Africa. Because each country has its own agro-ecological areas, agricultural production systems, political structures and cultural systems, factors involved in the decision of fertilizer use can be different between countries and between regions within the same country. In northern Ghana, the literature reveals a gap in the knowledge about the smallholder producers' decision to use fertilizer. This present study attempts to close the gap and develop a deeper understanding of smallholder producers' behavior for fertilizer use.

Chapter 3 - Method and Data

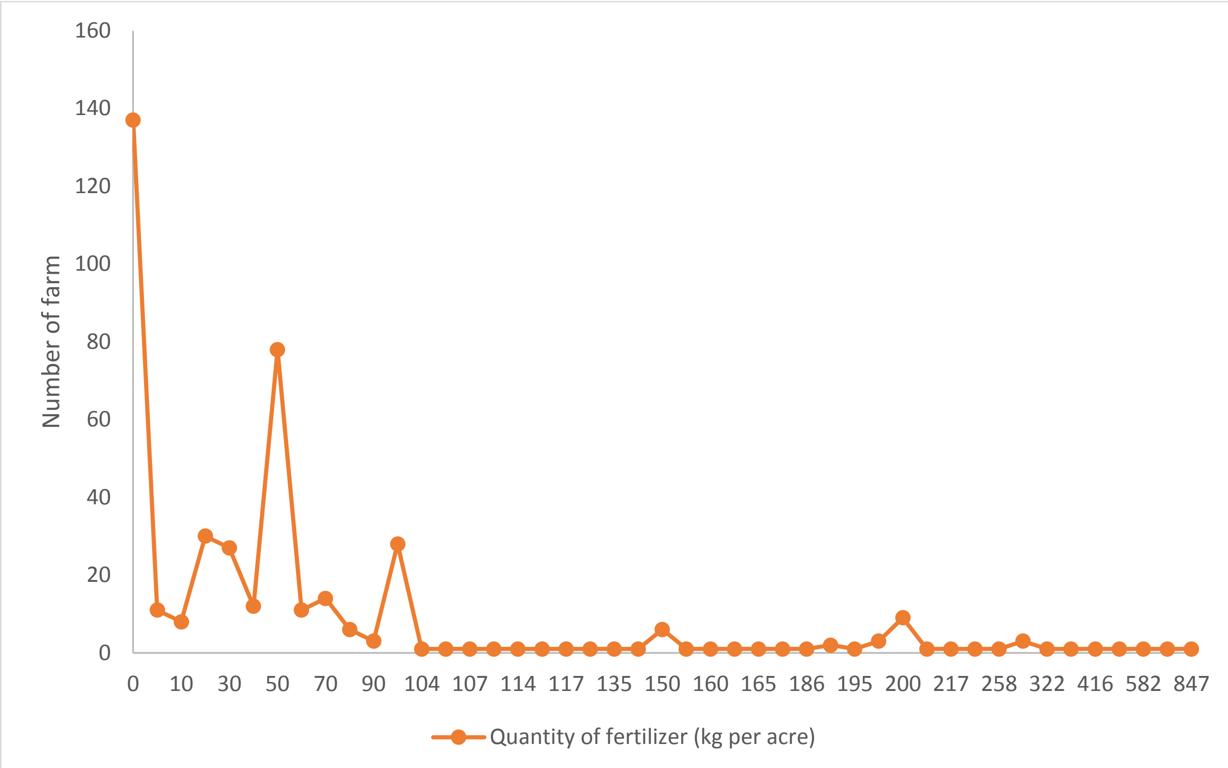
3.1 Surveys overview

The analysis is using data based on two surveys, the Population Based Survey (PBS) and the Agricultural Production Survey (APS), which have been designed using a two-stage stratified random sampling approach. The probability weights were developed for the PBS to account for differential probabilities of selection and non-responses from the households resulting in a survey design that is representative of the population in northern Ghana. In total, household demographic data from the PBS were collected among 4,410 households in across 25 districts in four regions as part of the Zone of Influence delimited by the United States Agency for International Development (USAID). The data was collected from July 1 to August 17th, 2012. In addition, production and sales data were collected from 527 smallholder producers as part of the APS during the 2013-2014 cropping season. These 527smallholders producers were selected from the PBS survey sample of 4,410 household. These surveys are part of Feed the Future initiative managed by the USAID in Ghana in order to ensure food security, to reduce poverty and hunger in northern Ghana. Production data, mainly focused on maize, rice and soybeans, were collected from the entire 2013 cropping season, from late June to mid-November. Sales data were collected during follow-up visits in January, February and March 2014.

3.2 Dependent variable specificity

Based on data from the APS regarding the fertilizer use among smallholder producers in northern Ghana (Figure 5), most of producers in the sample do not use fertilizer and the distribution is representing by a declining slope. This distribution is characteristic to Sub-Saharan African countries (Mason and Jayne, 2012; Liverpool-Tasie, 2014, Chapoto and Ragasa, 2013).

Figure 6: Distribution of Fertilizer Use in Northern Ghana



Source: USAID|Ghana, 2012b

For developed countries, the distribution of fertilizer users among producers is more likely to have a bell shape, with only a few producers not using fertilizer and an increasing slope until the optimal use followed by a declining slope. Because of this specific distribution, it is important to analyze the factors affecting the fertilizer use decision for both, users and non-users of fertilizer. The observations with the zero quantity of fertilizer used are referred to a corner solution and represent an important part of the analysis. It is important to examine these smallholder producers who are not adopting fertilizer use or not applying any fertilizer to their field plots and to identify the factors affecting their fertilizer use decisions. Therefore, those zero observations can be analyzed in order to know more about the factors affecting the change to fertilizer adoption.

3.3 Conceptual model

The objective of this study is to identify factors affecting the decision to use a chemical fertilizer (NPK), which can be separated in two sub-decisions. The first decision is the willingness to use fertilizer, and the second decision, conditioned on the first decision, is how much fertilizer to use. Consequently, the following two equations are used to represent the two decisions:

$$\boldsymbol{Y_i = \alpha_i Z_i + \beta_i F_i + \gamma_i M_i + \varepsilon_i} \qquad \text{participation decision} \qquad (1)$$

$$\boldsymbol{I_i = \alpha'_i Z'_i + \beta'_i F'_i + \gamma'_i M'_i + U_i} \qquad \text{intensity decision} \qquad (2)$$

On the left hand side, $\boldsymbol{Y_i}$ is a binary dependent variable representing the decision for each household (i) to adopt fertilizer where 0 indicates the non-use and 1 the use. In the equation (2), $\boldsymbol{I_i}$ is a continuous dependent variable characteristic of the fertilizer intensity decision. The latest is conditioned by the adoption dependent variable: if $\boldsymbol{Y_i = 0}$ there is no intensity decision so $\boldsymbol{I_i = 0}$, otherwise $\boldsymbol{I_i > 0}$ if $\boldsymbol{Y_i > 0}$. Then on the right hand side, the independent variables are gathered in three sets of variables representing in these equations by three different vectors: $\boldsymbol{Z_i}$ and $\boldsymbol{Z'_i}$ vectors of demographic variables, $\boldsymbol{F_i}$ and $\boldsymbol{F'_i}$ vectors of production variables, and $\boldsymbol{M_i}$ and $\boldsymbol{M'_i}$ vectors of market variables. For each vector is affected a coefficient $\boldsymbol{\alpha_i}$ and $\boldsymbol{\alpha'_i}$ for the demographic vector, $\boldsymbol{\beta_i}$ and $\boldsymbol{\beta'_i}$ for the production vector, and $\boldsymbol{\gamma_i}$ and $\boldsymbol{\gamma'_i}$ for the market vector. The vectors are written down differently in equation (1) and equation (2) because they can represent different set of variables and their estimated coefficients can be different too. Finally, $\boldsymbol{\varepsilon_i}$ and $\boldsymbol{U_i}$ are the error terms respectively of equation (1) and equation (2).

3.4 Estimation method

Each of the decision choices, adoption and intensity of use, can be estimated by a specific model. For instance, a Probit model can define the dependent variable as a binary variable and so, estimates the effect of independent variables on an adoption decision. Since the Tobit approach excludes the zeros from the dependent variable, it can be used to estimate the effect of independent variables on the fertilizer intensity decision where the quantity of fertilizer applied is greater than 0. By analyzing the models one after the other, it gives the information about factors affecting the decision to adopt fertilizer and based on the users it identifies the factors that incentive users to apply more fertilizer on their land. Once again, there is not much information about the non-users.

That is why, some models called two-part models combine a Probit and a Tobit model and allow more manipulations. These models include: the Type II Tobit Model (expended with the Exponential Type II Tobit Model (ET2T) and the Heckman's method (part of the ET2T)) and the Double-Hurdle Model. The Double-Hurdle Model created in 1971 by John G. Cragg is differentiated from the Type II Tobit Model in two main ways. First, the error terms of the two equations, $\boldsymbol{\varepsilon_i}$ and $\boldsymbol{U_i}$, are independent which enable the researchers to have a different set of variables for the adoption ($\boldsymbol{Z_i}$, $\boldsymbol{F_i}$ and $\boldsymbol{M_i}$) and the intensity decision ($\boldsymbol{Z'_i}$, $\boldsymbol{F'_i}$ and $\boldsymbol{M'_i}$). An independent variable included in both sub-decisions can have different signs in each decision. This allow a flexibility important to the understanding of the specific effect of the factors on a decision. The second characteristic of the double-hurdle model is the truncated normal distribution affected to a parameter of the dependent variable. This feature does not allow negative outcomes. Concretely for this study, the quantity of fertilizer applied will not be negative. For the analysis of the fertilizer use decision, these two characteristics of the double-hurdle model are essential. Therefore, the double-hurdle approach allows more flexibility, which is why it will be used for this paper.

3.5 Impact measurement of independent variables on the dependent variable

The double-hurdle model was estimated using Stata® 14. The output of the results are presented in Appendix A, the table is divided into two tiers. Tier 1 represents the relationship between the independent variables and the adoption decision of fertilizer and Tier 2 represents the interactions of those variables with the dependent variable representative of the intensity of fertilizer use. For the double-hurdle model, the variable coefficient does not correspond directly to the marginal effect of the independent variable on the dependent variable. The marginal effect provides important information as it represents how much the dependent variable changes in response to a unit increase in the independent variable.

For each independent variable, the Average Partial Effect (APE) is calculated by bootstrapping a hundred of iterations for each independent variables. After those iterations, the average coefficient is given, corresponding to the unconditional APE and also the standard error (p-value). The unconditional APE is valuable because it represents the effect of the relevant variables on the intensity decision for a random smallholder producer regardless if he used or did not use fertilizer. The APEU shows how the intensity decision will change by increasing the selected variable by one unit.

Chapter 4 - Variables description

Following the research paper from Chapoto and Ragasa (2013), Martey et al. (2014), and Akpan et al. (2012) cited in Chapter 2, the common variables with the PBS and the APS that were significant in these studies, have been selected for this thesis. Chapoto and Ragasa (2013) in their paper have calculated the unconditional average partial effect and found that the distance to agro shop is negatively significant on the use of fertilizer for any smallholder producer in Ghana and that smallholder producers using tractor to plow in row use significantly more fertilizer. In the article of Martey et al. (2014) which is focused on northern Ghana, the age and the access to credit have a negative impact on the decision to adopt fertilizer and the household head income has a negative effect on the intensity decision. To capture the income of each household in this thesis, only the income from the sale of crops has been studied in order to focus only on the agricultural productivity generated per household. For Akpan et al. (2012), who studied the factors affecting fertilizer use in northern Nigeria, the household size is a positive significant factor for fertilizer adoption as well as the age of household head, the gender, the commercial purpose of crop sold, and the output value that have a positive effect on the fertilizer intensity decision. The distance to a fertilizer selling point is a negative factor for the intensity decision and confirms the finding of Chapoto and Ragasa (2013). In this thesis, some other variables available from the surveys has been added to the variables from the literature review. They have been chosen because of their potential link to the fertilizer use decision: education, literacy, the use of tractor service (mechanization), the type of seed used, the practice of irrigation, the agricultural group membership, the technical assistance received, the fertilizer transport cost stated in Ghanaian cedi, the maize yield in kilogram per acre for the year of study (2013), the income received from the crop sales the previous year (2012), and the sowing during the optimal date of planting.

For a better analysis, Stata® 14 automatically reduces the observation number by the number of missing values. This is the reason why the number of observations is not constant for each variable. Those missing values represent the smallholder producers that did not give any answers to the question related to the variables.

4.1 Construction and hypothesis of variables

Table 3: Variables Summary Statistics

Variable name	Obs.	Average	Standard deviation	95% confident interval	
Dependent variable					
Quantity of chemical fertilizer applied (kg/acre)	416	57.19	91.30	48.39	65.99
Demographic variables					
Gender[b] (female = 1)	465	0.10		0.07	0.12
Education level[b] (educated = 1)	464	0.12		0.09	0.15
Age (year)	454	45.01	16.84	43.46	46.57
Household size (people)	464	10.69	5.69	10.17	11.21
Literacy[b] (literate = 1)	464	0.09		0.06	0.11
Production variables					
Type of seed[b] (certified new seeds = 1)	462	0.21		0.17	0.24
Mechanization[b] (no tractor use = 1)	462	0.44		0.39	0.48
Technical assistance[b] (assistance = 1)	465	0.26		0.22	0.30
Land ownership status[b] (no outright owner = 1)	453	0.24		0.20	0.28
2013 maize yield (kg/acre)	416	63.77	153.16	49.01	78.53
Optimal date of planting[b] (optimal = 1)	465	0.37		0.33	0.41
Crop irrigated[b] (irrigated = 1)	465	0.03		0.01	0.04
Market variables					
Commercial crop[b] (commercial = 1)	463	0.35		0.30	0.39
Agricultural group[b] (member = 1)	465	0.31		0.27	0.35
Credit access[b] (access = 1)	465	0.05		0.03	0.07
2012 crop sales (GHS)	462	692.62	1085.38	593.39	791.85
Fertilizer transport cost (GHS)	465	2.35	4.48	1.94	2.76

b represents binary variables

4.1.1 The dependent variable

The dependent variable retained here is the quantity of chemical fertilizer applied by smallholder producer in kilogram per acre, because it is directly related to the decision of fertilizer use. Indeed, if this indicator is equal to 0, the participation decision is “no” (no use of fertilizers), but if it is greater or equal to 1, the participation decision will be “yes” (usage of fertilizer).

4.1.2 The independent variables

The independent variables are categorized in three main groups depending on how they are related to the smallholder producers: demographic, production and market variables.

4.1.2.1. Demographic variables

The gender is interesting especially in Ghana because there is a lot of focus on increasing female empowerment in Ghana. Gender is a binary variable with 0 representing females and 1 representing males.

As a second variable, the age is expected to affect the decision because older smallholder producers are believed to be more risk averse than youngers (Ayamga, 2006). Age is represented as a discrete variable.

Another discrete variable is the household size. The hypothesis is that the larger the household, the higher will be the family expenditure and so the family may reduce its farm expenditure (Akpan et al., 2012).

Two more binary variables are analyzed, the literacy and the educational background. They are two parameters characteristic of independency on decision making. Furthermore, those variables are part of the sociability abilities of smallholder producers (Martery et al., 2014). The education variable is equal to 0 for smallholder producers with educational background and it is equal to 1 for smallholder producers without educational background (basic, secondary or post-secondary level). The literate binary variable takes into account the people able to read and write in Arabic, in English or in any local language represented by 1 and the illiterates coded by 1.

4.1.2.2. Production variables

The ownership status is represented by a binary variable indicating the land owned by family (20%), by a commune (3%) or other (<1%) by the value 0 and the outright owner by 1. The first thought is that outright landowners are likely to adopt new technologies more quickly than tenants (Fosu-Mensah et al., 2012). However, based on the sample studied in northern Ghana, the land tenants are in a minority. It is interesting to evaluate the impact of the Ghanaian land tenure on the decision to use fertilizer because it differs to the basic land tenure such as outright landowner and land tenant.

The continuous variable 2013 maize yield represents the quantity of maize harvested in kilogram per acre during the 2013 cropping season. The yield is on average 64 kg/acre for the northern Ghana sample compared to the estimated 404 kg/acre in Ghana (FAO, 2015b). The yield is characteristic to the agricultural productivity and the hypothesis behind this variable is that the success in agricultural productivity will be an incentive to invest in chemical fertilizers.

Through agricultural aid programs smallholder producers have gradually had access to technology that contributes to agricultural mechanization. For instance, this binary variable codes as 0 smallholder producers preparing their land manually or with animals and as 1 smallholder producers using tractor services for the preparation of their land. The mechanization is expected to have a positive relationship with the fertilizer use, it will confirm the results found by Chapoto and Ragasa (2013) but more specifically in northern Ghana.

Created by agricultural programs such as the Agricultural Technology Transfer Project (ATT) developed by the Ghanaian government and by international organization, a technical assistance is available for some smallholder producers (26 %). This idea is to analyze the effect of this assistance on the use of fertilizer. Technical assistance is a binary variable where 0 is the smallholder producers member of a technical assistance organization and 1 the smallholder producers with no assistance.

Another decision that can affect the usage of chemical fertilizer is the choice of seeds. The APS reports four type of seeds used by smallholder producers in the sample, the hybrid seeds, the improved open pollinated varieties (OPV) seeds, the retained OPV seeds, and the traditional seeds. A binary variable regroups in 0 the hybrid and improved OPV seeds and in 1 the traditional and retained OPV seeds. Since the certified new seeds is a growth input as well as chemical fertilizers, the interaction of these two inputs can increase the agricultural productivity (Matsumoto and Yamano, 2010). Therefore hypothesis is based on a higher incentive to use fertilizer with the certified new seeds.

According to the crop calendar available on the FAO official website (Table 4), the optimal date of planting binary variable codes as 0 the smallholder producers' sowing dates as optimal if included in the FAO's date of planting and as 1 if non-optimal. The idea behind is to see if there is any link between the non-optimal date of planting and the use of fertilizer to reduce the risk of bad harvest. Irrigation is representing through a binary variable with 0 for the crop irrigated and 1 for none irrigation. According to the report made by the FAO (2005) the efficiency of fertilizer use is related to the water availability. Indeed, irrigation helps for a better absorption of the nutrients by the crop and a quicker penetration into the soil.

4.1.2.3.Market variables

The purpose of the main crop grown can be a reason to use a different technology. Indeed, if the crop is grown to be sold, one goal would be to increase the productivity by applying more chemical fertilizer. This is what Akpan et al. (2012) find in their study as a raw result from the

Table 4: Optimal Date of Planting for Maize, Rice and Soybeans in Northern Ghana

Agro-ecological area	Crop	Family	Date of planting	Crop cycle length	Date of harvesting
Ghanaian savannah	Maize	Poaceae	05/20 to 06/20	90-120 days	09/10 to 09/30
Ghanaian savannah	Rice	Poaceae	06/10 to 07/31	110-120 days	11/10 to 12/10
Ghanaian savannah	Soybeans	Fabaceae	06/01 to 07/20	120-215 days	10/01 to 11/20

Source: FAO, 2010

second tier of the double-hurdle estimation. In this thesis, the results will be more precise with the computation of the unconditional APE but the result of previous study is used as a hypothesis to be tested. The commercial purpose of the crop is a binary variable where 0 represents crops grown for a commercial purpose and 1 for the other purposes.

Smallholder producers involved in an agricultural group such as agricultural cooperatives have an easier access to information and so give more insights to adopt and to use advanced technology, such as fertilizer (Olwande and Mathenge, 2010). This variable is binary where 0 refers to members of agricultural groups and 1 to the non-members.

Households receiving a credit from a Non-Governmental Organization, a formal lender or a group based in micro finance or lending including Village Saving and Loans Associations are gathered by a binary variable. They are coded as 0 for households having access to credit and 1 for those who do not have access to credit. The loan from friends or family hasn’t been taken into account to identify the contribution of official institutions to smallholder producers. Those “official” loans are supposed to encourage smallholder producers to invest in fertilizer and to increase its intensity (Martey et al. 2014).

The 2012 crop sales represents the income received from all crops the year before the APS. It is representing as a continuous variable stated in Ghanaian cedi (GHS). The average income received from crop sales is 692 GHS in 2012. Compared with the annual average of household income, in the entire Ghana, from agriculture in 2008, income increased by more than 50 % just in Northern Ghana (Ghana Statistical Service, 2008). As a matter of fact, this observation show the real life quality improvement occurring in Ghana. For this variable, the expectation is an increase of fertilizer quantity used for smallholder producers with higher incomes.

In order to obtain information about the access to fertilizer, the continuous variable representing the price to pick up fertilizer to a selling point is a good indicator. Instead of having the distance for information, the transport cost to collect chemical fertilizer looks more representative of the difficulties that smallholder producers encounter in this operation. The hypothesis made is a decrease in fertilizer use if the distance (transport cost) increase (See Amanze and Eze, 2010; Zhou et al. 2010; Olayide et al., 2009; all cited in Martey et al., 2014).

This variables' description is here to understand the meaning of each variable and the reason of their choice. They have been selected from previous studies and the hypothesis are based on literatures review. The next section will provide more information about the differences between fertilizer users and non-user.

4.2. Variable analysis

Table 5: Variable Comparison Between Fertilizer Users and Non-users

Variable name	All smallholder producers	Fertilizer users: Nonusers	Fertilizer users: Users	
Number of household	465	137	328	
Demographic variables				
Gender[b] (%) (female = 1)	9.7	6.6	11	+
Education level[b] (%) (educated = 1)	11.6	7.3	13.5	
Age (year)	45	43.8	45.5	+
Household size (people)	10.7	10.5	10.7	+
Literacy[b] (%) (literate = 1)	8.6	5.1	10.1	+
Production variables				
Type of seed[b] (%) (certified new seeds = 1)	20.6	29.9	16.6	
Mechanization[b] (%) (no tractor use = 1)	43.9	42.3	44.6	+
Technical assistance[b] (%) (assistance = 1)	26	19.7	28.7	
Land ownership status[b] (%) (outright owner = 1)	24.1	28	22.4	+
2013 maize yield (kg/acre)	63.8	62.3	64.3	+
Optimal date of planting[b] (%) (optimal = 1)	37	40.1	35.7	+
Crop irrigated[b] (%) (irrigated = 1)	2.8	0.7	3.7	+
Market variables				
Commercial crop[b] (%) (commercial = 1)	34.8	35	34.7	+
Agricultural group[b] (%) (member = 1)	31.2	32.1	30.8	+
Credit access[b] (%) (access = 1)	4.7	5.1	4.6	+
2012 crop sales (GHS)	692.6	893	609	
Fertilizer transport cost (GHS)	2.3	0	3.3	

+ indicates that the means are not different at a 5 % significant level

b represents binary variables

4.2.1 Demographic factors and fertilizer use

Among smallholder producers without educational background, there is a significant difference between the percentage of smallholder producers using fertilizer and the percentage of non-users. So smallholder producers having received an education are significantly more involve in the fertilizer use.

4.2.2 Production factors and fertilizer use

Type of seed and technical assistance are two variables correlated with fertilizer use decisions. On average there are 13.3 % more of smallholder producers plowing certified new seeds from the non-users of fertilizer than from the users. Smallholder producers may have to do a choice of advance technologies to optimize productivity due to their budget constraint and so some smallholder producers decided to choose to buy seeds with better potential rather than chemical fertilizer. In addition, fertilizer users are getting in average 9 % more technical assistance than the non-users.

4.2.3 Market factors and fertilizer use

Smallholder producers using fertilizer are selling in average 284 kg per acre less farm output than the non-users. This result does not take into account the crop kept for self-consumption and this data would have been interesting to analyze in order to put things into perspective. Naturally, fertilizer users have to pay the cost of transportation that is not applied for the non-users.

Chapter 5 - Results

The model gave some raw results that have been analyzed after the computation of the Average Partial Effect for each variables. The Table 6 summarized the results obtained with the four variables having a significant impact on the decision of fertilizer use.

Table 6: Double Hurdle Estimates of Adoption and Fertilizer Use Intensity

	Tier 1		Tier 2		APEU	
	Coef.	**P-value**	**Coef.**	**P-value**	**Coef.**	**P-value**
Demographic variables						
Gender[b] (female =1)	-0.31	0.433	-241.44	0.110	23.16	0.083
Education level[b] (educated =1)	-0.19	0.653	242.39	0.316	-16.62	0.263
Age (year)	0.00	0.541	1.13	0.704	0.04	0.857
Household size (people)	0.01	0.588	-12.4	0.217	-0.85	0.172
Literacy[b] (literate =1)	-0.40	0.368	-178.73	0.449	19.36	0.343
Production variables						
Type of seed[b] (certified new seeds =1)	0.09	0.664	102.56	0.482	-9.30	0.394
Mechanization[b] (no tractor use =1)	0.09	0.685	-218.55	0.120	-16.14	0.100
Technical assistance[b] (assistance =1)	-0.18	0.417	-152.36	0.218	14.34	0.163
Land ownership status[b] (no outright owner =1)	-0.12	0.608	-379.97	0.036	-31.57	0.002
2013 maize yield (kg/acre)	0.00	0.706	0.68	0.007	0.06	0.109
Optimal date of planting[b] (optimal =1)	-0.07	0.743	69.27	0.550	-4.53	0.667
Crop irrigated[b] (irrigated =1)	-4.99	0.969	-215.25	0.319	80.48	0.002
Market variables						
Commercial crop[b] (commercial =1)	-0.14	0.482	-10.28	0.927	1.05	0.898
Agricultural group[b] (member =1)	0.04	0.833	47.14	0.676	-4.29	0.643
Credit access[b] (access =1)	-0.08	0.837	235.14	0.420	-17.52	0.236
2012 crop sales (GHS)	0.00	0.298	0.02	0.646	0.00	0.923
Fertilizer transport cost (GHS)	1.40	0.000	31.18	0.016	20.57	0.572

***** p<0.01, ** p<0.05 and * p<0.10**
b represents binary variables

5.1 Gender and fertilizer use

As discussed above, in the variable description part, females in Ghana have a dominating position in the society and especially in the decision making. The results confirm this trend, and show in addition that females are more likely to use fertilizer with an estimated 28 kg per acre more than males. This difference is interesting by highlighting the position of women in this society and their potential role in fertilizer adoption in Northern Ghana.

5.2 Land ownership status and fertilizer use

The land ownership is mainly separated in two main group, the households' outright owner of their land (76%) and the households cultivating a land owned by their family (20%) or the commune (3%). In this situation, the results from the analysis show that the outright owners use less fertilizer by 30 kg per acre than the family and communal ownership.

This is not a situation where the outright ownership is compared with the land renting (0.44%) and the discussion is not the same. Indeed, by growing crops on a land owned by family or a commune, smallholder producers may have more support for a close entourage and so there are more incentives for them to make the land profitable. Those incentives can be varied such as the financial support from family to buy fertilizers, the closest relation with communal services (better access to fertilizer subsidies) or the willingness to show to the owners the good action they made by making available this land to the smallholder producers.

5.3 Crop irrigated and fertilizer use

The few agricultural producers having recourse to irrigation seems to use much more fertilizer than the irrigation non-users. They are estimated to apply an additional 50 kg per acre of chemical fertilizer. This shows that investments made in development of an irrigation system, no matter how elementary it is, is directly related to the use of fertilizer in smallholder producer mind.

In fact, smallholder producers who provide extra water to their crop will take advantage of this input by adding fertilizer to enrich the soil by nutrients and making them quickly and efficiently available to plants. Although access to irrigation is a difficult task in view of the systems currently available in Northern Ghana, some smallholder producers are aware about the advantage of the combination irrigation and chemical fertilizer for a better yield.

After having identified the important leverages that have truly a significant effect on the smallholder producers decision of increasing or decreasing the fertilizer quantity applied, some recommendation are evoking, in the next part, based on those results.

Chapter 6 - Recommendations

Based on those new insights, this last part will gather different ideas or recommendations for further decision making in order to improve the current agricultural situation in Ghana. The majority of the poor people who are targeted by the Feed the Future initiative have low agricultural inputs, such as land and have low intensity use of modern agricultural technology, including fertilizer. Yet, there is evidence that use of modern fertilizer can significantly improve the performance of smallholder producers, if well used. The need for chemical fertilizers is more critical when the soils on which most of these smallholder producers are operating has poor inherent quality because of overuse, low organic matter, erosion, poor rainfall and other factors. To help smallholder producers to increase their agricultural productivity with the fertilizer use, here are some ideas or details on the current situation.

6.1 Irrigation system

The potential of irrigation system is not reached since FAO (2014) estimates only 1.6 % of the lands are irrigated compared to the potential irrigable lands. In fact, on the 4.6 million hectares of arable lands, Ghana has the capability to irrigate 1.9 million hectares. But in 2007 only 33,800 ha were irrigated (FAO, 2014; Namara et al., 2011). According to a study led by Namara et al. (2011), the different types of irrigation systems existing in Ghana with their potential and their constraints are summarized below.

6.1.1 Public systems

Twenty-two systems managed by public institutes offer, for a fixed fee, an access to irrigation water from rivers, lakes and reservoirs. This system is effective at 59% (8,745 ha) because of the difficulty to maintain the pumping system efficient. To solve this problem this service has been offered for free to industries in return of a maintenance of the irrigation system. One of the limits is the lack of quota that control the use of water by the companies. Indeed, some excessive quantities of water have been pumped since this collaboration semi-public, semi-private (Namara et al., 2011).

6.1.2 Small reservoirs

Basically, the small reservoir is a water storage system digs at the soil surface. Those are more common and are profitable for more than 50,000 households with 6,116 ha irrigated. This storage system encourages smallholder producers to form small groups, called Water User Associations (WUA), to share this water. This irrigation system is based on open channel irrigation methods that is a source of water waste (Namara et al., 2011).

6.1.3 River/lake lift systems

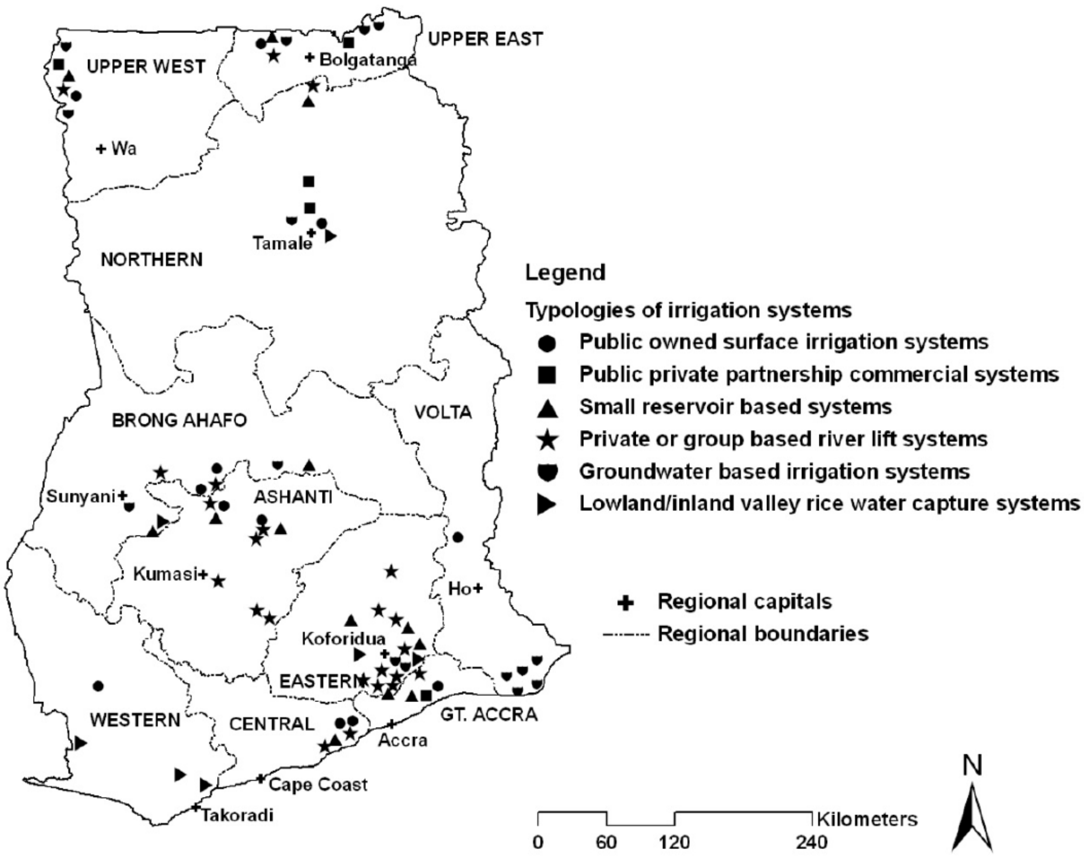
In this case, smallholder producers draw water essentially with pumps. Mainly two system coexist, the first one where smallholder producers purchase their own pump in neighboring countries (Togo pumps are half price) or they can rent it. The second one is a communal system, smallholder producers form a group and purchase their own pump. Those pumps are made accessible by NGO's and governmental programs via a financial support. The average size of land irrigated is in average less than 0.5 ha (Namara et al., 2011).

6.1.4 Groundwater irrigation

It is essentially based on a well system and is classified in seasonal or permanent system depending on the depth and on the structure of the well. The seasonal groundwater irrigation is basically a hole dug with common tools and smallholder producers are conscious that it will be flood during the rainy season. In the other hand, the permanent irrigation system is based on well deeper and sometimes consolidated with cement (Namara et al., 2011).

The irrigation systems are complex and diversified but can be more developed (Figure 7). However, its improvement is one of the priority of aids programs such as Feed the Future and is the key of a higher use of fertilizer. It seems important to keep in mind to use chemical fertilizers moderately in order to preserve the quality of the water sources which are most of the time the same for domestic and agricultural use. This aspect introduce the second point.

Figure 7: Distribution of Irrigation Systems in Ghana



Source: Namara et al., 2011

6.2 Summer training program

This initiative looks essential in this stage of Ghana's development. The farming training is the key to structure and to link the different technologies made accessible to smallholder producers by governments, private and public sectors. For instance, in the previous part (1.

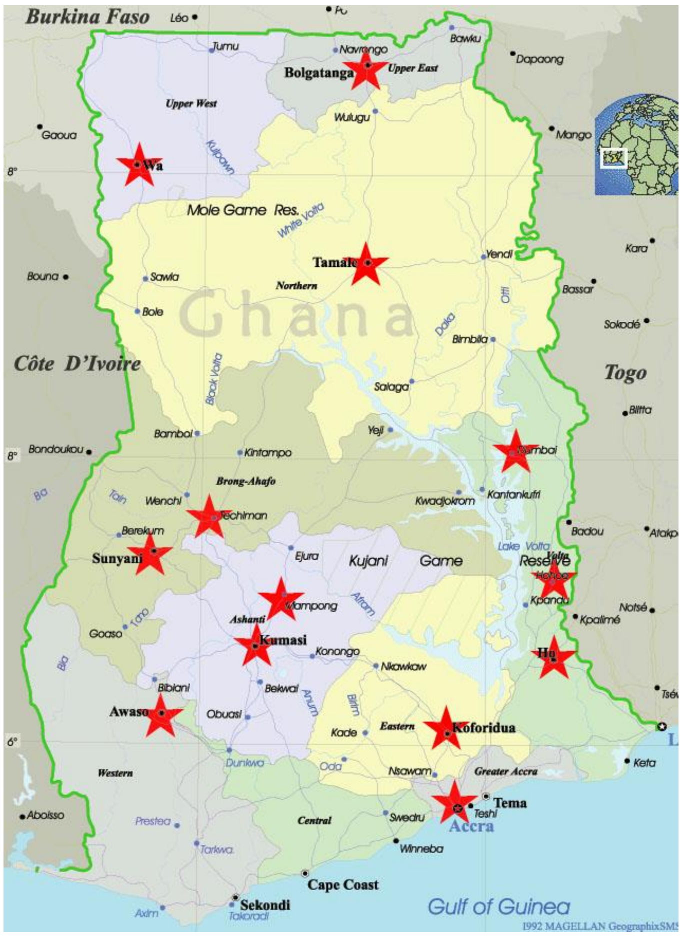
Irrigation system) smallholder producers could be aware of different technics to take advantage of the rainy season with better control of the flood to store water for the dry season. But this can be also a way to set a standard for applied fertilizer quantity in this region. Indeed, previously the dependent variable has been described and one of the remarks was the wide standard deviation showing an underuse for some smallholder producers but also an overuse for others. By training smallholder producers, they can have an idea of the standard quantity that should be applied while becoming more aware about the environmental impacts (especially for water pollution). Of course, specific agricultural practices can be taught in order to take fully advantage of the tractors (54% of users) combined with the technologies available such as, the different type of seeds, chemical fertilizers, irrigation systems, etc. Indeed, the use of tractor to prepare the land can be associated with a better application of chemical fertilizer. Also, with some training, smallholder producers can control more precisely the quantity applied. In addition, the tractor can be used to follow the principle of organic agriculture in order to build little by little a soil structured that keep nutrients and water as a source for crops.

Those learnings can be made by students of agricultural institutes from Ghana with the help of international known agronomists and agricultural specialists. It will be an opportunity for students to train Ghanaian smallholder producers for free and to get some experience monitored by famous specialists across the world. Furthermore, this initiative will give Ghana the possibility to acquire an agricultural independency by learning sustainable methods.

Concretely, the cities, located in the North and having universities where agricultural technics are taught, can be requested for offering a summer internship program to their students. The institutes that looks the most interesting to provide this training are the Bolgatanga and Tamale Polytechnic because of their location covering the upper and middle north (respectively in

Bolgatanga and Tamale, c.f. Figure 2). Since the University of Cape Coast is involved in the Feed the Future initiative, it can monitor and lead the summer internship program which can be offered for one month in late of May until beginning of June considering the 11th of June as the optimal maize planting date in Northern Ghana according to Koli (1970).

Figure 8: Map of Strategic Placement of Fertilizer Selling Concentration in Ghana



Source: Photobucket.com, 2015

This training mission has to be proceeded by the creation of some advice centers where smallholder producers can have feedback about the way the produce. Without any references, producers cannot improve their agricultural practices. And that is why some centers can be created close to Balgatanga, Tamale, Wa and Yendi (to cover the north) where young people (early graduated) can provide advises to local smallholder producers.

The chemical fertilizers should be seen as a way to boost the agriculture of Ghana in short term but this is also a way to get important funds (from chemical fertilizer industrial companies and United Nation's members) that can be used to make overlapped projects with sustainable agriculture.

6.3 More importance in agricultural groups

Again, based on the summary statistics, smallholder producers involved in an agricultural groups are numerous, 30% of them are working in interaction with other smallholder producers. This trend is interesting because by forming a group, agricultural smallholder producers increase their purchasing power but also their bargaining power, too. Moreover, this is a way to pool some expensive goods or services such as sharing a tractor, chemical fertilizer quantity, seeds, work force, irrigation system, etc. Furthermore, those groups are also sharing information more efficiently by discussing within a group. Therefore, by encouraging the formation of these kinds of groups with an incentive such as higher fertilizer, seed or agricultural tool subsidies, it can reinforce the smallholder producer's power. Also, it can make more accessible advanced technologies. Moreover, trainings can be easier to execute if it is directly addressed to a group of smallholder producers. By helping those groups with subsidies while encouraging smallholder producers to join them, the number of agricultural groups will increase and they will become more susceptible to buy new technologies (chemical fertilizers). It will enable a better communication through advertisement, for example to promote agricultural innovation or products. In fact, the development of smallholder producer's group is a way to reduce the number of representatives. Subsidies can be negotiated by the Ghanaian government with private firms. For a better implementation of this proposition, a survey is necessary to be conducted among the agricultural group to understand their incentives and meet as much as possible their expectations.

6.4 Fertilizer promotion

According to the results, maize growers, females are using more chemical fertilizers than the others. As a consequence, those producers might be a good target to promote fertilizer by giving more accurate information about the difference between the fertilizers. In addition, sellers, having been trained, will offer the best fitted choice to them. The communication campaign is not negligible. And the radio can be a very good way to share information. For instance, in Ghana, a radio station called Farm Radio International (FRI) is specialized on sharing agricultural information and reaches more than 70 % of the smallholder producers (World Food Programme, 2014). This radio could contribute to the expansion of fertilizer access and use by targeting, with a communication campaign, the women maize growers.

Chapter 7 - Conclusion

Optimal fertilizer use is a key aspect for increasing agricultural productivity in northern Ghana, and it will have an impact on addressing the poverty and food insecurity issues for many smallholder producers. This study sought to identify the factors that affect smallholder producer's decision to use fertilizer. These factors and how they influence a producer's decisions to use fertilizer were used to design strategies that increase the adoption of fertilizer use by smallholder producers in northern Ghana. The summary statistics and the result of the average partial effect of the relevant variables provided insight into a smallholder producer's behavior, customs and agricultural management. The unconditional APE underscored the variables that have a significant impact on influencing the amount of fertilizer that a smallholder producer decides to use. The results indicated that female producers and those producers who irrigate their fields were likely to use more fertilizers than other producers. Producers who owned their land were more likely to use less fertilizer than producers who shared the land with family or community members. These results were used to develop some recommendations to increase accessibility of fertilizer and educational programs to promote sustainable practices.

References

Africafertilizer.com, 2013. “To feed our people we must first feed our soil.”-Olusegun Obasanjo.http://www.fao.org/fileadmin/templates/ess/pdf/AfricaFertilizer.org_brochure__En__2012_.pdf [accessed November 30, 2014], 4 p.

African Union, 2006. Abuja Declaration on Fertilizer for an African Green Revolution. 13 June 2006, African Fertilizer Summit, Nigeria.

AGRA, 2014. Our history. http://agra-alliance.org/who-we-are/our-story/ [accessed November 30, 2014]

Agricinghana, 2013. Ghana Agri-input Dealers’ GIS Database. http://agricinghana.com/2013/08/09/ghana-agri-input-dealers-gis-database/ [accessed July 30, 2015]

Akpan S.B., Nkanta V.S. and Essien U.A., 2012. A double-hurdle model of fertilizer adoption and optimum use among farmers in southern Nigeria. Tropicultura, 30 (4), pp. 249-253.

Amanor-Boadu V., Zereyesus Y., and Asiedu-Dartey J., 2013. A district level analysis of the prevalence of poverty in northern Ghana. METSS-Ghana Research and Issue Paper Series, No. 01-2013, http://www.metss-ghana.k-state.edu/research-briefs/Poverty-Analysis-by-Districts-Final-3-11-2014.pdf [accessed July 30, 2015]

Angelucci F., 2012. Analysis of incentives and disincentives for maize in Ghana. Technical notes series, MAFAP, FAO, Italie: Rome, 41 p.

Ayamga M., 2006. Factors influencing the decision to participate in Microcredit Programmes: An illustration for Northern Ghana. Ghana Journal of Development Studies, 3 (2), pp. 57-65.

Braimoh A.K., Vlek P.L.G., 2006. Soil quality and other factors influencing maize yield in northern Ghana. Soil Use and Management, Vol. 22, pp. 165-171.

Burke W.J., 2009. Estimating and interpreting Cragg’s Tobit Alternative using Stata. https://www.msu.edu/~burkewi2/craggit_support.html [accessed July 5, 2015], Michigan State University.

Chapoto A. and Ragasa C., 2013. Moving in the right direction? Maize productivity and fertilizer use intensity in Ghana. International Food Policy Research Institute, Washington DC, 34 p.

C.I.A. (Central Intelligence Agency), 2014. The World Factbook. https://www.cia.gov/library/publications/the-world-factbook/geos/gh.html [accessed April 26, 2015]

Collier P. and Dercon S., 2014. African Agriculture in 50 Years: Smallholders in a Rapidly Changing World? World Development, Vol. 63, pp. 92-101

Cragg J.G., 1971. Some statistical models for limited dependent variables with application to the demand for durable goods. Econometrica, Vol. 39, No. 5, pp. 829-844.

Crawford E.W., Jayne T.S. and Kelly V.A., 2006. Alternative Approaches for Promoting Fertilizer Use in Africa. The International Bank for Reconstruction and Development / The World Bank, US: Washington DC, 69 p.

Drafor I., Filson G. and Goddard E.W., 2000. Cereal producers and the structural adjustment programme (SAP) in Ghana: a welfare analysis of the first decade of SAP. Development Southern Africa, Vol. 17, No 4, pp. 489-499.

FAO, 2005. Fertilizer use by crop in Ghana. ftp://ftp.fao.org/docrep/fao/008/a0013e/a0013e00.pdf [accessed November 29, 2014]

FAO, 2010. Crop calendar – An information tool for seed security. http://www.fao.org/agriculture/seed/cropcalendar/searchbycountry.do [accessed July 10, 2015]

FAO, 2014. Ghana: irrigation market brief. Food and Agricultural Organization of the United Nations, Italy: Rome.

FAO, 2015a. Country fact sheet on food and agriculture policy trends – Ghana. Food and Agricultural Organization of the United Nations, Italy: Rome.

FAO, 2015b. III Production. http://www.fao.org/docrep/w2698e/w2698e03.htm [accessed August 11, 2015]

Feed the Future, 2015a. About. http://www.feedthefuture.gov/about [accessed April 10, 2015]

Feed the Future, 2015b. Approach. http://www.feedthefuture.gov/approach/Inclusive--Agriculture--Sector--Growth [accessed April 10, 2015]

Fosu-Mensah et al., 2012. Farmers' perception and adaptation to climate change: a case study of Sekyedumase district in Ghana. Environment, Development and Sustainability, Vol. 14, pp. 495-505

Fuentes P., Bumb B. and Johnson M., 2012. Improving Fertilizer Markets in West Africa: The Fertilizer Supply Chain in Ghana. International Fertilizer Development Center (IFDC) and IFPRI, AL: Muscle Shoals.

Ghana Statistical Service, 2008. Ghana living standards survey report of the fifth round (GLSS 5). Ed. Appiah R., Ghana, p. 108.

Ghana Statistical Service, 2012. 2010 Population & Housing Census: Summary Report of Final Results. Statistical Service, Ghana: Accra, p. 16.

Ghanaweb.com, 2014. Gov't defaults in paying for subsidized fertilizers. http://www.ghanaweb.com/GhanaHomePage/business/Gov-t-defaults-in-paying-for-subsidized-fertilizers-314240 [accessed July 28, 2015]

Government of Ghana, 2015. The launch of the Agric Fertilizer Subsidy Programme and the way forward. http://ghana.gov.gh/index.php/media-center/features/1153-the-launch-of-the-agric-fertilizer-subsidy-programme-and-the-way-forward [accessed July 23, 2015]

Henao J. and Baanante C., 2006. Agricultural Production and Soil Nutrient Mining in Africa – Implication for Resource Conservation and Policy Development. An International Center for Soil Fertility and Agricultural Development, AL: Muscle Shoals.

Humphreys B.R., Lee Y.S., Soebbing B.P., 2009. Consumer Behavior in Lotto Markets: The Double Hurdle Approach and Zeros in Gambling Survey Data. University of Alberta, Canada: Edmonton AB, 14 p.

IMF, 2014. World Economic Outlook Database, October 2014. http://www.imf.org/external/pubs/ft/weo/2014/02/weodata/weorept.aspx?pr.x=28&pr.y=12&sy=2014&ey=2014&scsm=1&ssd=1&sort=country&ds=.&br=1&c=614%2C668%2C638%2C674%2C616%2C676%2C748%2C678%2C618%2C684%2C624%2C688%2C622%2C728%2C626%2C692%2C628%2C694%2C632%2C714%2C636%2C716%2C634%2C722%2C662%2C718%2C642%2C724%2C643%2C199%2C644%2C733%2C646%2C734%2C648%2C738%2C652%2C742%2C656%2C746%2C654%2C754%2C664%2C698%2C666&s=PPPPC%2CLP&grp=0&a= [accessed April 8, 2015]

Koli S.E., 1970. The optimum planting date for maize in Ghana. Ghana Journal Agricultural Science, vol. 3, pp. 73-81.

Krausova M. and Banful A.B., 2009. Overview of the agricultural input dealer sector in Ghana. International Food Policy Research Institute, draft, US: Washington DC, 30 p.

Larson D.F., Otsuka K., Matsumoto T. and Kilic T., 2013. Should African rural development strategies depend on smallholder farms? An exploration of the inverse-productivity hypothesis. Agricultural Economics, Vol. 45, pp. 355-367.

Liverpool-Tasie L.S.O., 2014. Fertilizer subsidies and private market participation: the case of Knao State, Nigeria. Agricultural Economics, Vol. 45, pp. 663-678.

Martey E., Nimo Wiredu A., Etwire P.M., Fosu M., Buah S.S.J., Bidzakin J., Ahiabor B.D.K. and Kusi F., 2014. Fertilizer adoption and use intensity among smallholder farmers in Northern Ghana: a case study of the AGRA Soil Health Project. Sustainable Agriculture Research, vol. 3, No. 1, pp. 24-36.

Mason N.M. and Jayne T.S., 2012. Fertilizer subsidies and smallholder commercial fertilizer purchases: crowding out, leakage, and policy implication for Zambia. Working paper 70, Indaba Agricultural Policy Research Institute (IAPRI), Zambia: Lusaka.

Matsumoto T. and Yamano T., 2010.Soil Fertility, Fertilizer, and the Maize Green Revolution in East Africa. Policy Research Working Paper 5158, The World Bank, US: Washington DC.

Minot N. and Benson T., 2009. Fertilizer subsidies in Africa: Are Vouchers the Answer? International Food Policy Research Institute, US: Washington DC, 8 p.

MOFA (Ministry of Food and Agriculture Republic of Ghana), 2011. Fertilizer subsidy programme discussed. http://mofa.gov.gh/site/?p=7068 [accessed November 29, 2014]

MOFA (Ministry of Food and Agriculture Republic of Ghana), 2015. Savannah Accelerated Development Authority (SADA). http://mofa.gov.gh/site/?page_id=282 [accessed July 6, 2015].

Namara R.E., Horowitz L., Nyamadi B. and Barry B., 2011. Irrigation Development in Ghana: Past experiences , emerging opportunities, and future directions. Ghana Strategy Support Program, GSSP Working paper No. 0027, International Food Policy Research Institute, Ghana: Accra.

Olwande J. and Mathenge M., 2010. Market Participation among the Poor Rural Households in Kenya. Tegemeo Institute, Egerton University, Kenya.

Okudzeto E., Mariki W.A., De Paepe G., Sedegah K., 2014. Ghana 2014. http://www.africaneconomicoutlook.org/fileadmin/uploads/aeo/2014/PDF/CN_Long_EN/Ghana_ENG.pdf [accessed April 9, 2015], 14 p.

Photobucket.com, 2015. http://s116.photobucket.com/user/voodoofunk/media/mapL.jpg.html [accessed July 20, 2015]

The World Bank, 2015. Fertilizer consumption (kilograms per hectare of arable land). http://data.worldbank.org/indicator/AG.CON.FERT.ZS [accessed April 12, 2015]

Time For Kids, 2015. http://www.timeforkids.com/destination/ghana/sightseeing [accessed April 8, 2015]

United Nations, 2013. MDG report 2013. Economic Commission for Africa, NY: New-York City, 25 p.

USAID|Ghana, 2012a. RFP USAID/Ghana SOL-641-12-000005. September 2012.

USAID|Ghana, 2012b. FTF Ghana Population-Based Survey in Northern Ghana: Baseline Protocol.https://www.usaid.gov/sites/default/files/documents/1867/FTF%20Ghana%20Population%20Based%20Survey%20Protocol.pdf [accessed August 14, 2015]

Vanlauwe B., Wendt J. Giller K.E., Corbeels M., Gerard B. And Nolte C., 2014. A fourth principle is required to define Conservation Agriculture in Sub-Saharan Africa: The appropriate use of fertilizer to enhance crop productivity. Field Crop Research, Vol. 155, pp. 10-13.

Vigneri M. and Santos P., 2007. Ghana and the cocoa marketing dilemma: what has liberalization without price competition achieved? ODI project briefing, No. 3, England: London.

Wanzala M., 2015. The Fertilizer Support Programme. http://www.nepad.org/foodsecurity/fertilizer-support-programme/about [accessed August 13, 2015]

World Food Programme, 2014. How radio programmes can support agriculture and market development. http://www.wfp.org/purchase-progress/news/blog/how-radio-programmes-can-support-agriculture-and-market-development [accessed July 20, 2015]

Zereyesus Y.A., Ross K.L., Amanor-Boadu V., Dalton T.J., 2014. Baseline Feed the Future Indicators for Northern Ghana 2012. Kansas State University, US: Kansas, Manhattan, p. 73

Appendix A - Double-Hurdle Result

Log likelihood = -1483.4548

Number of obs = 359
Wald chi2(17) = 35.42
Prob > chi2 = 0.0055

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Tier1						
gender	.3147014	.4332345	0.73	0.468	-.5344225	1.163825
commercial	.1432678	.2038489	0.70	0.482	-.2562687	.5428042
groupmbs	-.0440335	.208216	-0.21	0.833	-.4521294	.3640625
credit_access	.0810869	.3938657	0.21	0.837	-.6908756	.8530495
landown	-.1200083	.2338994	-0.51	0.608	-.5784427	.3384262
educ	.1953865	.4343919	0.45	0.653	-.656006	1.046779
seedT	-.0925775	.2133218	-0.43	0.664	-.5106806	.3255255
mechlandprepa	.0864512	.2128256	0.41	0.685	-.3306792	.5035816
techassist	.1776335	.2190495	0.81	0.417	-.2516957	.6069627
cropsales2012	-.0001021	.000098	-1.04	0.298	-.0002942	.0000901
literate	.4041588	.4490955	0.90	0.368	-.4760522	1.28437
ageresp	-.0034836	.0057021	-0.61	0.541	-.0146596	.0076923
hhsize	.0103591	.0191106	0.54	0.588	-.027097	.0478152
fert_transportq	1.396531	.2632923	5.30	0.000	.8804871	1.912574
maizeyield	.0005803	.0015386	0.38	0.706	-.0024353	.0035959
oDOP	.0729495	.2227237	0.33	0.743	-.363581	.5094799
irrigation	4.895988	103.2	0.05	0.962	-197.3722	207.1642
_cons	-.1868329	.437217	-0.43	0.669	-1.043763	.6700967
Tier2						
gender	241.2291	150.8153	1.60	0.110	-54.3635	536.8216
commercial	-10.25306	111.7647	-0.09	0.927	-229.3079	208.8018
groupmbs	-47.05313	112.5714	-0.42	0.676	-267.689	173.5828
credit_access	-234.867	291.0877	-0.81	0.420	-805.3883	335.6543
landown	-379.5568	180.227	-2.11	0.035	-732.7952	-26.31838
educ	-242.1727	241.1215	-1.00	0.315	-714.7621	230.4167
seedT	-102.4278	145.5363	-0.70	0.482	-387.6737	182.8181
mechlandprepa	-218.2898	140.2162	-1.56	0.120	-493.1085	56.52892
techassist	152.1816	123.3523	1.23	0.217	-89.58447	393.9478
cropsales2012	.024493	.0533234	0.46	0.646	-.0800189	.1290049
literate	178.5603	235.6661	0.76	0.449	-283.3368	640.4574
ageresp	1.13129	2.979729	0.38	0.704	-4.708872	6.971452
hhsize	-12.39078	10.01858	-1.24	0.216	-32.02684	7.245279
fert_transportq	31.14725	12.84992	2.42	0.015	5.961858	56.33263
maizeyield	.6786263	.2520451	2.69	0.007	.184627	1.172626
oDOP	-69.20259	115.6212	-0.60	0.549	-295.8159	157.4107
irrigation	215.0515	215.6913	1.00	0.319	-207.6956	637.7986
_cons	-292.2017	281.3403	-1.04	0.299	-843.6185	259.2151
sigma						
_cons	236.8767	56.78216	4.17	0.000	125.5858	348.1677

Appendix B - Africa's Millennium Development Goal performance at a glance, 2013

Goal	Status	Best performing countries, selected targets and indicators
Goal 1: Eradicate extreme poverty and hunger	Off-track	Target 1A: Egypt, Gabon, Guinea, Morocco, Tunisia
		Target 1A: Burkina Faso, Ethiopia, Togo, Zimbabwe
		Target 1C: Algeria, Benin, Egypt, Ghana, Guinea Bissau, Mali, South Africa, Tunisia
Goal 2: Achieve universal primary education	On-track	Indicator 2.1: Algeria, Egypt, Rwanda, Sao Tome and Principe
		Indicator 2.2: Ghana, Morocco, Tanzania, Zambia
Goal 3: Promote gender equality and empower women	On-track	Indicator 3.1: The Gambia, Ghana, Mauritius, Rwanda, Sao Tome and Principe
		Indicator 3.2: Botswana, Ethiopia, South Africa
		Indicator 3.3: Angola, Mozambique, Rwanda, Seychelles, South Africa
Goal 4: Reduce child mortality	Off-track	Indicators 4.1 and 4.2: Egypt, Liberia, Libya, Malawi, Rwanda, Seychelles, Tunisia
Goal 5: Improve maternal health	Off-track	Target 5A: Equatorial Guinea, Egypt, Eritrea, Libya, Mauritius, Rwanda, Sao Tome and Principe, Tunisia
		Target 5B: Egypt, Ghana, Guinea Bissau, Rwanda, South Africa, Swaziland
Goal 6: Combat HIV/AIDS, TB, malaria and other diseases	On-track	Target 6A: Ivory Coast, Namibia, South Africa, Zimbabwe
		Target 6B: Botswana, Comoros, Namibia, Rwanda
		Target 6C: Algeria, Cape Verde, Egypt, Libya, Mauritius, Sao Tome and Principe, Sudan, Tunisia
Goal 7: Ensure environmental sustainability	Off-track	Target 7A: Egypt, Gabon, Morocco, Nigeria
		Target 7C: Algeria, Botswana, Burkina Faso, Comoros, Egypt, Ethiopia, Libya, Mali, Mauritius, Namibia, Swaziland
Goal 8: Global partnership for development	Off-track	Target 8F: Kenya, Libya, Rwanda, Seychelles, Sudan, Uganda, Zambia

Source: United Nation, 2013