

**AN ECONOMIC ANALYSIS OF INORGANIC FERTILISER USE BY MAIZE
FARMERS IN GUINEA SAVANNAH AND TRANSITIONAL ZONES OF GHANA**

BY

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**THIS THESIS IS SUBMITTED TO THE UNIVERSITY OF GHANA, LEGON
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DECLARATION

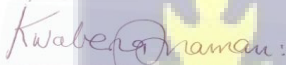
I, Fred Opoku Mensah Gyasi, do hereby declare that except for the references cited, which have been duly acknowledged, this work, "An Economic Analysis of Inorganic Fertilizer Use by Maize Farmers in Guinea Savannah and Transitional Zones of Ghana", is the result of my own research. It has never been presented either in whole or in part for any other degree of this University or elsewhere.

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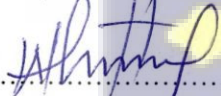
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DEDICATION

I am able to complete this thesis successfully through the abundant grace and favour of God.

I dedicate this work to my lovely wife; Mrs. Diamond Martinson Gyasi for her support and understanding throughout my studies. I also dedicate this work to all my family and friends whose selfless love and sacrifices have made me who I am today.



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ABSTRACT

Fertiliser plays a vital role in maize farming due to the decline in soil fertility, but its main role of improving livelihoods lacks empirical evidence beyond its positive effects on yields. The objective of this study was to determine the effect of inorganic fertiliser use on the commercialisation and profitability of maize farmers in the Guinea Savannah and Transitional zones of Ghana. This study examined the factors that affect the use of inorganic fertiliser among smallholder maize farmers, the effect of inorganic fertiliser use on maize productivity, estimated the effect of inorganic fertiliser use on farm commercialisation and the effect of inorganic fertiliser use on profitability of maize production. The study was conducted in 16 districts from eight regions in Ghana's Guinea Savannah and Transitional zones. Data was collected from 448 randomly selected respondent's in-situ using kobo collect toolbox. The study employed a double hurdle model to identify factors that determine use and intensity of inorganic fertiliser, a linear regression was used to examine the effects of inorganic fertiliser use on maize productivity, a Tobit model was used to estimate the effect of inorganic fertiliser use on the Household Commercialisation Index and the inorganic fertiliser use on profitability was estimated using the Value Cost Ratio. The probability of farmers' decision to jointly use inorganic fertiliser and intensity of inorganic application is high among farmers in the Guinea Savannah zone. The basal application of fertiliser integrated with improved seeds enhances maize productivity. The use of inorganic fertilisers raises farmers' levels of commercialisation which suggests that using inorganic fertiliser can be an important step in raising maize yield over the level needed for subsistence. The level of profitability among inorganic fertiliser users is low. Maize commercialisation and production credit increase maize profitability. The study recommends that, to improve maize profitability from inorganic fertiliser use, farmers must produce beyond the subsistence level to a more commercialised level.

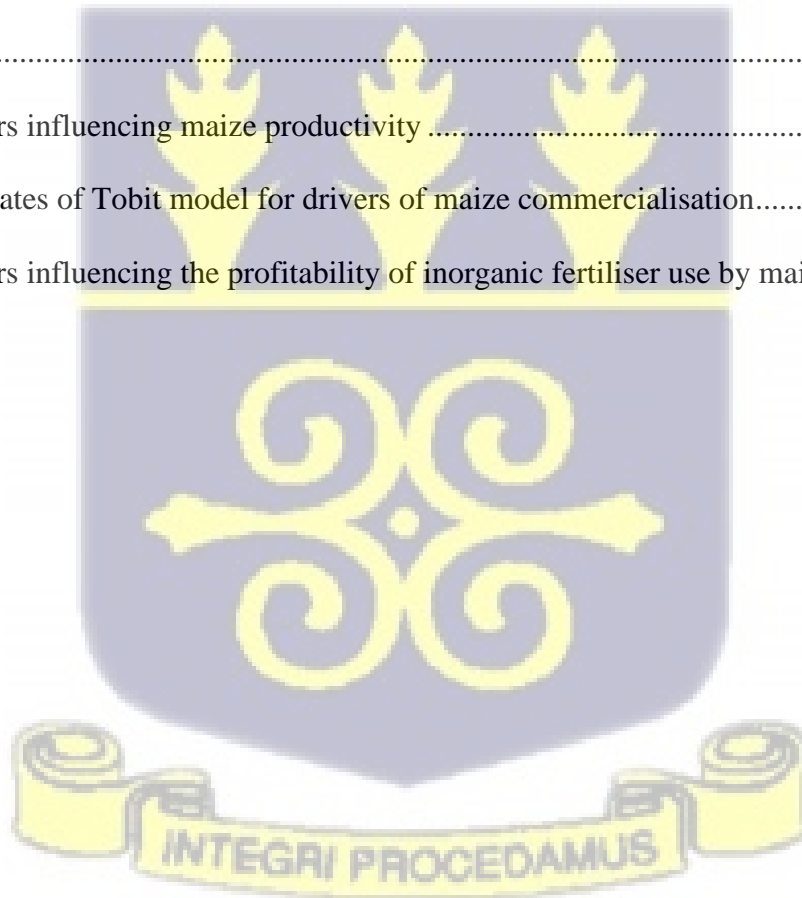
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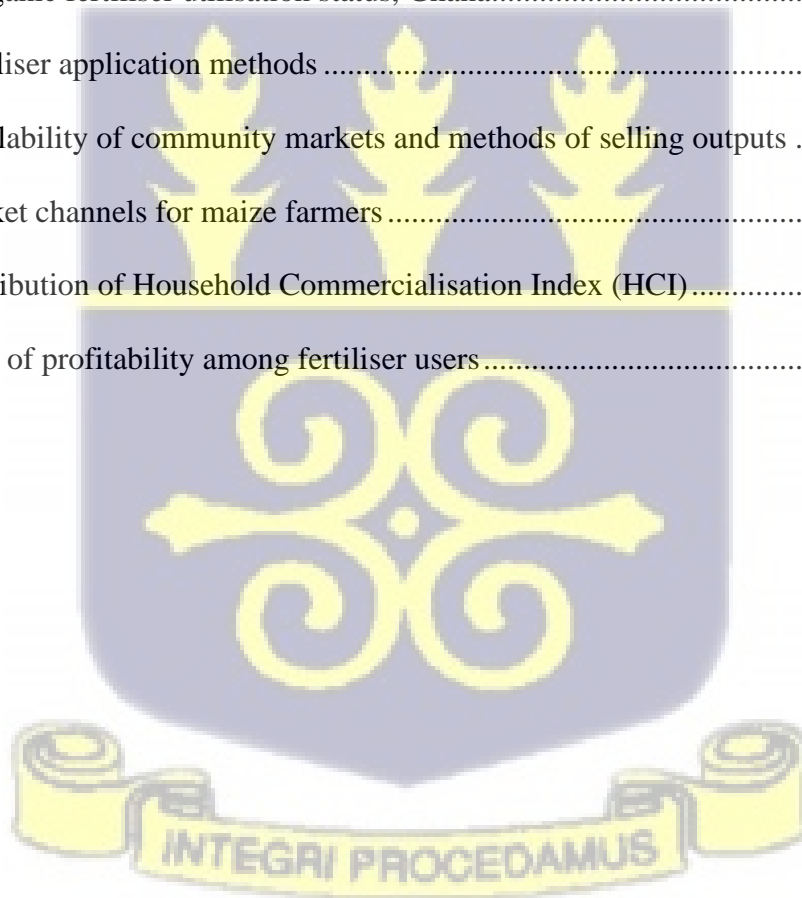
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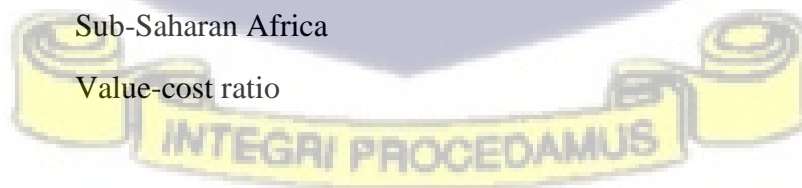
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LIST OF ACRONYMS

AVCR	Average Value-Cost Ratio
FAO	Food and Agriculture Organization of the United Nations
FBO	Farmer-Based Organisations
FERARI	Fertilizer Research and Responsible Implementation
FSP	Fertiliser Subsidy Program
GOG	Government of Ghana
GDP	Gross Domestic Product
GSS	Ghana Statistical Service
HCI	Household Commercialisation Index
IFAD	International Fund for Agricultural Development
IFDC	International Fertilizer Development Center
IFPRI	International Food Policy Research Institute
LDC	Louis Dreyfus Company Ghana
MiDA	Millennium Development Authority
MoFA	Ministry of Food and Agriculture
MVCR	Marginal Value-Cost Ratio
OLS	Ordinary Least Squares
PFJ	Planting for Food and Jobs
RCT	Rational Choice Theory
SDGs	Sustainable Development Goals
SIDA	Swedish International Development Association
SSA	Sub-Saharan Africa
VCR	Value-cost ratio



CHAPTER ONE

INTRODUCTION

1.0 Background to the Study

The Sustainable Development Goals (SDGs) one and two strive to respectively eliminate poverty and hunger by 2030 (United Nations, 2015). A key to achieving these SDGs in many African countries is agricultural development. As such, governments across Sub-Saharan Africa (SSA) have introduced technologies including high yielding seeds, quality fertilisers, irrigation systems and other agricultural subsidies in bid to improving yield and farm incomes. The equation for determining global food security heavily depends on smallholder farmers in developing countries. According to Fan and Rue (2020), more than 80% (475 million) among all farms worldwide are situated on less than two hectares of land. These farms generate nearly 80% of the food produced in SSA despite making up only 12% of global agriculture (Lowder, Skoet & Singh, 2014). Notwithstanding their critical role, these smallholder farmers prioritize subsistence production, with the goal of meeting domestic and household food needs first and then selling only if there is a surplus. Subsistence farms are usually characterized by low cultivated area, low technology adoption and access to market difficulties (Dodd et al., 2020).

Ghana's economy continues to be significantly reliant on agriculture, with an average annual growth rate of approximately 6% from 2017 to 2022 and contributing to about 21% of the nation's Gross Domestic Product (GDP) (Ghana Statistical Service, 2023). Its role in ensuring food security, provision of industrial raw materials, source of income and employment for many people is very important (Nyamekye, Tian & Cheng, 2021). Based on information derived from the 2021 National Census conducted by the Ghana Statistical Service, agriculture employed approximately 33% of the workforce in 2021. Despite its significance, Ghana's agricultural sector is marked by

low productivity, small-scale farms, underdeveloped huge tracts of land that are perfect for agricultural growth, poor soil conditions and expensive fertiliser, as well as inadequate infrastructure (Iddrisu et al., 2021). The majority of smallholder farmers have experienced increased poverty as a result. According to the International Food Policy Research Institute (IFPRI), changes in environmental conditions caused by high population growth rates are one of the key causes of low productivity. Ghana's high population expansion in rural and urban areas has raised demand for food and energy (Kousar et al., 2021). According to van Loon et al. (2019), to meet food demand in the near future, agricultural productivity in the country must double by 2050. Rapid population growth has also boosted demand for cultivable land, resulting in forest destruction (Acheampong et al., 2019). This has a negative impact on the environment's sustainability by exposing farmland to erosion and rendering agricultural production subject to weather changes, as well as loss in soil fertility that is difficult to repair. Soil fertility decline is linked to insufficient recycling of soil nutrients, which leads to steady loss of soil organic matter (Scotti et al., 2015). This reduces agricultural output and, as a result, raises poverty levels.

Ghana's agricultural policies and agricultural transformation agenda over the years indicate a goal to transition from subsistence to market-oriented agriculture. Agricultural Mechanization Services Enterprises Centers, the Fertiliser Subsidy Program (FSP), and the Block Farms Program are notable interventions that have been implemented since the late 2000s (Benin et al. 2013). Many of these initiatives have already been incorporated into the current government's flagship Planting for Food and Jobs (PFJ) initiative, which was launched in 2017. All these interventions notwithstanding, there is still a persistent yield gap for many crops including maize. The low soil fertility status that emerges from continuous cropping without replacing the nutrients lost in harvested food is a major cause of the significant output disparities (Kongor et al., 2019; Sanchez,

2002). Large yield gaps and the quick rise in global demand for nutritious foods offer opportunities to increase agricultural output on a local and international scale. Yet agricultural productivity remains stagnant in most countries in Africa. This is because smallholder farmers have been reluctant to invest in their small farms due to the meagre returns in food and farm income they can generate (Franke et al., 2014; Ritzema et al., 2017).

The continued depletion of soil fertility and the need to improve yields have led to the promotion of fertilisers for crop production. The PFJ initiative provides improved seeds and fertiliser to farmers at subsidised prices (MoFA, 2017). Fertiliser is an important basic input in agricultural development and a major factor in efforts to increase agricultural productivity for food and nutrition security. Even though the fertilisers are mostly subsidised, its use especially at recommended levels remain a challenge. Farmers make production decisions based on the prevailing conditions, such as resource availability, production environment and socio-cultural customs (Adzawla et al., 2021). The motivation of smallholder farmers to use the right quantity of fertiliser is therefore hinged on the profitability of fertiliser use.

Smallholder agricultural commercialisation can be broadly defined as the degree to which smallholder farmers and markets are linked at any particular time. Different definitions of agricultural commercialisation have been proposed by researchers. Some believe that commercialisation entails raising production above the point of subsistence, which results in the selling of marketable surplus (Goletti et al., 2003). Others characterize agricultural commercialisation as the propensity for farmers to sell a greater proportion of their products (Pradhan et al., 2010). Smallholder farmers' commercialisation of production systems, according to Seyoum, Lemma, and Karippai (2011), is the process by which a household's production purpose shifts from subsistence to profit maximization, as well as a production system in which

households generate market-oriented items based on consumer preferences. As a result, smallholder commercialisation refers to a process whereby smallholder farmers intentionally employ their land, labour, tools, and inputs in order to maximize profit from the crops they produce or the animals they raise for trade or sale (Ejupu, 2001). This is because, in the age of globalization, smallholder farmers must produce for the market since they compete with farmers in their vicinity as well as those producing the same commodity at the regional and global levels (Berhanu et al., 2006).

It is essential to remember that commercialisation may have an impact on production or supply markets by buying, selling, or a combination of the two. Smallholder commercialisation may also be viewed as a dynamic process, depending on how quickly household-level changes in the ratio of inputs and outputs over time. One of the motivating tools culminating into one of the focuses of the PFJ offers auxiliary services such as extension services and output marketing (MoFA, 2017). Commercialisation is thus critical for increasing farm profitability and farmers' overall livelihood. According to Gebreselassie and Sharp (2007), the goal of becoming commercialised is to generate improved welfare outcomes for smallholders by transitioning from subsistence to market-oriented farming. However, engaging in commercialisation would require smallholder farmers to have a significant surplus for sale, which can be increased by using inorganic fertiliser to replenish lost nutrients.

1.1 Problem Statement

Agricultural development and transformation are crucial for the socioeconomic development of Ghana, especially the rural areas. Despite the modern technology and adoption of different maize varieties, the productivity of smallholder farmers remains low. According to Rabbi et al. (2019),

many factors contribute to the low productivity and decline in agriculture. Largely, this includes lack of credit provision, slow adoption rate of farming techniques, limited quantities of inputs, lack of infrastructural facilities, trade and marketing restrictions and lack of agriculture finance. These challenges are continually being worsened by the depletion of arable soils.

A major step to restore nutrient for crops is to apply fertilisers. But this increases the cost of crop production for the already under-resourced poor farmers. Beyond the cost, the use of inorganic fertilisers is expected to generate higher revenue through higher outputs. Hence, the issue is neither about the cost of the inorganic fertiliser inputs to the total cost, nor revenue, but the profitability of the farms. Both supply-side and demand-side issues might be held responsible for the low inorganic fertiliser use in Africa (Druilhe & Barreiro-Hurlé, 2012). The profitability of inorganic fertiliser use is a significant demand-side element that may contribute to Africa's low inorganic fertiliser utilisation. Because most farmers undoubtedly find using inorganic fertiliser to be either unprofitable or just marginally profitable, there is a low demand for commercial inorganic fertiliser among farmers. Low inorganic fertiliser response rates, high crop yield variability, credit constraints, and high inorganic fertiliser costs relative to crop output prices frequently undercut the incentives to apply inorganic fertiliser. The demand for inorganic fertiliser is further exacerbated by a lack of knowledge regarding the availability and cost of inorganic fertiliser, farmers' inability to raise the funds required to buy inorganic fertiliser, and insufficient understanding on the side of many farmers regarding the efficient use of inorganic fertiliser. On the supply side, issues including an unfavourable business climate, tight regulations, exorbitant taxes and fees, and a lot of rent-seeking prevent farmers from using fertiliser. The challenges and factors may be location, crop or time specific. For Ghana, maize is an important food security crop. Therefore, the effects of these factors on the food security of the country can be dire if not checked.

According to IFAD-IFPRI (2011), despite the rising emphasis on connecting smallholder farmers to markets, agricultural commercialisation remains low. Ghana's average marketable surplus ratio, which shows commercialisation, is 33%, which is low but higher than the SSA average (IFAD-IFPRI, 2011). According to the Swedish International Development Association (SIDA), just 10% of Sub-Saharan African smallholders produce sufficient marketable surpluses (Siziba et al., 2011). Maize which has the potential to increase income, is nevertheless commonly grown as a staple crop in the northern part of the country (MiDA, 2010). Low production per hectare, crop diversity, small farm sizes, and large household sizes all contribute to the low level of commercialisation (IFAD-IFPRI, 2011). According to Chamberlin et al. (2007), the limited access to input and product markets, financial services, and consulting services is the underlying cause of the low level of commercialisation. The new political economy development with regards to Russia-Ukraine war has a significant adverse effect on agriculture in Ghana. This is because, as stressed in the political economy literature, the agricultural sector cannot be isolated from international dynamics including externally induced economic shocks beyond the sector. It is important to note that, Russia is the largest exporter of inorganic fertilisers and minerals in the world. The new 2022 Western sanctions on Russia, and the Russia-Ukraine War over the refusal of the Ukrainian government to implement the 2014/2015 Minsk Agreement brokered by France, Germany, and Russia which ended the 2014 Civil War with Russian-speaking rebels in Eastern Ukraine, are affecting the international prices of inorganic fertilisers. This development had led to the shortage of inorganic fertilisers and could affect the cost of production leading to the lower income levels of farms.

Research into the correlation between technology adoption, particularly inorganic fertiliser, and smallholder commercialisation and profitability are few in the economic literature, particularly in

developing nation settings such as Ghana. Furthermore, the view that fertiliser use is insufficient is predicated on the assumption that higher rates than those currently utilised by smallholder farmers are profitable. There is, however, little substantive empirical data to support this claim. While various research has been conducted to study fertiliser yield response in crop production, (see Adzawla et al., 2021; Senkoro et al., 2018; Ragasa & Chapoto, 2017; Chapoto et al., 2015), the number of studies investigating the profitability of fertiliser use in Ghana is not high.

Researching the effects of inorganic fertiliser use on commercialisation and profitability, particularly in developing countries such as Ghana, opens up a new channel for connecting smallholder farmers to urban food value chains, which could be a viable instrument for rural poverty reduction. It may not be justifiable to conclude that beyond the positive effects of fertiliser use on yields, fertiliser is key for improving the livelihoods of the farmers without empirical evidence. To contribute to the debate on the need for farmers to increase investment in soil fertility improvement through inorganic fertiliser application, it is important to analyse the profitability of inorganic fertiliser application as well as the effect of inorganic fertiliser use on commercialisation.

1.2 Research Questions

The questions formulated to address the problem identified include:

1. What are the factors that affect inorganic fertiliser use among smallholder maize farmers in the research area?
2. What is the effect of inorganic fertiliser use on maize productivity of smallholder farmers in the research area?

3. What is the effect of inorganic fertiliser use on maize commercialisation by smallholder farmers in the research area?
4. What is the effect of inorganic fertiliser use on profitability of maize production in the research area?

1.3 Research Objectives

The main objective of the study is to examine the effect of inorganic fertiliser application on maize commercialisation and profitability in the Guinea Savannah and Transitional zones of Ghana.

The specific objectives are to:

1. Examine the factors that affect the use of inorganic fertiliser among smallholder maize farmers in the research area.
2. Analyse the effect of inorganic fertiliser use on maize productivity of smallholder farmers in the research area.
3. Estimate the effect of inorganic fertiliser use on maize commercialisation by smallholder farmers in the research area.
4. Estimate the effect of inorganic fertiliser use on profitability of maize production in the research area.

1.4 Significance of the Study

This study is useful to various stakeholders in the agricultural sector by providing empirical evidence on the factors that influence the commercialisation and profitability in the use of inorganic fertiliser among maize farmers. This information can be used in setting policies aimed

at transforming smallholder farmers, especially in reacting to market incentives for increased agricultural earnings, which in turn leads to decreased poverty and increased food security. Understanding the extent and drivers of the move towards smallholder commercialisation and profitability has significant scope for coherent policymaking. As such studying the effect of inorganic fertiliser adoption on commercialisation and profitability is an avenue for linking smallholder farmers to urban food value chains that might be a promising tool for rural poverty alleviation. This information is important to MoFA, considering that two out of the five pillars of the PFJ program by the government are to subsidise fertiliser and create market opportunities for farmers. This study provides information regarding farmer-specific variables that influence market participation as well as the profitability of inorganic fertiliser use, which would be valuable to farm households in making decisions. Farmers, for example, can choose to join farmer-based organisations.

The findings of this study will contribute to enhancing the existing literature on fertiliser utilization for maize production in the Guinea Savannah and Transitional Zones of Ghana. Another relevance of the study is its potential to inform policymakers and agricultural stakeholders about the specific challenges and opportunities related to inorganic fertiliser use in the Guinea Savannah and Transitional Zones of Ghana. The study can guide the development of tailored policies and interventions aimed at not only boosting the commercialisation and profitability of maize farming but also improving overall agricultural productivity and food security in these specific regions.

1.5 Organisation of the Study Report

This research is organised into five chapters. The first chapter which is the introduction, includes the background to the study, problem statement of the study, the objectives of the study, the

research questions, significance of the study and organisation of the study. The second chapter presents a review of relevant literature including the theoretical literature review which discusses the theories that underpin the study, the conceptual literature review which discusses the various concepts that are used in the study and finally the empirical review looks at the previous studies that have been done around the study area. Chapter Three describes the methodology employed in the study. The outcome and discussion are presented in Chapter Four. Chapter Five summarizes the research and provides the conclusions, recommendations, and suggestions for further studies. After chapter five, there are references and appendices.



CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

Background information on maize production, soil quality, and fertiliser use in Ghana is provided in the literature review that follows. In addition, the concept of smallholder farm commercialisation is discussed. The chapter concludes with a summary of the results obtained from empirical works that have examined the factors that affect the use of inorganic fertiliser, yield response to inorganic fertiliser use, effect of inorganic fertiliser uses on farm commercialisation and inorganic fertiliser use profitability.

2.1 Maize Production in Ghana

Ghana's total country area including land and water areas is 23,853,000 hectares, land area of 22,753,300 hectares and inland water area of 1,100,000. Agricultural land area accounts for approximately 55% (12,603,740 hectares) of total surface area, with arable land accounting for 37%. (4,708,900 hectares), (FAOSTAT, 2021).

Maize is a widely farmed and consumed staple crop in Ghana. The second crop, cassava, accounts for around half as many calories as maize, according to the Ghana Statistical Service (GSS) (2018). According to Gage et al. (2012), approximately 75% of maize consumption is self-produced, showing that maize has little potential as a revenue crop. Launched in 2017, the Planting for Food and Jobs (PFJ), which is a government's flagship program, gives priority to the distribution of maize seed and fertiliser and promotes smallholder market participation (MoFA, 2019). Ghana's maize production from 2000 to 2020 is shown in Figure 2.1.

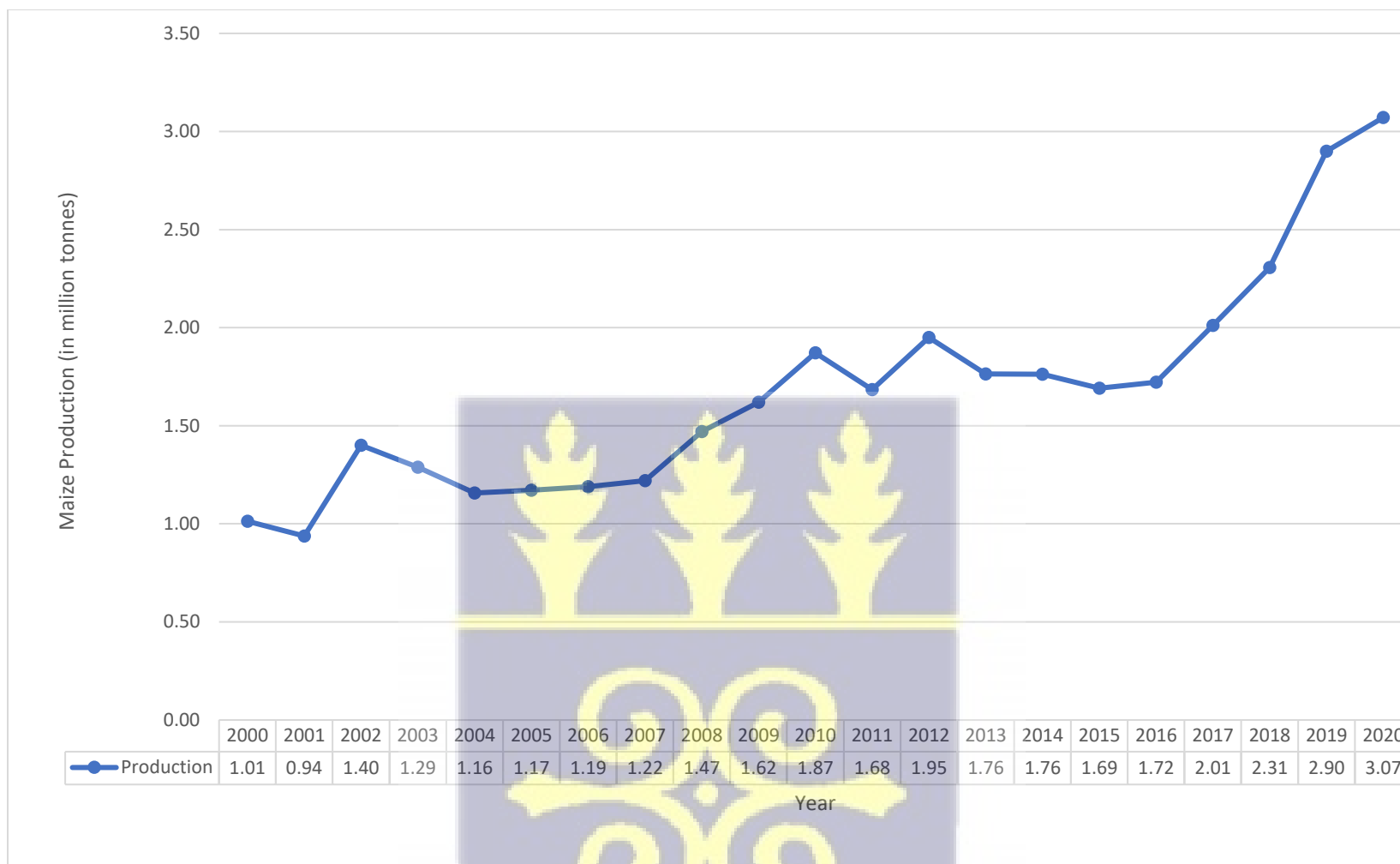


Figure 2.1: Maize Production in Ghana

Source: FAOSTAT, 2022



For the years 2000 through 2020, the average amount of maize produced was 1.68 million tonnes. It's important to note that the average output of maize from 2017 to 2019 has increased by 48% compared to the average output from 2013 to 2016. The government places this enormous rise in output on PFJ. Ghana's performance in maize production must be measured with that of its neighbours. Figure 2.2 compares Ghana's maize production to other selected countries in Africa. Ghana's maize production has been increasing in the past 10 years. The average maize yield in 2020 was 2.0 tons/ha. Comparing maize yields in Ghana with other African countries shows that maize yields have been higher than Burkina Faso, Benin, Nigeria, Kenya and Togo for the past decade. However, neighbouring Cote d'Ivoire and Mali's maize yields have been higher than Ghana in the past decade.



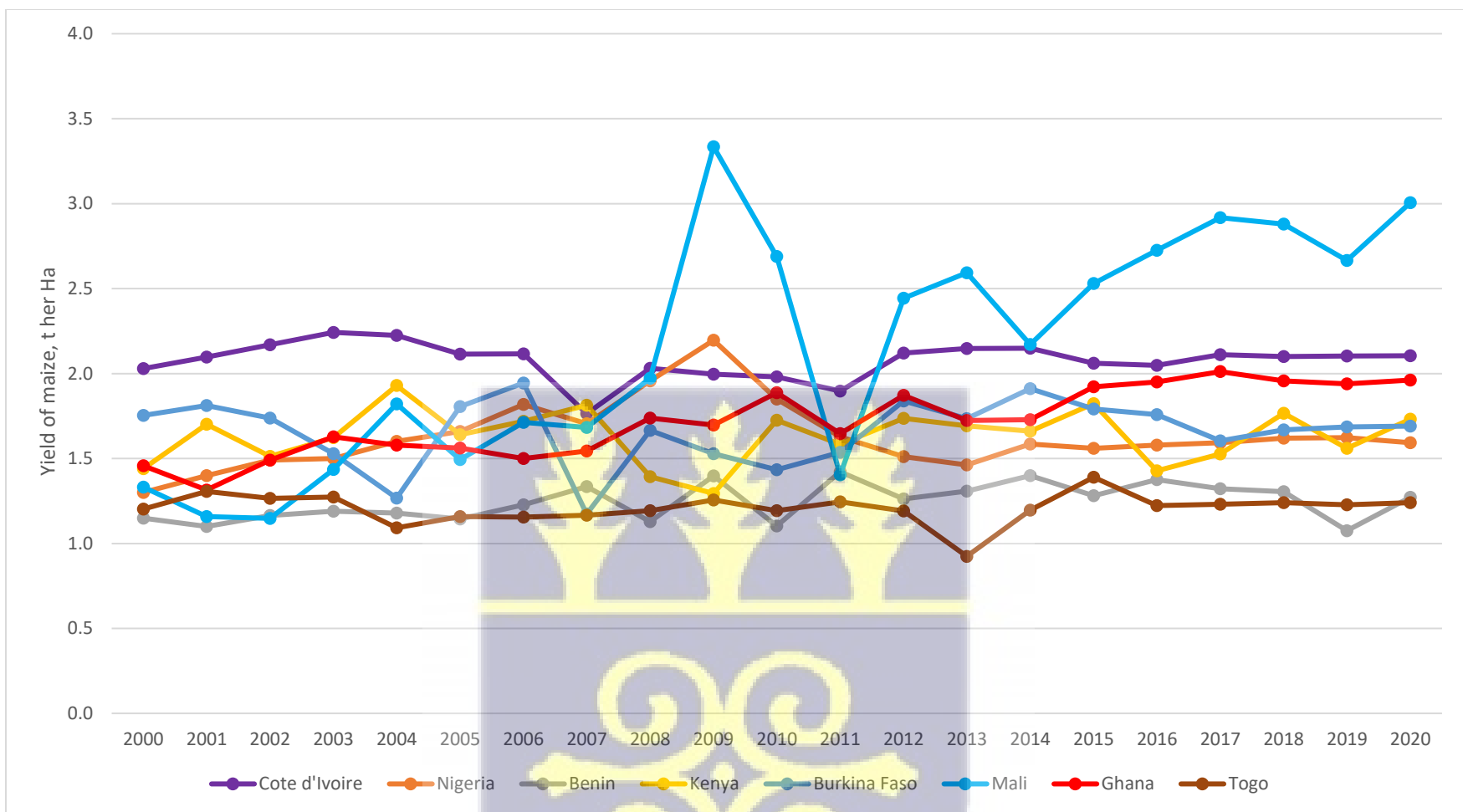


Figure 2.2: Ghana's Maize Yield Compared to Yields in Selected Countries

Source: FAOSTAT, 2022



2.2 Overview of Soil Quality, Fertiliser Use and Subsidy Program

2.2.1 Soil Quality

Soil quality in SSA has been degrading for some time, and Ghana's soil is no different (Kihara et al., 2020). Significant nutrient shortages have been determined all over Ghana, and they seem to be caused, at least in part, by poor farming practices. Permanently cultivated soils in the northern part of the country have been found to have much worse chemical and nutritional characteristics than soils with natural vegetation (Bramoh & Vlek, 2004). With the use of inorganic fertiliser in Southern Ghana, rice yields were demonstrated to dramatically rise (Moro et al., 2008). Available estimates show that Ghana experiences yearly nutrient losses of over 60 kg/Ha NPK, one of the highest rates in SSA (Henao & Baanante, 1999; Stoorvogel et al., 1993).

2.2.2 Fertiliser Use in Ghana and the Sub-Saharan African Region

Numerous studies in SSA have demonstrated that substantial increases in fertiliser use are necessary to reduce the enormous nutrient losses happening on a considerable portion of SSA's arable land (see Wallace & Knausenberger, 1997; Crawford et al., 2005; Morris et al., 2007). Despite the fact that inorganic fertiliser is strongly highlighted in national development objectives, Ghana currently has a low usage rate (Bationo et al., 2018). Sub-Saharan Africa has an average fertiliser application rate of 22 kilograms per Ha, compared to a world average seven-times higher (146 kilograms per Ha). Some countries, such as China and Chile, are closer to 400 kilograms per hectare, according to the World Bank (2022). This is less than the target set by the Abuja Declaration in 2006 for African countries achieve an average of 50 kilograms per Ha by 2015 (Hill & Kirwan, 2015).

Figure 2.3 shows the production, imports, exports and apparent use of fertiliser products in 2021 for some selected countries namely Benin, Burkina Faso, Cote d'Ivoire, Ghana, Kenya, Mali, Nigeria, Senegal, Tanzania and Togo. It is important to note that, although Nigeria produced about 2.7 million metric tonnes of urea fertiliser in 2021, 1.3 million metric tonnes were exported of which 87% (1.18 million metric tonnes) were exported to Brazil. (Vifaa Nigeria Dashboard, 2022).

Ghana has limited data on fertiliser use by crop, however it appears that the largest fertiliser and application rates are used on crops like vegetables, cocoa, and palm oil, which are mostly cash crops. Maize application rates fall into the middle range. In Ghana, just 31% of families utilise fertilisers, while regional differences exist in this percentage (Bationo et al., 2018). Less than 10% of small - scale farmers with farms smaller than 1.0 ha use fertiliser, compared to over 20% of those with farms larger than 5.0 ha. Figure 2.4 compares Ghana' fertiliser apparent consumption from 2010 – 2020 with other countries.

Figure 2.4 shows that, apparent consumption of fertiliser has been on an upward trend for the selected countries, albeit experiencing some dips in certain years. Favourable global commodity and fertiliser prices, government initiatives like subsidy programs, and investments from private sector in the production, blending, distribution, and marketing of fertilisers are the three key driving forces which led to a significant increase in fertiliser consumption in the major fertiliser markets in West Africa between 2015 and 2020. Despite a significant increase in fertiliser imports and usage following the 2008 worldwide oil and food crises, Ghana's fertiliser market is still considerably smaller than that in several other countries, including Kenya and Nigeria.

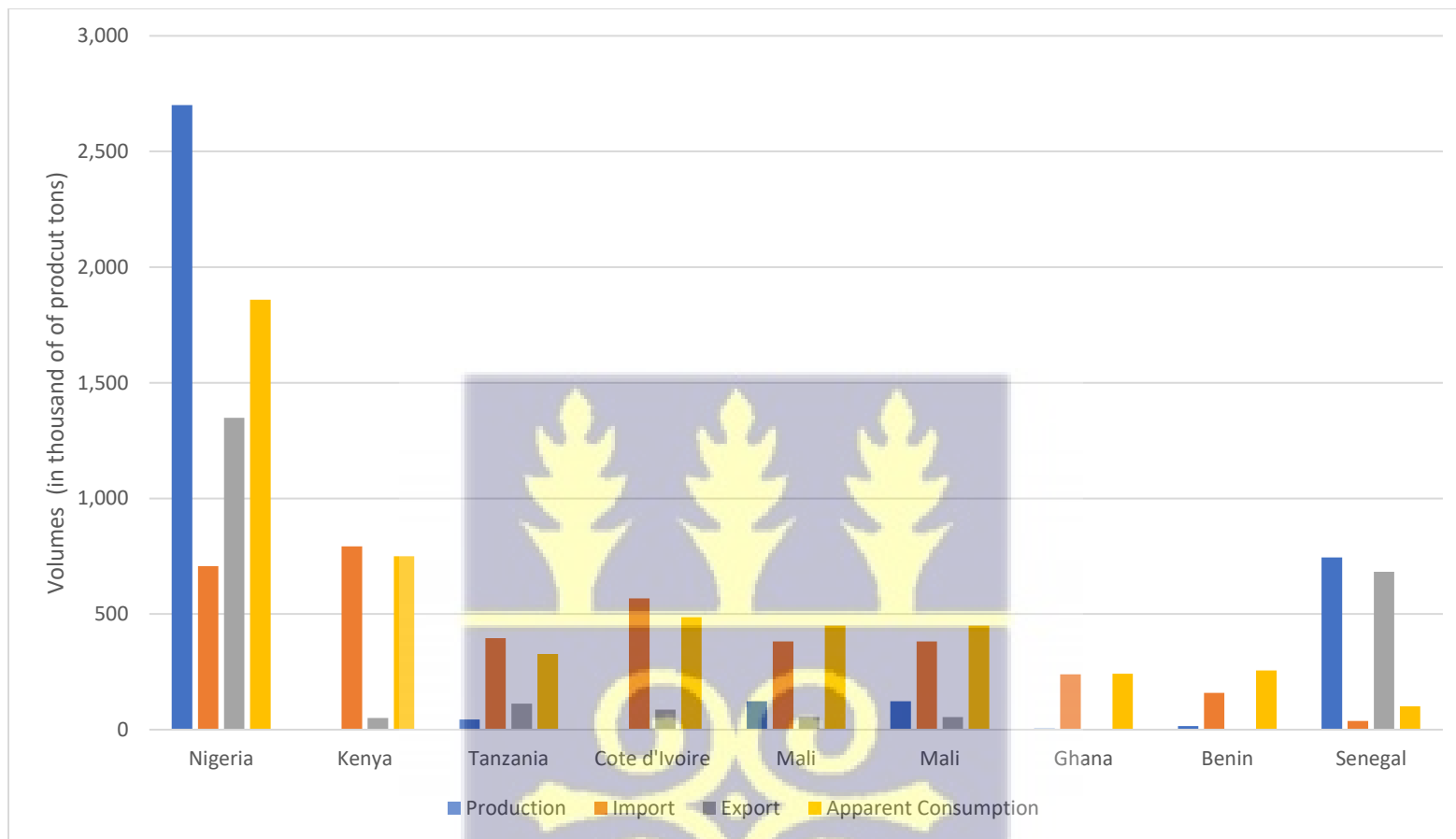


Figure 2.3: Fertiliser Production, Imports, Exports and Apparent consumption, 2021

Source: AfricaFertilizer.org



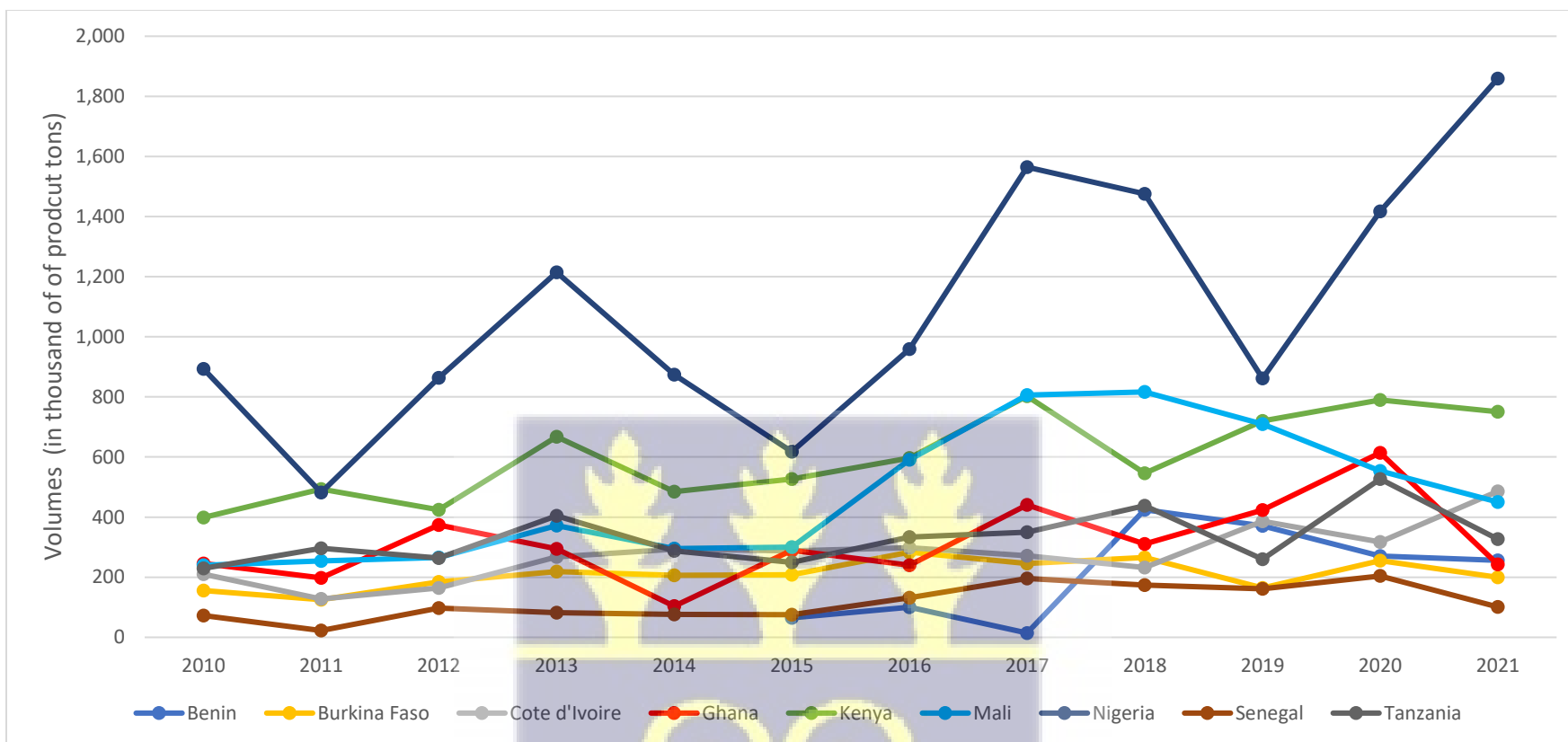


Figure 2.4: Apparent consumption of fertiliser products in selected countries

Source: AfricaFertilizer.org



In 2021, most countries saw reduction in fertiliser imports which affected the apparent consumption of fertilisers as a result of the oil price increases. With the Russia-Ukraine war in 2022, making fertiliser commodity scarce, many African countries may not meet their fertiliser needs for food production unless there are interventions by governments and private sector.

2.2.3 The Ghana Fertiliser Market and Subsidy Program

Inorganic fertilisers are not produced in Ghana. Therefore, all the inorganic fertilisers that are used in the country are imported mostly from Russia, Norway, Latvia, Morocco, Italy, United States, Spain, and Finland. Imported inorganic fertilisers usually come in bulk and compound form. A network/system of wholesalers and retail agro dealers distributes the bulk inorganic fertilisers in a variety of formulations. Six of the largest importers – Agricultural Manufacturing Group, Chemico Ghana Limited, GloFert Limited, Louis Dreyfus Company Ghana, OmniFert Limited, and Yara Ghana Limited have made investments in inorganic fertiliser blending facilities that enable them to create various inorganic fertiliser formulations. It is important to note that every blending facility is in the southern part of the country at places like Tema, Kpong, Dawhenya and Teacher Mantey. Locally, ACARP, Safisana, and JEKORA Ventures generate a tiny portion of organic fertilisers.

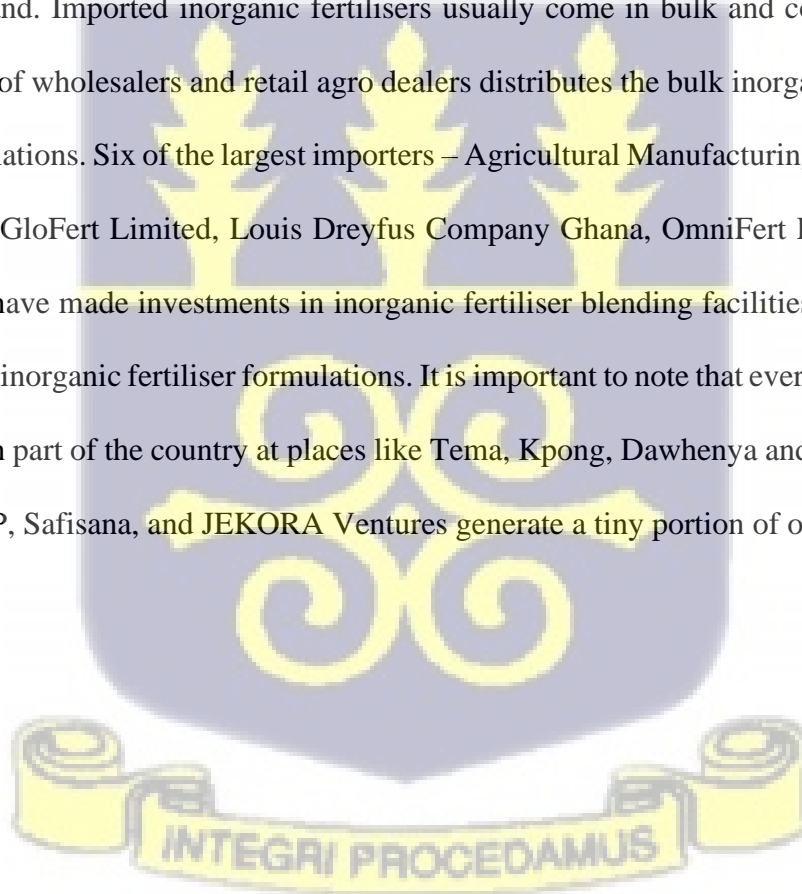


Table 2.1: Fertiliser Imports in Ghana

Fertiliser Name	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
NPK	67,071	50,405	127,393	117,047	44,880	138,140	132,632	213,887	224,176	217,024	299,423	152,267
Ammonium sulphate	29,570	38,474	61,585	54,863	6,282	64,015	23,268	43,865	10,084	17,326	43,994	32,561
MOP	37,832	30,505	43,420	19,849	22,715	18,707	13,842	24,235	15,993	42,235	55,611	15,329
Urea	14,025	2,838	17,665	36,104	202	18,348	39,035	88,259	42,005	77,011	89,956	3,800
Organic fertilisers	88	13	275	6,465	5,523	7,818	8,772	37,643	5,875	4,673	270	2,495
TSP	79,042	50,177	92,456	47,173	21,258	32,052	13,802	26,766	9,460	29,300	35,268	-
Other fertilisers	18,288	24,905	30,971	16,587	10,223	11,077	8,532	9,582	7,564	37,542	94,117	32,610
Total, metric tonnes	245,916	197,317	373,765	298,086	111,083	290,156	239,883	444,236	315,157	425,110	618,638	239,062

Source: AfricaFertilizer.org

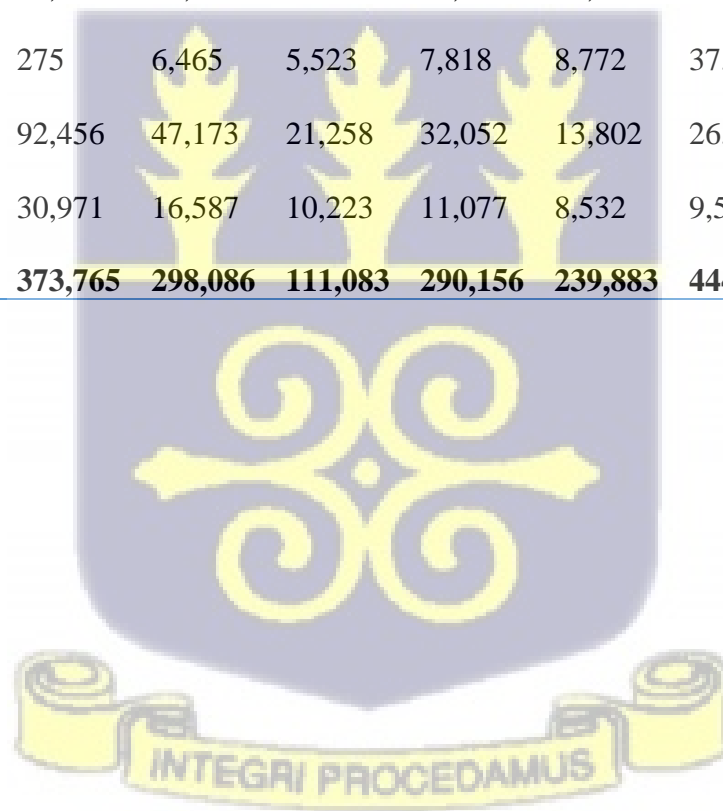


Table 2.1 shows that, the average fertiliser imports to Ghana between 2017 to 2020 was about 450,000 metric tonnes. However, in 2021, imports reduced to less than 250,000 metric tonnes as a result of price hikes in the world market as prices of inorganic fertilisers doubled in ending 2020 and throughout 2021.

The Fertiliser Subsidy Program (FSP), a nationwide agricultural farming support program, existed prior to the PFJ initiative. For supply, delivery, and retail, it made use of the fertiliser industry's private sector. Agricultural extension agents gave vouchers in 2008 and 2009 that were region- and fertiliser-specific and might be used as a portion of the purchase price for fertilisers at any shop that would accept them. (Baltzer & Hansen, 2012; Banful, 2010). In response to criticism regarding the insufficient performance of the voucher scheme, the government took action in 2010 by discontinuing the voucher program. Instead, they opted to directly cover half of the fertiliser costs and all transportation expenses (Banful, 2011).

The expense of the FSP reportedly got intolerable after rising from GHS 20.65 million (\$3.28 million) in 2008 to GHS 239 million (\$37.94 million) in 2017. It was by far the highest yearly rise in the program's fiscal allocation since 2008, with the amount the government spent on the FSP rising by nearly 73 percent in 2017 compared to 2016. Between 2008 and 2016, the government spent around GHS 570,80 million (\$90,60 million) on this initiative. MoFA claimed that the FSP had very little of an impact on smallholder farmers' access to and adoption of fertiliser. This stemmed from the fact that, majority of the program's target; smallholder farmers, still lacked the financial means to purchase fertiliser even at a reduced cost. As such large commercial and wealthy farmers ended up being the only beneficiaries of the initiative.

As a result of the challenges with the FSP, a new strategy was required that incorporated a flexible payment system into the subsidy in order to encourage the use of fertilisers by smallholder farmers.

The PFJ was created to take care of this issue. As a result, the PFJ's fertiliser-subsidy program included a novel option that encouraged fertiliser intake by farmers, particularly by smallholders, whose incomes were low and who had little money to spend on agricultural supplies.

In particular, the program provided qualifying farmers with a 50 percent subsidy, permitting them to pay 25 percent of the cost of the fertiliser as a deposit and the other 25 percent upon harvest. There were sanctions meted out to any farmer who defaults in paying for the fertilisers. Beneficiaries would be removed from the program and lose their eligibility until they covered the final 25 percent of the cost of fertiliser for two consecutive planting seasons. Each qualifying farmer was also limited to using a total of six bags of organic fertiliser for soybean, ten bags of NPK fertiliser, and five bags of urea or sulphate of ammonia fertiliser for all other crops. To avoid abuse, this equated to a two-hectare maximum fertilised crop area per farmer.

The estimated cost of the PFJ's national fertiliser subsidy during a three-year period from 2017 – 2019 was GHS 1.8 billion (\$401 million). The PFJ's implementation was continued past 2020 due to its perceived success. At a reduced input subsidy rate of less than 30% in 2021, the government of Ghana spent \$70 million to fund the program. In 2022, the government is investing \$98 million in the initiative, a 40 percent increase in funding from 2021. Despite the initial shortcomings of the program, following its implementation, maize yields in Ghana have shown a significantly greater increase compared to those in other West African countries that do not offer subsidies.

2.2.4 Fertiliser Recommendation in Ghana

Over the years, research have been carried out to determine the appropriate fertiliser rate for Ghana. From 1948 to 1970, thorough research was done to provide fertiliser recommendations in

Ghana, and the government's recommended 80N-40P₂O₅-0K₂O per acre for maize was established. (FAO, 1971). It is important to note that studies carried out in 2017 and 2018 by Gondwe and Nkonde (2017) and Tetteh et al. (2018) improved the previously developed fertiliser recommendations with much effort. As a result, the current fertiliser nutrient rate for maize in the Guinea Savannah zone is 100N-40P₂O₅-40K₂O + 2.1Zn and Forest Savannah Transition zone is 90N-60P₂O₅-60K₂O + 2.1Zn kg per ha.

The recent fertiliser recommendations, according to IFDC (2019), aim to raise maize production from an average of 1.8 t ha⁻¹ to 5 t ha⁻¹. To further improve future recommendations, given the vast range of soil variations, it is important to investigate the underlying reasons of the yield response to these rates. If not, those rates can still be regarded as general fertiliser recommendations with little application to diverse smallholder farms. According to Zingore et al. (2007), it is essential to apply inorganic fertilisers and manure selectively based on the soil type and previous field management in order to increase crop yields and optimize nutrient use.

2.3 The Concept of Farm Commercialisation

2.3.1 Conceptualising Smallholder Commercialisation

Smallholder agricultural commercialisation has diverse definitions in academia. Some view it as elevating production beyond subsistence for surplus sales (Goletti et al., 2003), while others regard it as increasing the portion of production sold (Pradhan et al., 2010). Seyoum, Lemma, and Karippai (2011) define it as a shift from subsistence to profit-driven household production, resulting in market-oriented products. Essentially, smallholder commercialisation represents deliberate efforts by farmers to maximize income from crops or livestock intended for sale or trade (Ejupu, 2001).

In a nutshell, it can be seen from the various definitions that, there is no definite definition of smallholder commercialisation. Based on the farmer's objectives, goals, and aspirations, it can be described. Therefore, smallholder commercialisers of agriculture production might be viewed of as small-scale farmers who are more integrated into the local, national, and international markets. This is due to the fact that smallholder farmers nowadays must produce for the market since they are in competition both with local farmers and with farmers that produce the same commodity on a regional and global scale (Gebremedhin et al., 2006). It is significant to note that the objectives and aspirations of smallholder farmers influence how agricultural production is defined as being commercialised. This includes production that is primarily intended for sale and is motivated by the desire to maximize profits while meeting the varied needs and interests of the consumer.

2.3.2 The Historical Context of Agricultural Commercialisation

Many established and emerging economies have demonstrated the effectiveness of commercialising agricultural produce in promoting industrial and economic progress (Jaleta et al., 2009; Kofi Annan Foundation, 2011). Large-scale commercialised agriculture using cutting-edge machinery and technologies has significantly aided economic and industrial growth in North America, Europe, Israel in the Middle East, and countries in Southern America such as Brazil and Argentina, as well as Asian economies such as China and India (Eicher & Staatz, 1985).

Commercial farming was primarily introduced by European colonial masters in developing nations, particularly in Sub-Saharan Africa, Asia, and South America, to feed their industries in Europe (Eicher & Staatz, 1985). According to Robbins and Ferris (2003), the commercialisation of agriculture prompted the creation of infrastructure and the introduction of cash crops, both of

which continue to make up a sizable portion of the national GDP of the majority of developing countries today (like coffee export from Uganda, tea export from Kenya and cocoa export from Ghana).

Commercialisation of smallholder agriculture in Ghana has a lengthy history that dates back to the colonial eras. The first crops to emerge were oil palm, rubber and, later, cocoa for export. The production of cocoa significantly increased smallholder commercial farming. The smallholder-led approach minimized the colonial state's failure to expropriate locals' land as part of a plan for agricultural commercialisation. Cocoa growers were maintained in a cycle of trading activity, debt, and sensitivity to the ups and downs of the global commodities markets by providing inputs, training, fixed prices, and promised markets. A farming system that had historically included a variety of crops was rapidly replaced by oil palm and cocoa due to the commercial production of agricultural export commodities. Female farmers who combined autonomous and home farming with selling produce on their own behalf and that of their male household leaders generated the majority of the staple foods grown by farmers and sold in Ghana and in marketplaces throughout West Africa. However, compared to the cocoa business, commercialised food production did not have the same advantages or enjoy the same level of strong institutional and policy support. The post-colonial state continued smallholder commercial farming for cocoa after becoming independent, but it also made an attempt to build and support state-owned and privately held plantations and engage in contract farming for a number of important food crops and oil palm. Due to weak management and operational abilities, a lack of resources, and fluctuating prices, particularly for non-consumable items, the majority of these large-scale commercial farms have not persisted in the post-independence era. Despite producing less marketable surplus and being

insufficient to lift them out of poverty, the bulk of African farmers went to smallholder subsistence farming to survive.

The four commercial agriculture models currently employed in the agrarian political economy are smallholder agriculture, contract farming, medium-scale independent farms, and plantation agriculture (Yaro, Teye, & Torvikey 2017). These models work together to draw synergies and occasionally compete for resources, as well as to increase social differentiation in rural areas. In terms of total acreage, the people participating, and its significance for food security, smallholder agriculture continues to dominate the other three models, while plantations make up the least amount of Ghana's commercial agriculture, contract farming and medium-scale farming are currently of interest to policymakers due to their role in the expanding horticultural industry and the policy discourse that views them as more sustainable approach to agricultural modernization that avoids pitfalls like the extensive peasant dispossession that comes with it. (Smalley, 2013; Sitko & Jayne 2014).

Due to gender bias in hiring practices, the unequal access that males and females have to land and other resources, participation in these models continues to be sex-based. Women are therefore underrepresented in other agricultural models, despite having a good representation in smallholder agriculture. Additionally, there are still ideas about male and female crops in the agricultural system, which vary depending on the situation (Lambrecht et al. 2018). The majority of Ghana's impoverished are smallholder food crop farmers, despite their dominance in the country's commercial agriculture (Ghana Statistical Service, 2018). Long-standing policy views that see industrial agriculture as an idealized paradigm of agricultural modernization are the cause of this inconsistency. (Tsikata & Yaro 2014).

2.3.3 Measuring Smallholder Agricultural Commercialisation

While concentrating on commercialisation in its static form, several scholars have utilised various metrics of success to determine the agricultural commercialisation levels at the family level. For instance, von Braun and Kennedy (1994) proposed three categories of household commercialisation indices: a household's level of participation in the economic system, output and input side commercialisation, and rural economy commercialisation. The authors developed metrics to gauge the degree of household commercialisation for each of the three indices they had previously discovered.

The first index measures proportion of agricultural output sold to the market and input acquired from market to the total value of agricultural production. For the second type, commercialisation of the rural economy is defined as the ratio of the value of goods and services acquired through market transactions to total household income. Here, it is assumed that some transactions might be made in kind, such as paying for land use with food items. Third, the ratio of the cash value of goods and services purchased to total household income is used to measure how much a household is integrated into the cash economy (von Braun & Kennedy, 1994). The Household Commercialisation Index (HCI), which measures the level of commercialisation unique to each household, was used by Govereh et al. (1999) and Strasberg et al. (1999). It is a ratio of the gross value of all crop sales per home per year to the gross value of total crop output. ($HCI = \frac{\text{Total volume of crop sold}}{\text{Total volume of crop produced}} \times 100$). It's vital to note that this ratio excludes the livestock sector, which in some agricultural production may be more crucial than crops.

Gabre-Madhin et al. (2007) recently evaluated the level of household commercialisation using sales-to-output and sales-to-income ratios, net and absolute market positions (as a net buyer, net seller, or self-sufficient family), income diversification, and level of agricultural production

specialization. According to Gabre-Madhin et al. (2007), the sales-to-output ratio compares the total gross value of a household's agricultural sales to the total gross value of its agricultural production. Several writers have previously determined this ratio of agricultural output sold to total agricultural production (Abercrombie, 1961; Cleave, 1974; Ruthenburg, 1980 as referenced in Randolph, 1992; von Braun et al., 1994).

The term "total sales-to-income ratio" refers to the gross value of all sales to all income from crop production. This index excludes revenue from livestock, off-farm sources, and non-farm sources in favor of using agricultural output income as a proxy for total family income. The sales and purchases ratio to total stock, which is the sum of storage from the prior production year and current production year, is used to assess a household's competitive position. The specialization index aims to measure the degree of specialization in farm households' production in order to take advantage of comparative advantages by producing what they are skilled at and outsourcing their less-skilled labor. According to this metric, families spend a certain percentage of the overall value of agricultural produce on agricultural goods. According to this review, the typical approach for evaluating the amount of smallholder farmer's commercialisation appears to rely on the ratio of sold agricultural output to purchased agricultural inputs.

2.4 Empirical Review

Gebresilassie (2015) explored the factors that influence fertiliser use by smallholder farmers in Northern Ethiopia. Tobit model was used to econometrically analyse factors affecting fertiliser use. A total of twelve explanatory variables were used in the model. Based on the results of the analysis, it was discovered that six factors (household head, family size, distance from market, sex, access to credit, perception of household regarding cost of fertiliser, and farm size) influenced

significantly the use of fertiliser by smallholder farmers. The study recommended taking into account socioeconomic traits and adoption factors while intervening in development via improved agriculture technologies.

In the setting of Ghana, Hill and Kirwan (2015) investigated the variables that affect whether or not a farmer uses inorganic fertiliser. Their research was based on the assertion that Ghanaian farmers' methods may increase yields by closing the yield gap, which at the time was only around one-third of estimated potential. The researchers concluded that yields in Ghana may most likely be increased by strengthening the use of inorganic fertiliser, other inputs, and improved irrigation systems. According to the study's findings, the closeness of a farmer to the closest weekly marketplace, the presence of a pre-harvest agreement, and the presence of property rights on the field all have a major impact on fertiliser usage. Chapoto and Ragasa (2013) published empirical data on the response of maize production to fertiliser use and intensity, as well as the economics of fertiliser use with and without using cross-sectional data on 630 maize farmers and 645 maize plots in Ghana. Their research focused on the impact of fertiliser use and intensity, as well as the economic aspects of fertiliser use. The findings indicated a statistically significant positive effect of fertiliser application on maize production, aligning with previous studies in Ghana, where one kilogram of nitrogen led to a yield increase of 22 kilograms per hectare. Furthermore, the study revealed that factors such as the adoption of modern seed varieties, the utilization of livestock manure, herbicide application, and the total amount of family labor hours dedicated to working in the maize fields all contributed to higher maize yields. Plots fertilised with livestock manure, for example, had a 400-kilogram higher output, while plots treated with herbicide had a 170-kilogram higher yield. Plots planted with contemporary varieties also produced around 570 kilograms more

per hectare than plots planted with traditional kinds. Their research findings highlighted a significant increase in yields when fertiliser treatment was combined with other agricultural inputs.

Tesfay (2020) examined how the use of fertilisers influenced smallholder commercialisation as technological advances enhanced agricultural output and land-use intensification in a land-scarce context such as Ethiopia. The study employed cross-sectional farm household data gathered during the 2014–2015 cropping season from a randomly selected sample of 626 farm households located in rural Tigray, northern Ethiopia. With a control function technique, Ordinary Least Squares (OLS) was used to evaluate plot-level productivity. An endogenous switching regression model is used to analyse the direct influence of fertiliser adoption on smallholder farmers commercialisation in order to account for selection concerns connected to adoption decisions. The addition of fertiliser had a positive and considerable impact on plot-level productivity, according to the study's findings. The application of inorganic fertiliser was also found to have a large and positive impact on smallholder commercialisation through higher productivity.

Using longitudinal household survey data, Xu et al. (2009) investigated in Zambia, the factors determining the profitability of fertiliser use on maize. The study categorized crop production inputs as growth inputs and yield scaling variables, which helped to broaden the asymmetric framework. The underlying crop growth process is considered in this paradigm, which also considers the effects of non-input elements. The study's findings demonstrated that timely fertiliser supply increases yields, whereas interaction with extension officers and an abundance of rain decreases them. Furthermore, the study revealed that estimates of nitrogen's Marginal Value-Cost Ratio (MVCR) and Average Value-Cost Ratio (AVCR) in various small-farm scenarios fell below the profitability threshold. Factors such as the rate of fertiliser application, reliable fertiliser supply, recent adult mortality rates, adoption of hybrid seeds, and the maize-fertiliser pricing ratio,

influenced by factors like road and market accessibility, were identified as key determinants of fertiliser use profitability.

Theriault, Smale, and Haider (2018) calculated the average and marginal value-cost ratios using estimated coefficients from the maize yield response function using farm household survey data over three cropping seasons (2009/10 to 2011/12) from Burkina Faso. Plot managers frequently apply fertiliser at a lower rate than the rate that maximizes revenues because farming is uncertain and fertiliser markets are undeveloped. The study's findings also demonstrated that while using fertiliser was lucrative with a 50% fertiliser subsidy, it was not profitable at full market costs. Even with the subsidies, the motivations to use fertiliser remained small, especially when transactional costs in the fertiliser supply are included. The study's findings back up Kousoubé and Nauges' (2017) conclusion that supply-side limitations must be eased for farmers to gain from fertiliser use.

2.5 Gaps in the Literature and Conclusion

As identified in the literature review, numerous research studies have explored the impact of fertiliser use on maize commercialisation. Additionally, various research endeavours have investigated how fertiliser use affects the profitability of maize farmers. There is a need for more in-depth economic analyses that examine the actual profitability for smallholder farmers. This should consider input costs, market prices, and the overall financial viability of using inorganic fertilisers in different regions of Ghana. There is the need for more research on the long-term environmental consequences of intensive use of inorganic fertilisers including issues such as soil degradation and water pollution as understanding the sustainability of these practices is crucial for

maize farming in the long run. The characteristics of inorganic fertiliser markets in Ghana, including pricing mechanisms, supply chain issues, and the influence of price volatility on farmers' decisions to invest in fertilisers, should be studied further.



CHAPTER THREE

METHODOLOGY

3.0 Introduction

This chapter describes the methods and procedures used in this study. It begins with the theoretical framework and the conceptual framework underpinning the study. The chapter also includes the data analysis method for each of the objectives, the data collection, sampling techniques and a description of the study area.

3.1 Theoretical Framework

Production function is a basic tool when conducting economic analysis of a firm. The production demonstrated the technological relationship between factors of inputs (land, labour, capital) and output. It is typically depicted by the marginal rate of returns on an input or set of inputs used in production. It is implicitly assumed that the production function of a firm, such as that of a farmer, operates in a technically efficient manner, meaning it is assumed to be characterized by diminishing returns to scale.

Generally, the production function is defined as $Q=f(K, L)$, where Q is the output produced from the use of capital (K) and labour (L). Such theoretical function is often defined practically using the Cobb-Douglas and translog production functional forms. The Cobb-Douglas production function, which was applied in this study, is one of the frequently used functions in economics to depict the relationship between inputs and outputs. It enables the direct estimation of the marginal rate of returns from the function itself.

Previous research has shown a high correlation between rational decision-making and actions, or behaviours taken by farmers in the agricultural industry. For instance, it is typical for researchers and policymakers in agriculture to recognise that many smallholder farmers make rational decisions about the usage of their inputs, such as fertiliser (Rogers, 2010; Adejumo et al., 2014). This indicates that farmers are known to analyse the potential benefits and estimate the potential costs to be incurred in each situation before making decisions. Rational Choice Theory (RCT) is the most widely utilised theory to explain this occurrence (Boudon, 1998). Since RCT argues that individual action is instrumental, the motive or will of the actor to achieve particular goals serves as an explanation for the action taken by an individual (Boudon, 1998). According to RCT, an actor is subject to specific (individual and societal) limitations. He or she assesses the options in light of the limits and selects the one that best accommodates their preferences (Opp, 2019). In this situation, constraints limit the options available to the actor, while preferences define the objective they are trying to achieve.

The core element of RCT is that individuals within a society make decisions in an effort to maximize their benefits and reduce their costs that reflect the patterns of behaviour in that community. RCT's applicability was extremely ingrained in agricultural organisations. It is thought that lowering the farmers' costs will lighten their burden and enhance their profit. Giving farmers agricultural subsidies is an example of how RCT is used. Farmers consent to subsidy programs because they understand the possible benefits of receiving the subsidy and the risks of not receiving it.

The study sought to examine the effect of inorganic fertiliser use on farm commercialisation and profitability of smallholder maize farmers. Although, Ghanaian smallholder maize farmers are concentrated in the rural areas with farming largely as an inherited occupation, they do not

arbitrarily make the decisions on farming and farming activities. Smallholder maize farmers do not use inorganic fertiliser at random, but rather follow a systematic decision-making process that considers the costs and benefits of using or not using inorganic fertiliser.

3.2 Conceptual Framework

This study seeks to examine the effect of inorganic fertiliser use on farm commercialisation and profitability of maize farmers. This study's conceptual framework is shown in Figure 3.1. It is assumed that inorganic fertiliser usage by farmers has the potential to improve soil fertility, leading to higher maize productivity, profit, and commercialisation among farmers. However, the utilization of inorganic fertilisers among farmers in developing countries, notably Ghana, remains at a low level, and there are numerous factors contributing to this low adoption rate. Some of the major factors attributed to low inorganic fertiliser usage could be high cost of inorganic fertiliser, poor access to inorganic fertiliser information and usage, inadequate access to production credit, gender issues, low access to market outlets, among others.

It is crucial to note that using inorganic fertiliser, which is a farm input, increases cost of agricultural production, especially in maize production. However, appropriate combination of inorganic fertilisers, along with the right quantity of application, improved seeds, sufficient labour, improved land management practices, and favourable climatic conditions will result an increase maize yields and profitability. The profitability of any venture is principally a function of the cost incurred in that activity and revenues that are generated from the product of the activity, for instance, farm revenue. Therefore, smallholder farmers will use inorganic fertilisers at the farm level if the expected marginal revenue will be higher than the marginal cost of production. There

are other socioeconomic factors such as the availability and distance to a market that also influences the profitability of farm activities.

Also, increased yields mean that there are more grains for farmers beyond their subsistence levels. Therefore, the output of the farmers can be distributed in different ways. The increased yields can be divided into two broad ways: a proportion for consumption and a proportion for sale or commercial purposes. Important to this study is the proportion that is commercialised and this in addition to inorganic fertiliser use, influenced by other factors such as market access and credit access.



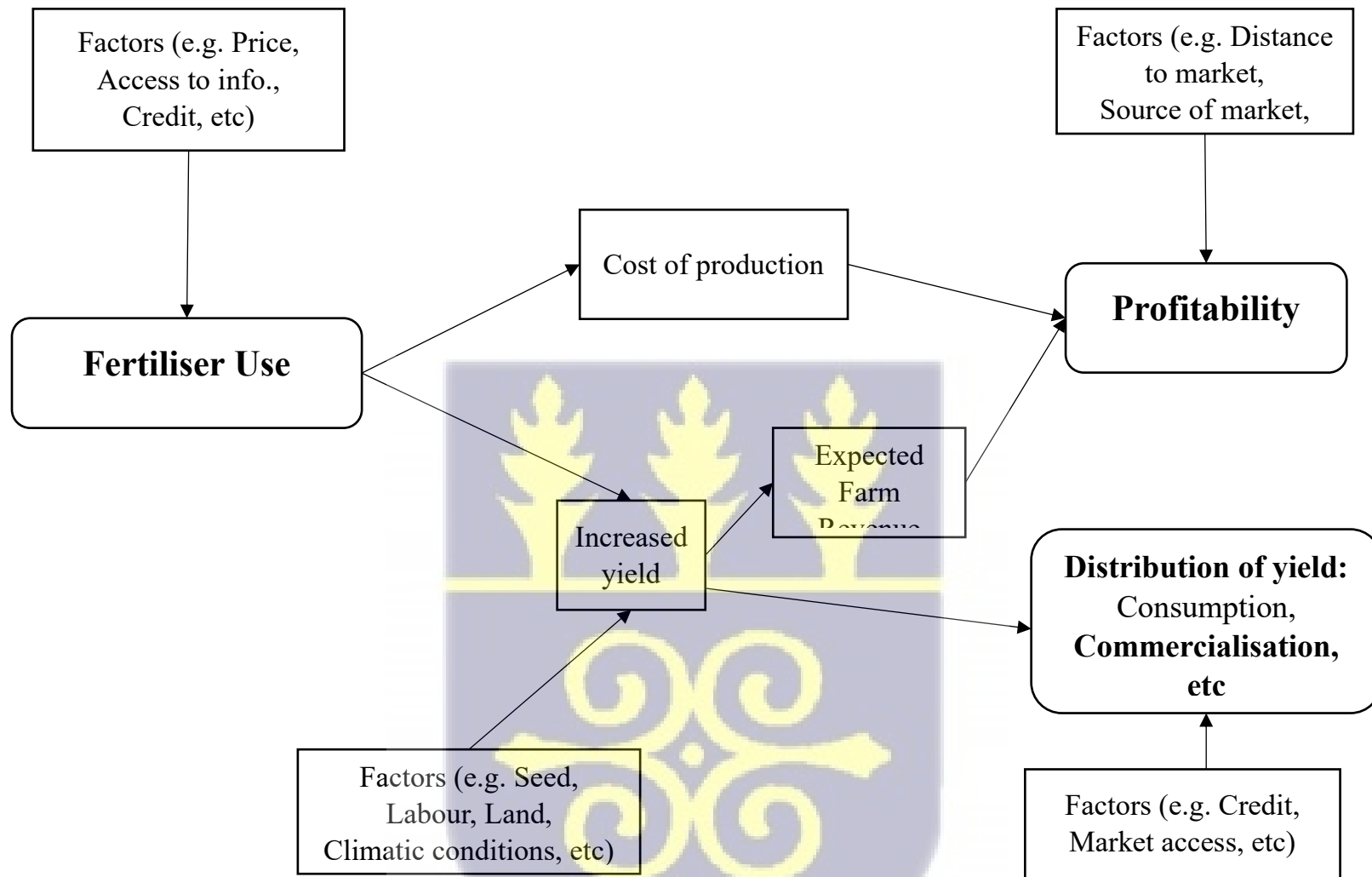


Figure 3.1: Conceptual Framework

Source: Author's Construction



3.3 Methods of Data Analysis

The data was analysed using STATA, SPSS and Microsoft Excel. The analytical procedure was based on the study's objective. This is detailed in the subsequent sub-sections.

3.3.1 Examine the factors that affect inorganic fertiliser use among smallholder maize farmers

One of the objectives is to examine the socioeconomic factors affecting inorganic fertiliser usage among maize farmers in the Guinea Savannah and Transitional zones of Ghana. For the purpose of this study, the decision of a farmer to use inorganic fertiliser and quantity used (intensity of inorganic fertiliser usage) is referred to as inorganic fertiliser use/usage. An intricate web of socioeconomic, demographic, technical, and institutional indicators affect farmers behaviour to use inorganic fertiliser at farm level to increase productivity, especially in developing countries. Therefore, it is now essential to model farmers' responses to the use of inorganic fertiliser as well as the intensity of use.

An input's adoption or usage, as well as its intensity of use, can theoretically be decided either jointly or separately (Gebremedhin & Swinton 2003). This flaw can be filled by the Cragg (1971) double-hurdle model, which has been widely used in a number of empirical research. When the double-hurdle approach is used, both hurdles—the choice to use and the level of use—have equations attached to them that take into account the effects of the farmer's conditions and traits. Such explanatory variables might appear in one, both, or neither of the equations. Most crucially, a variable that appears in both equations may have diametrically opposed effects (Teklewold et.al. 2006). Depending on how the adoption variable is measured, either as a decision or as intensity of adoption.

In order to establish the variables that affect the application and intensity of inorganic fertiliser, a double hurdle model is used in this study. The double-hurdle model is a parametric version of the Probit model in which the application of inorganic fertiliser is determined by two different stochastic processes. Probit model forecasts the probability of factors of whether a smallholder farmer uses inorganic fertiliser or not. Because it could confine the utility value of the choice to adopt variable to fall between zero and one and because it could solve the heteroscedasticity problem, the Probit model was suitable (Bright, Victor & Daniel 2011). The model particularly permits the factors that affect the decision to adopt and the intensity of adoption to vary on their own (Temitayo & Kabir, 2016).

The First Hurdle-Adoption Equation (P_i)

The double-hurdle model has inorganic fertiliser adoption equation given as:

$$P_i^* = \beta_i X_i + \mu_i \quad (3.1)$$

$$P_i = \begin{cases} 1, & \text{if } p_i^* > 0 \\ 0, & \text{if } p_i^* \leq 0 \end{cases} \quad (3.2)$$

Where: P_i^* is the latent variable that takes the value 1 if the smallholder maize farmer uses inorganic fertiliser and 0 if otherwise; X_i is a vector of independent variables affecting the use of inorganic fertiliser by smallholder maize farmers; β_i is a set of unknown parameters to be estimated; μ_i is an error term which is normally distributed with mean (0) and standard deviation of 1, and captures all unmeasured variables.

The empirical model employed to determine the inorganic fertiliser use is given as:

$$P_i = \beta_0 + \beta_1 \text{Sex} + \beta_2 \text{Age} + \beta_3 \text{Maize as major crop} + \beta_4 \text{Off-farm} + \beta_5 \text{Production scale} + \beta_6 \text{Credit access} + \beta_7 \text{Agroecological zone} + \beta_8 \text{Production purpose} + \beta_9 \text{Home to farm distance} + \beta_{10} \text{Own land} + \beta_{11} \text{Education} +$$

$$\beta_{12}FBO + \beta_{13}Extension\ access + \beta_{14}Use\ of\ improved\ seeds + \beta_{15}Very\ fertile + \beta_{16}Fertile + \beta_{17}Unit\ price\ of\ fertiliser + \mu_i \quad (3.3)$$

Where, β_0 is the constant term, $\beta_1, \beta_2, \beta_3, \dots, \beta_{17}$ are the parameters of the respective explanatory variables in the model, and μ_i is the error term.

The Second Hurdle-Outcome Model (intensity of inorganic fertiliser use)

Determining the variables that affect the intensity of inorganic fertiliser application is the second stage of analysis. The extent of inorganic fertiliser use intensity is calculated using the truncated regression model in the second hurdle model. The intensity of inorganic fertiliser use Y_i can be modelled as:

$$Y_i = \frac{\text{Quantity of Fertilizer Used (kg)}}{\text{Total Area of Land (Ha)}} \quad (3.4)$$

The decision to intensify inorganic fertiliser use is modelled as a regression truncated below the average inorganic fertiliser use intensity as expressed below:

$$Y_i^* = X_i\beta + \mu_i, \mu_i \sim N(0, \sigma^2) \quad (3.5)$$

$$Y_i = \begin{cases} Y_i^* & \text{if } Y_i^* > 0 \text{ and } d_i = 1 \\ 0 & \text{if } Y_i^* \leq Y_0 \text{ and } d_i \leq 1 \end{cases} \quad (3.6)$$

Where Y_i is the inorganic fertiliser use intensity which depends on the latent variable Y_i^* being greater than zero and conditional to the decision to use inorganic fertiliser (d_i), X_i is the vector of explanatory variables hypothesized to influence inorganic fertiliser use intensity, Y_0 is the threshold inorganic fertiliser use intensity.

The empirical model employed to determine the inorganic fertiliser use intensity is given as:

$$Y_i = \beta_0 + \beta_1 \text{Sex} + \beta_2 \text{Age} + \beta_3 \text{Maize as major crop} + \beta_4 \text{Off-farm} + \beta_5 \text{Production scale} + \beta_6 \text{Credit access} + \beta_7 \text{Agroecological zone} + \beta_8 \text{Production purpose} + \beta_9 \text{Home to farm distance} + \beta_{10} \text{Own land} + \beta_{11} \text{Education} + \beta_{12} \text{FBO} + \beta_{13} \text{Extension access} + \beta_{14} \text{Use of improved seeds} + \beta_{15} \text{Very fertile} + \beta_{16} \text{Fertile} + \beta_{17} \text{Unit price of fertiliser} + \mu_i \quad (3.7)$$

Where, β_0 is the constant term, $\beta_1, \beta_2, \beta_3, \dots, \beta_{17}$ are the parameters of the respective explanatory variables in the model to be estimated, and μ_i is the error term.

3.3.2 Effect of inorganic fertiliser use on maize productivity

This objective is to establish the relationship between inorganic fertiliser use by maize farmers and productivity in the study area. A linear regression was used to analyse this, yield was used as the dependent variable and inorganic fertiliser plus other production variables as the independent variables. A Cobb-Douglas functional form was fitted as:

$$\ln(\text{Maize Farm Productivity}) = \beta_0 + \beta_1 \ln(\text{maize farm size}) + \beta_2 \text{Family labour} + \beta_3 \text{Hired labour} + \beta_4 \text{Seed expenditure} + \beta_5 \text{Top dressing fertiliser} + \beta_6 \text{Basal fertiliser} + \beta_7 (\text{Basal fertiliser} * \text{Improved Seed}) + \beta_8 \text{Pesticide Frequency} + \beta_9 \text{Age} + \beta_{10} (\text{Age} * \text{Maize Experience}) + \beta_{11} \text{Sex} + \mu_i \quad (3.8)$$

Where, β_0 is the constant term, $\beta_1, \beta_2, \beta_3, \dots, \beta_{11}$ are the parameters of the model's respective explanatory variables, and μ_i is the error term.

3.3.3 Effect of inorganic fertiliser use on farm commercialisation by maize farmers

This objective sought to analyse the effect of inorganic fertiliser use on farm commercialisation among maize farmers. Agricultural Household Commercialisation Index (HCI) was computed as a measure of the level of commercialisation. HCI measures the extent to which household crop

production (in this case maize) is oriented towards the market. The HCI value ranges between 0 to 1 (or 0-100%). In interpreting the HCI, a value of zero (0%) signifies a household entirely focused on subsistence farming, while a value of 1 (100%) indicates a farmer fully engaged in market-oriented agricultural activities (fully commercialised farmer). The HCI is computed as:

$$HCI = \frac{\text{Total volume of crop sold}}{\text{Total volume of crop produced}} \times 100 \quad (3.9)$$

A Tobit model was then used to estimate the effect of inorganic fertiliser use on the HCI of the maize farmers. The Tobit model assumes that the observed dependent variable Y_i for observations $j = 1 \dots \dots n$ satisfy:

$$Y_j = \max (Y_j^*, 0) \quad (3.10)$$

where Y_j are the latent variables derived from the classical linear regression model:

$$Y_j = \beta' X_j + U_j, \quad Y_j = \begin{cases} Y_j^* & \text{if } Y_j^* > 0 \\ 0 & \text{if } Y_j^* \leq 0 \end{cases} \quad (3.11)$$

X_j denotes vector of explanatory variables, β' is the corresponding parameters to be estimated. U_j are assumed to be independently normally distributed.

The empirical model employed to examine the effect of inorganic fertiliser use on farm commercialisation by the research area's smallholder farmers are defined as:

$$Y_j = \beta_0 + \beta_1 \text{Sex} + \beta_2 \text{Age} + \beta_3 \text{Maize as major crop} + \beta_4 \text{Off-farm} + \beta_5 \text{Production scale} + \beta_6 \text{Credit access} + \beta_7 \text{Agroecological zone} + \beta_8 \text{Production purpose} + \beta_9 \text{Home to farm distance} + \beta_{10} \text{Own land} + \beta_{11} \text{Education} + \beta_{12} \text{FBO} + \beta_{13} \text{Extension access} + \beta_{14} \text{Experience} + \beta_{15} \text{Household size} + \beta_{16} \text{Community market} + \beta_{17} \text{Maize price information} + \beta_{18} \text{Fertiliser quantity} + \mu_i \quad (3.12)$$

where, β_0 is the constant term, $\beta_1, \beta_2, \beta_3, \dots, \beta_{17}$ are the parameters of the model's respective explanatory variables, and μ_i is the error term.

3.3.4 Effects of inorganic fertiliser use on farm profitability

The objective analyses the effect of inorganic fertiliser use on maize farmers profitability. The profitability of inorganic fertiliser use was estimated using the Value Cost Ratio (VCR). The VCR is a common method for examining the financial incentives to use inorganic fertiliser. It is defined as the ratio of technical response to inorganic fertiliser uses and the fertiliser-output price ratio (Kelly, 2006). Following the definition, the VCR can be computed as:

$$VCR = \frac{O}{N} / \frac{P_N}{P_O}$$

Where: VCR = measure of profitability

O = output of maize

N = quantity of inorganic fertiliser used (nutrients)

P = Price of inorganic fertiliser

$\frac{O}{N}$ = output-nutrient ratio (amount of maize output per N units of inorganic fertiliser)

$\frac{P_N}{P_O}$ = nutrient-output price ratio (the ratio of the cost per one unit of inorganic fertiliser to the value of one unit of output).

If the VCR is greater than one, inorganic fertiliser use is profitable and incentivized because the value of the output generated exceeds the cost of the inorganic fertiliser; however, according to literature, the usual rule for developing countries is that the VCR must be greater than two before

a farmer will consider applying inorganic fertiliser, and in certain high-risk conditions, the VCR may need to be as high as four (Morris et al. 2007). This is because farmers may face additional costs to applying fertiliser and they may face risks each year that could lower output, lowering their VCR. In this study, a farmer is considered profitable from inorganic fertiliser use if the VCR is greater than 2 and not profitable if the value is not more than two.

Having estimated the VCR and classified into two, profitable and non-profitable farmers, a binary model, specifically the probit model, was estimated to determine the factors influencing the profitability of the farmers. The probability that inorganic fertiliser use is profitable for maize farmers is given by:

$$P\left(Y = \frac{1}{X}\right) = P(Z_i < \beta_0 + \beta_j X_{ij}) = F(Y_i) \quad (3.13)$$

$$P\left(Y = \frac{1}{X}\right) = F(XB) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{XB} e^{-\frac{(XB)^2}{2}} dx \quad (3.14)$$

$$X = (1, x_{1i}, x_{2i}, \dots, x_{ki}) \quad (3.15)$$

$$\beta' = (\beta_0, \beta_1, \dots, \beta_k) \quad (3.16)$$

Where $P\left(Y = \frac{1}{X}\right)$ is taken as the probability that the inorganic fertiliser use is profitable given the values of explanatory variables X, and where Z_i is a random variable normally distributed with mean zero and unit variance, $Z_i \sim N(0, \sigma^2)$. The relative effect of each explanatory variable on the likelihood that inorganic fertiliser use will be profitable is specified as follows:

$$\frac{\partial P_i}{\partial X_{ij}} = \beta_{ij} * f(Z_i) \quad (3.17)$$

where $f(Z_i)$ is the inverse of the cumulative normal function and β_{ij} are the estimated parameters.

The elasticity of the predicted probability is then computed as:

$$\frac{\partial P_i}{\partial X_{ij}} = \beta_{ij} * f(Z_i) * \frac{\bar{X}}{p_i} \quad (3.18)$$

The empirical model employed to determine the profitability of inorganic fertiliser use is given as:

$$VCR = \beta_0 + \beta_1 Sex + \beta_2 Age + \beta_3 HCI + \beta_4 Off - farm + \beta_5 Production scale + \beta_6 Credit access + \beta_7 Community market + \beta_8 Carting asset + \beta_9 Education + Experience_{10} + \mu_i \quad (3.19)$$

where, β_0 is the constant term, $\beta_1, \beta_2, \beta_3, \dots, \beta_{17}$ are the parameters of the model's respective explanatory variables, and μ_i is the error term.

The double hurdle model delved into the decision-making process of farmers regarding inorganic fertiliser use. By establishing two hurdles, the first hurdle identified the factors influencing the initial decision to use or refrain from fertilisers. Subsequently, the second model further explored the factors affecting the intensity of inorganic fertiliser use among those who chose to make use of it. Following this, a linear regression analysis uncovered the relationship between inorganic fertiliser use and maize productivity. This analysis revealed how changes in inorganic fertiliser use from the double hurdle model can influence the productivity of maize crops. Having established the role of inorganic fertilisers in productivity improvement, it is important to understand the commercialisation of the output of the farmers and the role of the use of inorganic fertilisers in influencing the extent to which the farmers commercialise their outputs. The level of commercialisation among maize farmers was measured through the Household Commercialisation Index (HCI). A Tobit model was then employed to explore the effect of inorganic fertiliser use on commercialisation. Finally, the Value-Cost Ratio (VCR) analysed the profitability of inorganic

fertiliser use in maize farming, providing insights into the economics of inorganic fertiliser use in relation to maize production, as a way of ensuring that beyond the potential roles of inorganic fertiliser use in increasing productivity and commercialisation among farmers, its use remain economic viable investment among the farmers. Overall, these points together offer a holistic analysis of the role of inorganic fertiliser use in improving the productivity, commercialisation, and profitability among maize farmers.



3.4 Description of Variables

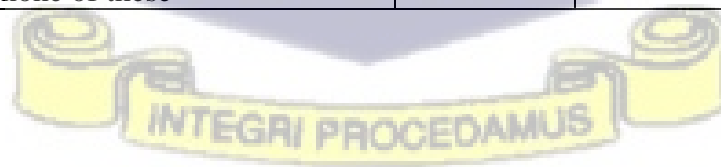
Table 3.1 presents the definition and measurement of the variables that have been used in the study.

Table 3.1: Description of Variables

Variable	Definition	A priori expectations				
		Fertiliser use decision	Fertiliser use intensity	Maize productivity	Maize commercialisation	Maize Profitability
Dependent variables						
HCI	The proportion of total volumes of output sold to total production volume					+
VCR	A measure of the product of the maize yield response to inorganic fertiliser and the fertiliser-output price ratio					
Inorganic fertiliser usage	Dummy: 1 if farmer uses inorganic fertiliser and 0 if not					+
Inorganic fertiliser intensity	Kilogram per hectare					
Independent variables						
Sex	Dummy: 1 if farmer is a male and 0 if a female	+	+	+	+	
Age	The total number of years from birth to the time of the data collection	-	-	+	-	+
Maize as major crop	Dummy: 1 if the farmer cultivated maize as a major crop and 0 if a secondary crop	+	+		+	
Off-farm	Dummy: 1 if farmer engaged in any economic activity in addition to farming and 0 if not	-	+		+	+
Production scale	Dummy: 1 if the farmer cultivated more than 2ha of maize and 0 if 2ha or less	+	+			-

Variable	Definition	A priori expectations				
Credit access	Dummy: 1 if farmer had access to credit during the production season and 0 if not	+	+		-	+
Agroecological zone	Dummy: 1 if the farmer is located in Guinea Savannah zone and 0 if in the Transitional zone	+	-		-	+
Production purpose	Dummy: 1 if the primary aim of producing maize is for home consumption and 0 if for sale	+	+		+	
Home to farm distance	The total distance from the farmer's residence to the farm in kilometres	-	-			
Own land	Dummy: 1 if the farmer cultivated maize on his/her own land and 0 if not	-	-		+	
Top-dressing fertiliser	Dummy: 1 if the farmer uses top-dressing of fertilisers and 0 if not			+		
Basal fertiliser	Dummy: 1 if the farmer uses basal dressing of fertilisers and 0 if not			+		
Maize farm size	Hectare (Ha)				+	
Family labour	Number of family labour per hectare			-		
Hired labour	Number of hired labour per hectare			-		
Education	the total number of years of formal education	-	-	-	+	+
FBO	Dummy: 1 if farmer belonged to an FBO and 0 if not	-	-		+	+
Extension access	Dummy: 1 if the farmer had access to extension and 0 if not	+	-		-	+
Use of improved seeds	Dummy: 1 if the farmer used an improved maize seed variety and 0 if local seed	+	+			
Unit price of fertiliser	The price per kilogram of fertiliser			+		
Pesticide	Number of times pesticides are used per hectare				+	

Variable	Definition	A priori expectations				
Seed expenditure	Ghana Cedis per Hectare (GHS/Ha)			+		
Ready market	Dummy: 1 if the farmer had access to ready market and 0 if not					+
Community market	Dummy: 1 if the farmer had access to community market centres and 0 if not				+	
Very fertile	Dummy: 1 if the farmer perceived that he/she can obtain maximum/expected yield on farmland without external inorganic fertiliser application and 0 if the land cannot be used for maize production without fertiliser application	-	-			
Fertile	Dummy: 1 if the farmer perceived that he/she can obtain some yield on farmland but can only obtain expected yield with an external inorganic fertiliser application and 0 if the land cannot be used for maize production without inorganic fertiliser application	-	-			
Maize price information	Dummy: 1 if farmer had access to maize price information and 0 if not				+	
Household size	The number of people in the household				-	
Experience	The number of years the farmer has been engaged in farming				+	+
Fertiliser use	Dummy: 1 if farmer applied the right quantity of inorganic fertilisers and 0 if not				+	
Carting asset	Dummy: 1 if farmer own any of bicycle, motorbike, motorking (aboboya), donkey or a car and 0 if own none of these					



3.5 Data Collection and Sampling Techniques

This data for this study is a subset data of a larger dataset collected with other students. The larger dataset was obtained through a multistage sampling procedure. Purposive sampling was employed in the first stage to choose eight regions in the Guinea Savannah and Transitional ecological zones. These regions were purposively selected because of their high involvement in maize production and the implementation of several agricultural programs including International Fertilizer Development Center's (IFDC) Fertilizer Research and Responsible Implementation (FERARI) program. In each of the regions, two districts were randomly selected in the second stage from a pool of districts considered by FERARI in its past studies. This was to ensure that the results generated in this study can be favourably compared with previous studies in the districts. In the third stage, simple random sampling was used to select four communities in each selected district, resulting in a total of 64 communities for the study. In the final stage, 12 farmers were randomly selected from each of these chosen communities, making a total of 768 farmers.

However, among the 768 farmers, there were individuals engaged in cultivating maize, rice, and/or soybeans. Since this study specifically focused on maize farmers, a subset of the data was created by excluding farmers who did not cultivate maize. After sorting the data, it was discovered that one district had records for only 28 maize farmers. To give equal weight of sample size for each district and representation of the population, 28 maize farmers were selected randomly from each district. Given this, the total sampled of maize farmers used for the study is 448 (see Table 3.2 for details).

The data for this study was collected using questionnaire. The questionnaire is a composite one designed for this study and other objectives that were considered by FERARI. The questionnaire received inputs from the thesis supervisors and the FERARI team. Relevant to this study, the data

was collected on socioeconomic characteristics, production inputs, fertilisers, and marketing of maize output. The questionnaire was programmed onto the kobo collect toolbox, a free and open-source toolkit for building forms and collecting interview responses. After the design, the tool was tested by the author and the other students to ensure accuracy.

FERARI supported the data collection with other enumerators. The enumerators were trained on how to use the kobo collect toolbox as well as the questionnaires they were to administer. Two trainings were done, one in Tamale and the other in Kumasi. After the training in Tamale, a pre-testing of the questionnaire with the enumerators was done. This afforded the researcher the opportunity to modify some of the questions to make them relevant and clearer. Other questions were modified with appropriate units of measurement to help in collecting the right information. The research assistants (enumerators) departed to the various regions and districts for the actual data collection.

Table 3.2 Regions, Districts and Communities sampled

Regions	Districts	Communities	Total
Ahafo	Tano South	Adomakokrom, Brosankro, Kwasu, Owen Nkwanta	28
	Asutifi	Guom Asamang, Kenyasi No. 3, Kramokrom, Kwakurikrom	28
Bono	Berekum East Municipal	Akatim, Namaasua, Pepaase, Senease	28
	Wenchi Municipal	Agubie, Boasu, Nchiraa, Subinso	28
Bono East	Techiman Municipal	Abrefi, Bomiri, Kenteen, Tadiaso	28
	Kintampo South	Jema, Krutakyi, Pamdu, Paninamisa	28
North East	East Mamprusi Municipal	Boayini, Jawani, Teanoba, Zarantinga	28
	West Mamprusi Municipal	Gbani, Takorayiri, Wungu, Zangum	28
Savannah	Central Gonja	Kalinkaa, Sankoyili, Sankpagla, Sankungyili	28
	North East Gonja	Fuu, Kpanshegu, Tantuyani, Yepala	28

Upper East	Kassena Nankana East	Namolo, Saboro, Warania, Wusungu	28
	Bongo	Balungo, Kuyellingo, Nayorigo, Sambolgo	28
Upper West	Sissala East	Kong, Kowie, Sakai, Sakalu	28
	Sissala West	Buoti, Jawiah, Kandia, Pulima, Silibelle	28
Northern	Gushegu Municipal	Bogu, Jinwoog, Tumtuzei, Yiborigu	28
	Kumbungu	Bihinaayili, Dalun, Voggu Kushibo, Zangbalung	28
Total			448

3.6 Description of the Study Area

The six major ecological zones of Ghana are Sudan Savannah, Guinea Savannah, Transitional, Semi-Deciduous Rainforest, High Rainforest, and Coastal Savannah. This study, however, was conducted in the Transitional and Guinea Savannah zones as seen in Figure 3.2. This was because most locals farm crops, these communities are predominantly agrarian. The climate, soil, and native vegetation of each zone are often different.

The major rainy season, which starts in April through to the second week of July, is what distinguishes the rainfall pattern in the Transitional zone from other regions. More than 75 percent of the yearly rainfall may be measured during this time. After the minor rainy season in September and October, there is a protracted dry period from November through the end of March or the beginning of April. The range of the annual total precipitation is 1100 to 1400 mm. With the lowest recorded temperature in August and the highest recorded in December, January, and February, the temperature range in the zone is 17 to 33 °C.

On the other hand, the Guinea Savannah zone is distinguished by clearly defined rainy and dry seasons that last roughly equal lengths of time and have mean annual rainfall between 900- and 1100-mm. Rainfall totals rise steadily each month starting in March and peaking in August or

September. All through the year, the average monthly temperatures are high, averaging between 25-degree celsius and more than 33 degree celsius. When it's dry and hot, relative humidity drops to 35 percent from 75 percent during the rainy season.

The climate in the research region is divided into three separate zones: humid in the south, semi-humid in the centre, and semi-arid in the north. The cold and humid South-West Monsoon winds that blow in from the Atlantic Ocean in the south and the hot, dusty, and dry North-East Trade Winds (Harmattan) that blow in from the Sahara Desert in the north dominate the climate (Dickson & Benneh, 1988). The grasslands that make up the Guinea Savannah zone's predominant vegetation are studded with trees and shrubs like mango, shea, baobab, and neem. However, the Transitional zone is distinguished by dry woods with a few big trees and shrubs and grasses growing beneath them.

The area's primary land-use activity is still agriculture. The majority of agricultural operations are rain-fed, subsistence farming (Ofosu et al., 2014). Therefore, during the rainy season, it's typical to find a number of small farm fields dispersed around the region. According to Atengdem et al. (2013), farmers in the research areas mostly rely on crop cultivation, poultry, and livestock for their income. The principal crops grown in the Guinea Savannah zone are maize, millet, sorghum, cowpea, and yam, while maize, cowpea, and yam are primarily grown in the Transitional zone. Due to the fact that farming is rainfed, it is primarily restricted to the rainy season, with little to no farming occurring during the dry season.

It is worth noting that, unlike farmers in the Guinea Savannah zones, who are able to grow crops once a year using rainfed, farmers in the Transitional zone can do so twice a year (major and minor). The production techniques utilised and the yields obtained by farmers reflect the differences in growing seasons, weather, soil, and vegetation cover between the zones. According

to Asravor et al. (2019), farmers in the Transitional zone were 45 percent more productive than those in the Guinea Savannah zone. Similarly, Wongnaa and Awunyo-Vitor (2019) reported that maize farmers in the Guinea Savannah zone had an average output of 2.2 tonnes per hectare, while those in the Transitional zone had an average yield of 4.2 metric tons per hectare.



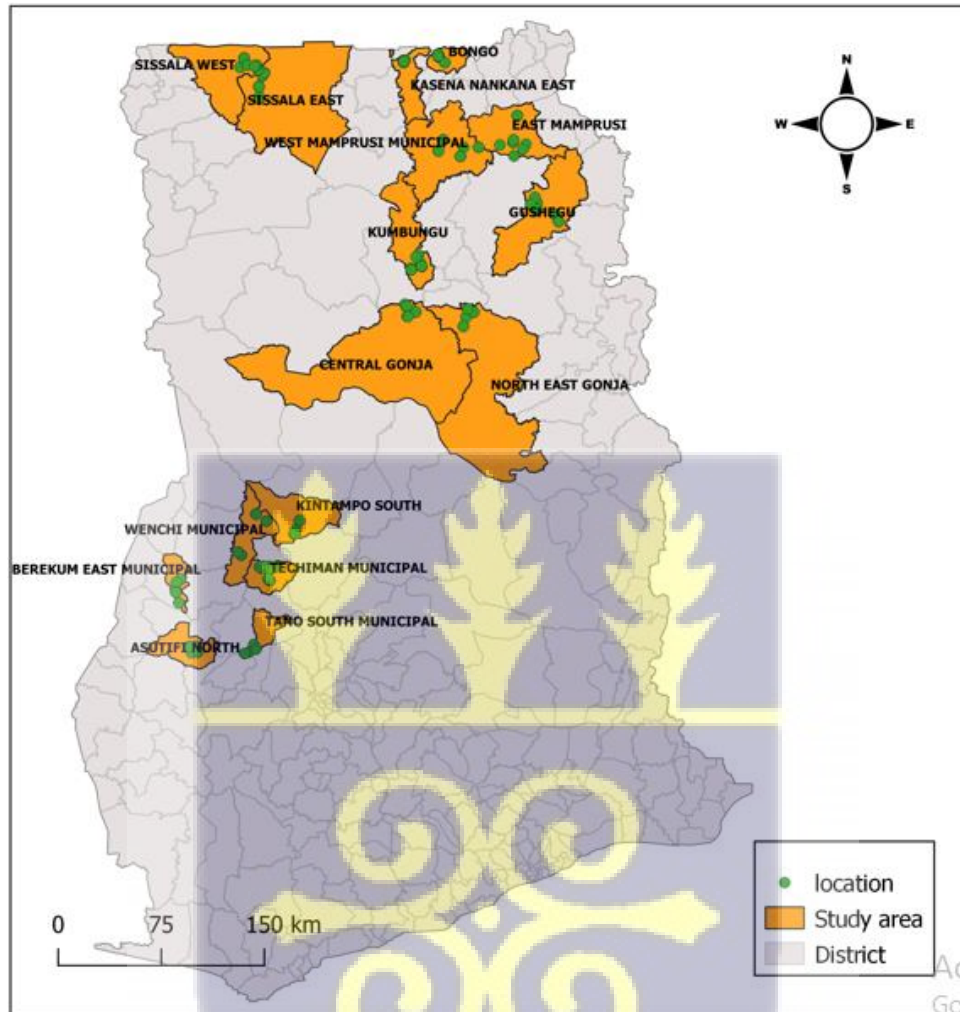


Figure 3.2: Map of the Ghana with indications of the Study Area

Source: IFDC database

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Introduction

This chapter presents the results and the discussions of the study. The first section discusses the socioeconomic characteristics of sampled farmers. The factors influencing farmers' decision to use inorganic fertilisers and the intensity of inorganic fertiliser application are discussed next. This discussion is followed by the presentation of the effects of inorganic fertiliser application regimes on maize productivity, the effect of quantity of inorganic fertiliser on commercialisation and the drivers of profitability of inorganic fertiliser application in maize production.

4.1 Socio-economic and Farm Characteristics of Respondents

The profile of the sampled farmers results is presented in Table 4.1. The average age of the farmers was 45.8, ranging from 18 to 80 years. Almost eight out of ten (78.8%) of the farmers were males. The dominant role of males in maize production could be linked to their control of relatively higher levels of production resources as compared to those available to female maize farmers. About 72.8% of the sampled farmers cultivated maize as a major food crop and 59.8% of them engaged in off-farm income generation activities. On average, the farmers had about five years of formal education. The average household size was about 9.5 and ranged from 1 to 30. The average number of years of farm experience of respondents was 17.2; this ranged from 1 to 57.

In terms of the size of maize farms, the average was 5.6 ha and the farm was about five km from the home/homestead. The average farm size for maize farm is above national land holding for a farm household (MoFA, 2021). About 13 out of 20 (65%) farmers cultivated more than two hectares (Ha). The semi-subsistence nature of farmer production was indicated by the fact that

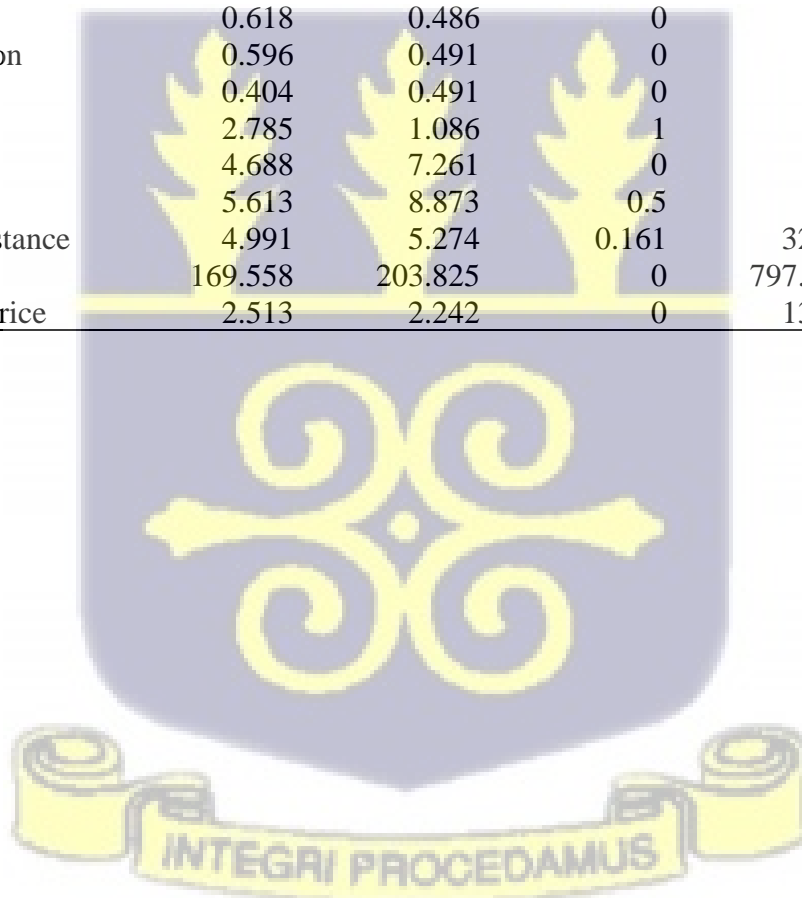
about three out of four (75.2%) of the responding farmers cultivated maize for household consumption. Slightly over half (52%) of the farmers cultivated maize using their own land resources, while slightly over one in four (26.8%) of the farmers had access to credit. Access to agricultural extension services was indicated by almost half of the farmers (47.3%). The use of improved maize seed varieties was indicated by 42.9% of the farmers.

With regards to the geographical location of the farmers, about five out of eight (62.5%) of the farmers were based in the Guinea savannah agroecological zone. Slightly over one third (34.4%) of the respondents belonged to farmer-based organisations (FBO). In terms of farmland fertility, about 19.2%, 19%, and 61.8% of the farmers responded that their farmlands were less fertile, very fertile, and fertile respectively. Farmers form their opinions about the land they use for farming based on things like the kind of soil, its colour, and the types of weeds that grow there, number of years of cultivating the land, etc. This result would suggest an overall moderately-fertile nature of the land and possible need for the use of inorganic fertilisers to enhance maize production and productivity.

There are two common methods for the application of inorganic fertilisers. These were the basal application (first application/dosage) and top-dressing (second application/dosage). About 60% of the farmers used basal fertiliser dosage while 40% used the top-dressing dosage. Table 4.1 also indicates that the average numbers of family labour and hired people used for work on farms were 2.8 and 4.7, respectively. The average farmer applied about 169.56 kg/Ha (3.4 bags of fertiliser per hectare) of fertiliser to a maize farm. The fertiliser unit price at the time of the study was GHS 2.50, meaning the cost of a farmer applying inorganic fertiliser per hectare was approximately GHS 424.00.

Table 4.1: Characteristics of sampled farmers

Variable	Mean	Std. Dev.	Min	Max
Sex	0.788	0.409	0	1
Age	45.8	12.728	18	80
Education	5.056	5.434	0	16
Off-farm activity	0.598	0.491	0	1
Household size	9.467	5.260	1	30
Experience	17.158	12.141	1	57
Production credit	0.268	0.443	0	1
Agroecological zone	0.625	0.485	0	1
Own land	0.52	0.500	0	1
Membership to FBO	0.344	0.475	0	1
Extension	0.473	0.500	0	1
Improved seeds	0.429	0.495	0	1
Less fertile land	0.192	0.394	0	1
Very fertile land	0.19	0.393	0	1
Fertile land	0.618	0.486	0	1
Basal application	0.596	0.491	0	1
Top-dressing	0.404	0.491	0	1
Family labour	2.785	1.086	1	4
Hired labour	4.688	7.261	0	50
Farm size	5.613	8.873	0.5	130
Home-Farm distance	4.991	5.274	0.161	32.18
Fertiliser	169.558	203.825	0	797.531
Fertiliser unit price	2.513	2.242	0	13.18



4.2 Inorganic Fertiliser Utilisation

Figure 4.1 illustrates the inorganic fertiliser utilisation and utilisation distribution respectively in Ghana by region. From the sample, 60% of the farmers used inorganic fertilisers while 40% did not use. Specifically, in the Northern region, about 80% of farmers used inorganic fertiliser in maize production. About 98% and 55% of farmers in Upper West and Upper East regions used inorganic fertiliser in maize production respectively. Additionally, inorganic fertiliser utilisation in Savannah and North-East regions was estimated to be 39% and 71% respectively. In Bono East and Bono regions, inorganic fertiliser utilisation stood at 77% and 48% respectively. The inorganic fertiliser utilisation was about 7% in the Ahafo region of Ghana.

4.3 Inorganic Fertiliser Utilisation Intensity Methods among Farmers

The inorganic fertiliser application methods are first (basal) application and second (top-dressing) application. Farmers used different kinds of inorganic fertiliser for basal and top-dressing applications in maize production. The result of utilisation and inorganic fertiliser utilisation rate for both basal and top-dressing are presented in Table 4.2. By inspection, NPK 15:15:15 (42.57%), NPK 23:10:5+4MgO + 2Zn (20.79%), and NPK 15:10:10 (11.22%) were the first top three inorganic fertiliser types farmers used for the basal application while NPK 21:10:10+2S (1.65%) and NPK 12:30:17+0.4 Zn / NPK 17:10:10 (0.99%) were least popular inorganic fertilisers farmers used in the basal application in maize production. For top-dressing inorganic fertiliser utilisation, the first top three types used were SoA (41.45%), Urea (21.24%), and NPK 15:15:15 (19.17%); the least popular types were NPK 21:10:10+2S (1.04%) and NPK 12:30:17+0.4 Zn / NPK 17:10:10 (0.52%).

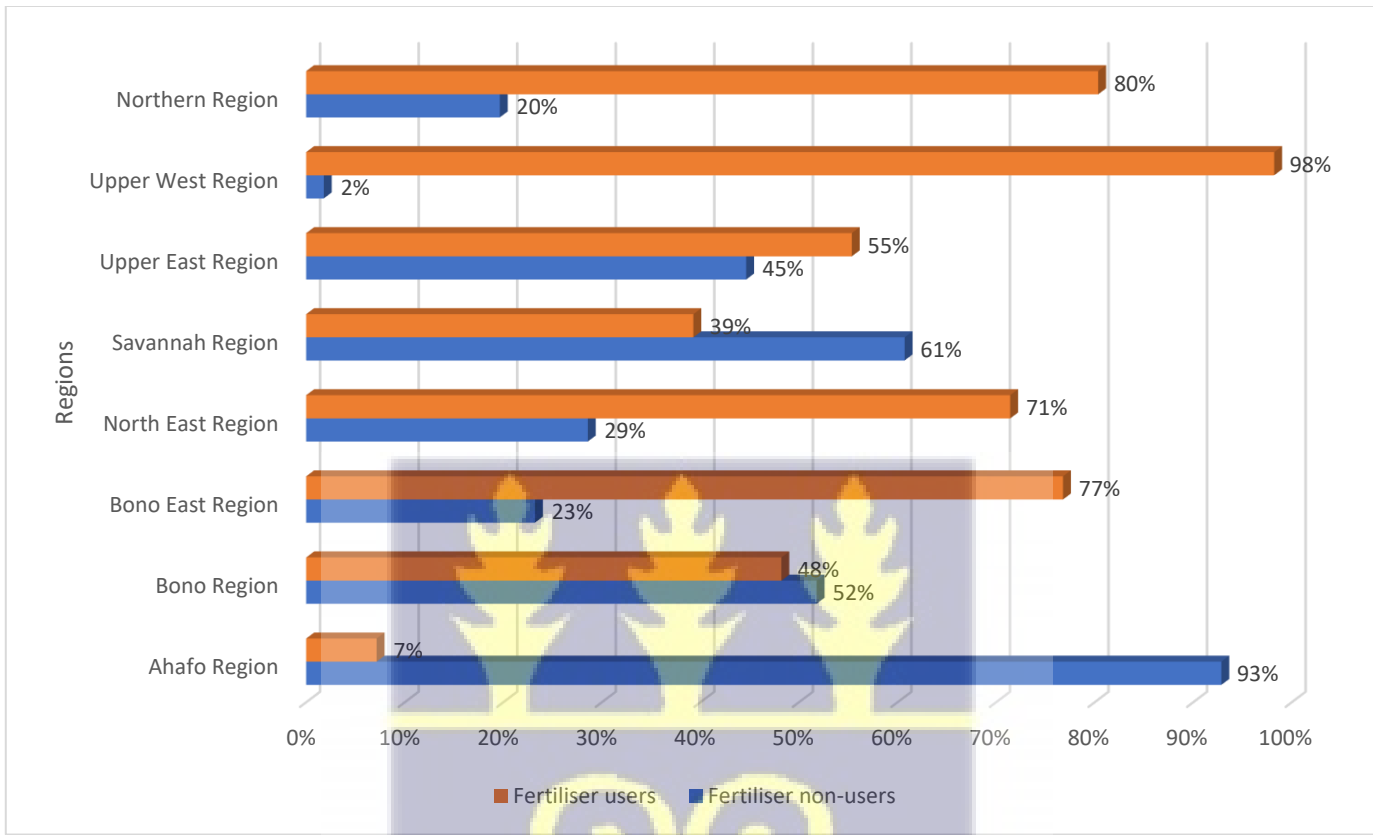


Figure 4.1: Inorganic fertiliser utilisation status, Ghana

Source: Field Survey



Table 4.2: Declared types of inorganic fertilisers used for basal and top-dressing regimes

Fertiliser	Basal			Top-dressing		
	Freq. (%)	Mean (Kg/Ha)	Std. dev.	Freq. (%)	Mean (Kg/Ha)	Std. dev.
NPK 15:15:15	129(42.57)	197.2	134.9	37(19.17)	170.4	170.7
NPK 15:20:20+0.7Zn	9(2.97)	356.2	201.7	7(3.63)	377.3	185.8
NPK 12:30:17+0.4 Zn	3(0.99)	378.2	85.2	1(0.52)	229.3	.
NPK 17:10:10	3(0.99)	318.5	77.0	1(0.52)	41.2	.
NPK 20:10:10 3S+2MgO	12(3.96)	264.4	133.0	1(0.52)	185.2	.
NPK 25:10:10	34(11.22)	292.9	185.5	12(6.22)	258.4	153.7
NPK 21:10:10+2S	5(1.65)	219.4	113.5	2(1.04)	67.9	8.7
NPK 23:10:5+4MgO+2Zn	63(20.79)	188.9	145.9	11(5.70)	168.0	100.2
Urea	23(7.59)	99.7	75.8	41(21.24)	146.7	150.1
SoA	22(7.26)	142.7	114.1	80(41.45)	195.9	140.9
	303(100.00)			193(100.00)		

Note: 50 kg of fertiliser equals to 1bag

Source: Derived from survey, 2022

The results demonstrated that the utilisation rate for NPK 15:15:15 for basal and top-dressing were estimated to be 197.2kg/Ha and 170.4/Ha respectively among maize farmers. The estimates further revealed that maize farmers applied 356.2kg/Ha for basal application and 377.3kg/Ha for top-dressing of NPK 15:20:20+0.7Zn. In terms of NPK 12:30:17+0.4Zn, maize farmers applied 378.2kg/Ha for basal application and 229.3kg/Ha for top-dressing. Maize farmers applied about 318.5kg/Ha for basal application and 41.2kg/Ha for top-dressing using NPK 17:10:10. About 264.4kg/Ha of NPK 20:10:10 3S+2MgO used the basal method of application while 185.5kg/Ha

using the top-dressing method. About 292.9kg/Ha of NPK 25:10:10 was applied for the basal method, and 258.4kg/Ha was applied for the top-dressing method. While 219.4kg/Ha of NPK 21:10:10 +2S was applied to maize through the basal method, about 67.9kg/Ha was applied to maize farms using the top-dressing method. Turning to NPK 23:10:5 + 4MgO + 2Zn fertiliser, about 188.9kg/Ha used in the basal method and 168kg/Ha used in the top-dressing method by farmers. About 99.7kg/Ha and 146.7kg/Ha of Urea were applied using basal and top-dressing methods respectively. Finally, about 142.7kg/Ha and 195.9kg/Ha of SoA were applied to maize through the basal and top-dressing methods respectively.

In the Guinea Savannah zone, 100N-40P₂O₅-40K₂O+2.1Zn is the recommended inorganic fertiliser application nutrient rate, and in the Transitional zone, 90N-60P₂O₅-60K₂O+2.1Zn is recommended (FeSeRWAM, 2022). NPK is recommended for basal application and urea or SoA for top-dressing. 200-300kg/Ha of NPK 15:20:20 + 0.7Zn is recommended for basal while 100-150kg/Ha of urea is recommended for top-dressing. 400kg/Ha of NPK 20:10:10 3S+2MgO is recommended for basal while 100kg/Ha of urea is recommended for top-dressing. This suggests that some farmers do not use the types and rates of application that are recommended. The study also found that 26% of farmers used organic fertilisers for maize production. However, the interest of this study is on inorganic fertilisers. Hence, no further analysis of organic fertilisers was done.

4.4 Adoption of Inorganic Fertiliser Application Methods among Farmers

There are three fertiliser application methods commonly known to farmers in Ghana. These are the broadcasting, side placement and injection into soil. The methods actually used by the sampled farmers are presented in Figure 4.2. Approximately 88% of maize farmers used the side placement approach to apply inorganic fertiliser; about 11% of the farmers applied using the injection into

soil method, only 1% of the farmers used the broadcasting method. The reason for the vast majority of the maize farmers adopting the side placement method could be that this method was less labour and time-intensive compared to the other two methods.



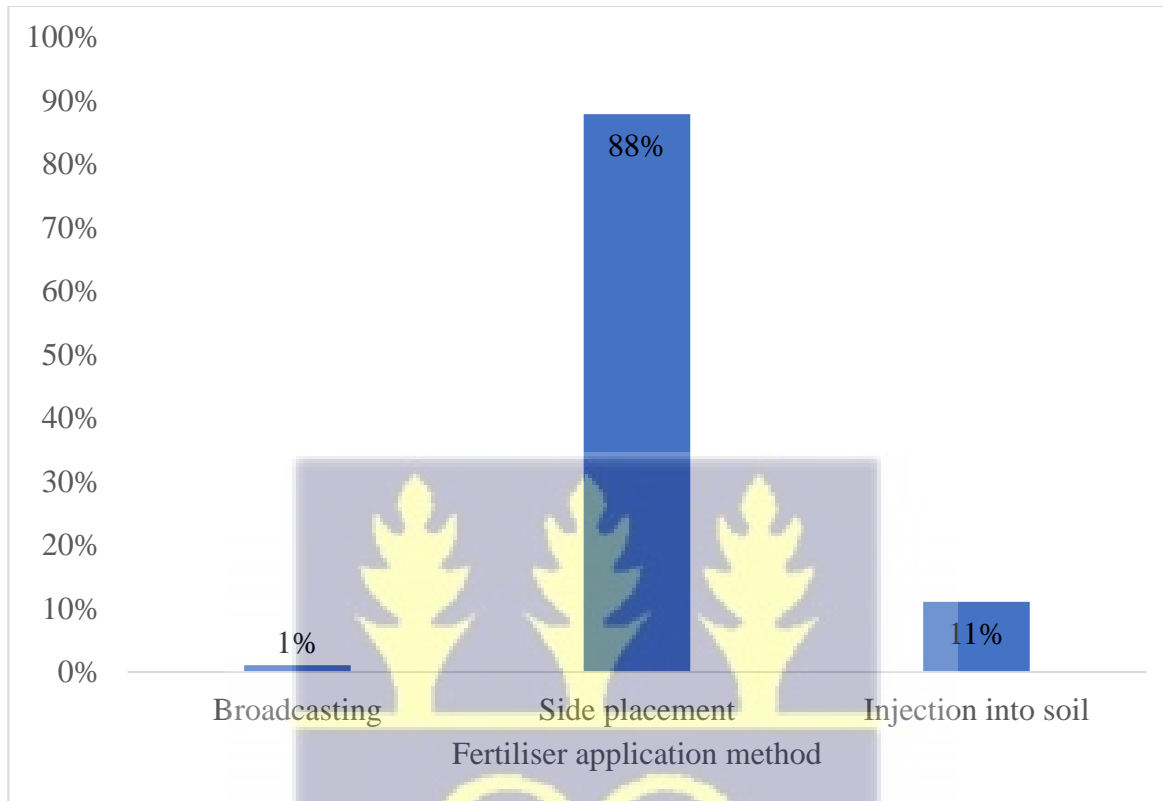


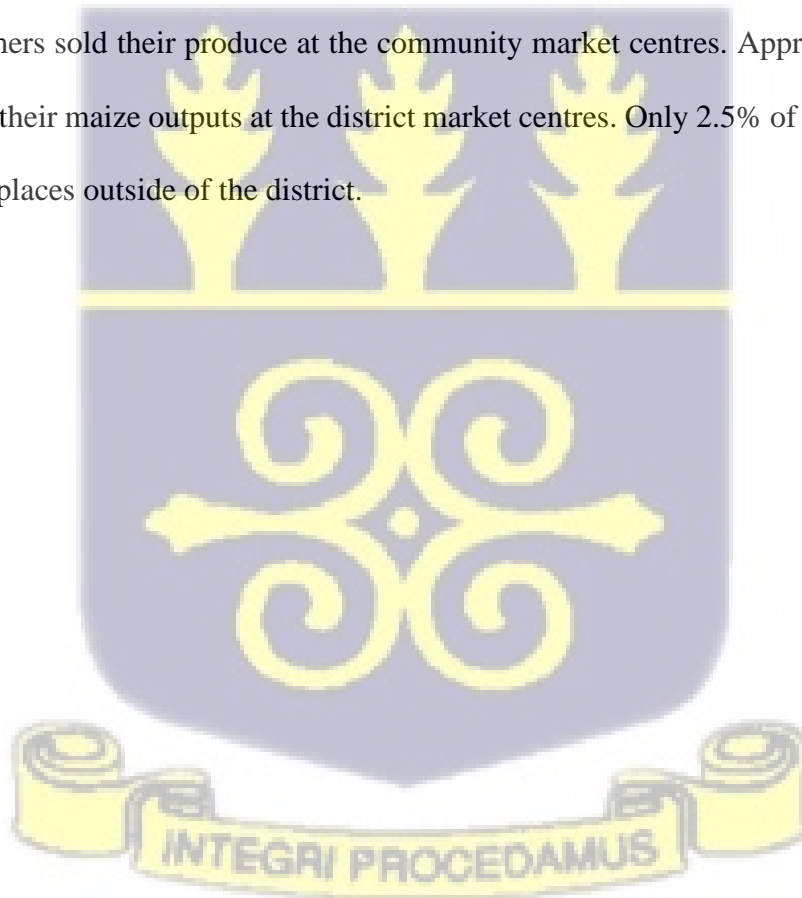
Figure 4.2: Fertiliser application methods

Source: Derived from survey, 2022



4.5 Access to Markets

Figure 4.3 represents the results of access to farm inputs and outputs markets in the study area. Slightly over six out of ten (60.2%) respondents indicated that they had market centres in their communities. Approximately 74.8% of farmers sold their agricultural products at community market centres to various maize value chain actors. Additionally, 72.32% of the survey respondents mentioned that they had established markets readily available for their maize products, which could potentially be attributed to contractual agreements. Farmers sell their maize output to value chain actors at different places (refer to Figure 4.4). The most popular place was at the home of the farmer and this was indicated by almost two-thirds (64.73%) of the farmers. Almost one in ten (9.82%) farmers sold their produce at the community market centres. Approximately 23% of the farmers sold their maize outputs at the district market centres. Only 2.5% of the farmers traded their produce at places outside of the district.



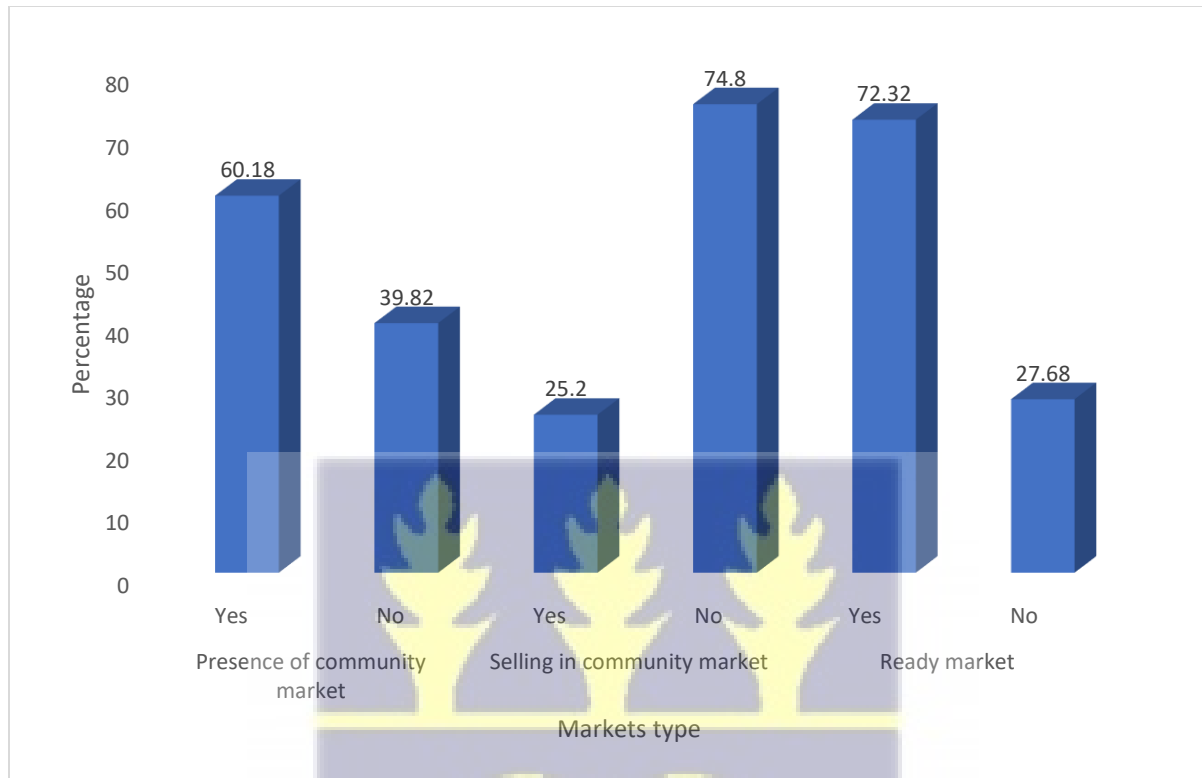
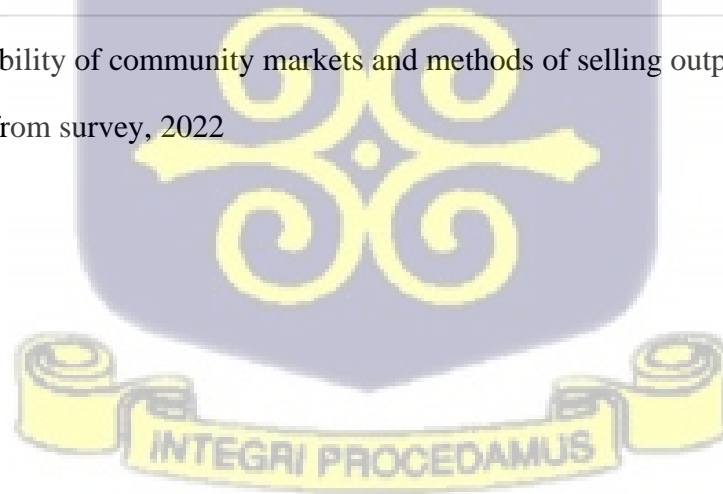


Figure 4.3: Availability of community markets and methods of selling outputs

Source: Derived from survey, 2022



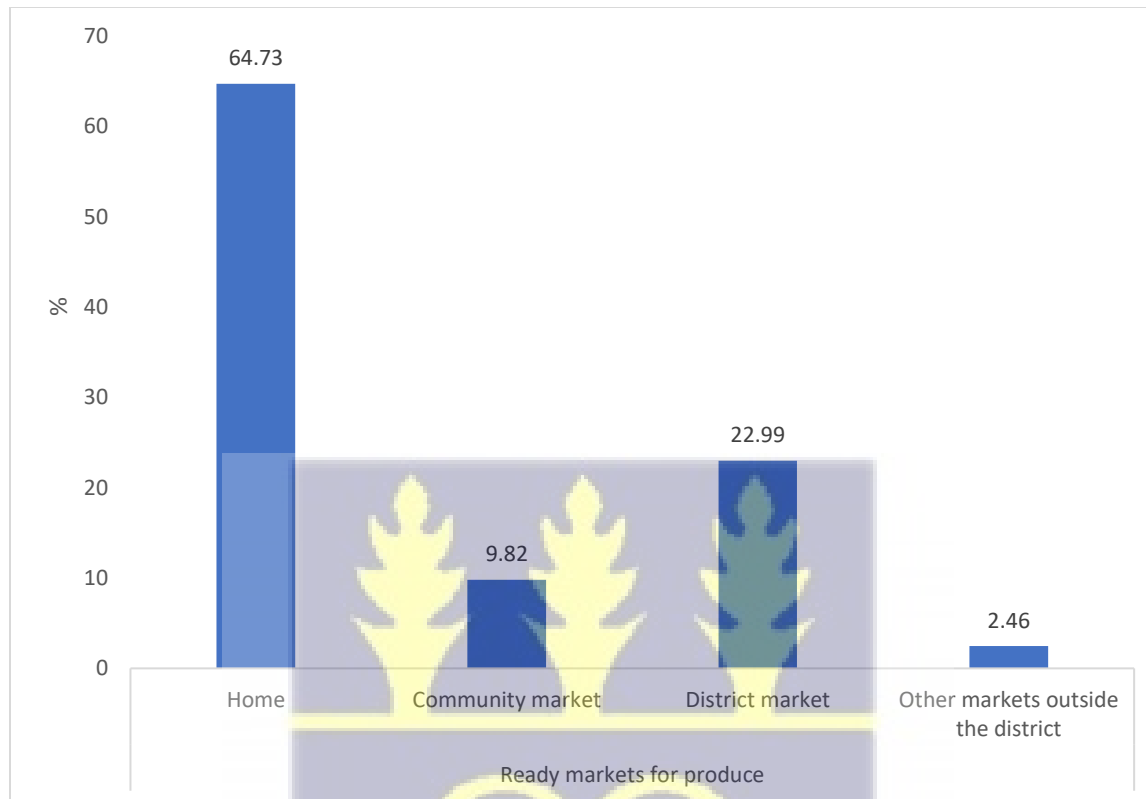


Figure 4.4: Market channels for maize farmers

Source: Derived from survey, 2022

4.6 Access to Market Information Services

Access to maize farm inputs and output price information are important to link farmers to value chain actors to increase productivity and profit margin. Table 4.3 represents the results of the analysis of the types of information maize farmers accessed to in the study area. Six out of ten farmers had access to information related to the sale of maize outputs and almost three out of four farmers (73.7%) had information on the prices of maize outputs. The percentage of farmers who had access to agro-input prices and storage facilities and procedures were 75.7% and 31.9% respectively. Almost one in four (24.6%) farmers had information on the desired quality attributes of their products required by various value chain actors.

Table 4.3: Access to information about inputs and outputs

Information type	Yes		No	
	Freq.	%	Freq.	%
Where to sell output	269	60.04	179	39.96
Price of output	330	73.66	118	26.34
Source of agro-inputs	344	76.79	104	23.21
Prices of agro-inputs	339	75.67	109	24.33
Storage facilities and procedures	143	31.92	305	68.08
Desired qualities of the products by actors (e.g., moisture content, packaging)	110	24.55	338	75.45

Source: Derived from survey, 2022

4.7 Factors Influencing the Decision and Intensity of inorganic Fertiliser Application

Inorganic fertiliser plays a critical role to enhance maize production and productivity. Several factors are responsible for farmers' decision to use inorganic fertiliser and the rate of utilisation. The Cragg hurdle model was employed to examine factors influencing farmers' decision to use inorganic fertiliser and their subsequent rates of inorganic fertiliser utilisation. The results are presented in Table 4.4. The parameter of the *sigma* was statistically significant at a 1% level, signifying that the model was fit for the analysis, instead of the ordinary least squares (OLS) model. Since the model required a two-stage estimation procedure, the model needed to be identified. The unit price of inorganic fertiliser was used for the model identification.

Farmers who cultivated maize as major crop were found to have a positive significant effect on farmers' decision to use inorganic fertiliser at 1% but had no significant effect on the rate of inorganic fertiliser application rate. This indicated that farmers who cultivated maize as a main crop were more likely to utilise inorganic fertiliser in maize cultivation than those who did not. The reason for this result could be that farmers cultivated maize as a major food crop, in both partial and full commercialisation systems. Hence, commercialisation would motivate farmers to use inorganic fertiliser to raise productivity to generate food for the household and to sell surplus maize outputs to generate cash incomes.

Off-farm participation was observed to have a positive significant effect only on the decision to use inorganic fertiliser at a 1% level. This indicates that a farmer who participated in off-farm income generation activities was more likely to use inorganic fertiliser compared to their counterparts. Off-farm activities helped farmers to access and purchase inorganic fertiliser. Off-farm activities build farmers' capacity to be resilient to market shocks which could affect maize production and productivity. Ali et al. (2018) argued that smallholder participation in off-farm

income generation activities assisted them to overcome financial challenges for purchasing farm inputs. Several studies found that off-farm activities also have a positive impact on the adoption of agricultural innovations (Beshir, 2014; Danso-Abbeam and Baiyegunhi, 2017), while others have a negative association with the adoption intensity of farm production technologies (Zakaria et al., 2020).

Agricultural extension service is one of the top critical indicators influencing farmers' decisions to apply farm production technologies. The importance of access to agricultural extension services to agricultural technology uptake and subsequent adoption is widely acknowledged in the literature. As shown in Table 4.4, this study established that farmers access to extension services had a positive significant effect on farmers' decision to use inorganic fertiliser at the 1% level. The implication is that farmers who had access to extension services were more likely to use inorganic fertiliser than those without access to extension services. This is plausible since extension agents link farmers to quality farm inputs such as inorganic fertilisers in rural areas. Extension agents do not only link farmers to the farm input markets but also provide information about the appropriate method and timely application of inorganic fertiliser to farmers. This conclusion is consistent with the findings of other studies (Kassie et al., 2013; Djokoto et al., 2016; Ali et al., 2018) that extension is an asset that enhances farmers' adoption decision of inorganic fertiliser technology to promote agricultural production.

The agroecological zone was found to have a positive effect on both decisions to use and the intensity of inorganic fertiliser utilisation at 1% level. This finding suggested that farmers located in the Guinea Savannah agroecological zone were more likely to use inorganic fertiliser than those located in the in the Transitional zone in Ghana and also were more likely to use inorganic fertiliser at higher intensity levels. The Guinea Savannah is one of the dry areas in West Africa. The major

food crops cultivated in this agroecological zone include maize, sorghum, millet, cowpea, and groundnuts. Poor soil fertility has a significant impact on the production of these important crops. Farmers in the Guinea Savannah agroecological zone rely on artificial fertilisers to boost maize yield and productivity. Anang et al. (2020) and Addison et al. (2022) observed that, there was a favourable relationship between location and the adoption of inorganic fertiliser methods in Ghana. Farmland fertility plays a major role in influencing farmers' decisions to use inorganic fertiliser. Based on the findings summarized in Table 4.4, farmers with fertile or very fertile land were less likely to use inorganic fertilisers. This reduced likelihood to use inorganic fertilisers for farmers having fertile or very fertile land indicated the rational behaviour of producers of avoiding excessive cost of replenishing soil nutrients that are already sufficient. Nevertheless, those farmers with very fertile lands who used inorganic fertilisers used them more intensively. Di Falco et al. (2013) indicated that farmers with fertile land in Ethiopia exhibited similar behaviour of reduced likelihood of use of inorganic fertilisers.

As shown in Table 4.4, the production purpose was found to have a positive significant effect on both decisions to use inorganic fertiliser and the rate of utilisation at 5% and 10% levels respectively. The implication is that farmers who cultivate maize purposely for household consumption were more likely to apply inorganic fertilisers to enhance maize productivity. Farmers' decision to supplement farmland with inorganic fertiliser was motivated by having more mouths to feed with small farm sizes coupled with low soil fertility. The home-farm distance was found to have a negative association with the rate of inorganic fertiliser utilisation at a 5% significant level.

Farm households whose farmlands are far from home are less likely to increase the rate of inorganic fertiliser utilisation. This result could be due to the relatively high transportation costs of inorganic fertilisers from the home to the farm and also other transaction costs associated with the movement of inorganic fertilisers from the home to the farm such as time involved with negotiating with transport owners to carry inorganic fertilisers to the farm. Simtowe et al. (2016) established in their study in Malawi that distance from the home to the farm had a negative association with adoption. Yet, the finding contradicts that of Zakaria et al. (2020) who showed that distance had a positive effect on the adoption of climate-smart technologies adoption in Ghana.

The results summarized in Table 4.4 showed that own land had a negative marginal effect on the rate of inorganic fertiliser utilisation at the 10% significance level, though it did not have a significant link to the likelihood of using inorganic fertilisers. This finding may be attributed to the moral hazard problem experienced by farmers who own their land, stemming from their access to communal land resources. Having access to a substantial pool of communal land could potentially discourage intensive inorganic fertiliser use on a specific piece of land. Farmers with such access might opt to abandon land showing signs of infertility and shift their cultivation efforts to other unused portions of the communal land. However, the results of this study are not consistent with other studies such as those of Abdulai et al. (2018), Teklewold et al. (2020) and Addison et al., (2022) who established that land tenure security enhanced farmers' capacity to invest in the adoption of production technologies.

FBO membership is a social capital investment that promotes technological uptakes. Membership in FBO was found to have a negative association with inorganic fertiliser rate of utilisation, which was marginally significant at a 10% level. Farmers belonging to FBOs were less likely to increase

inorganic fertiliser application rates compared to their counterparts. This finding of this study did not conform to the a priori expectations.

Farmers who adopted improved maize varieties were not more likely to use inorganic fertilisers. However, those farmers who adopted improved varieties were more likely to use higher levels of inorganic fertilisers when they choose to use inorganic fertilisers on their farms. Finally, the price of inorganic fertilisers had a statistically negative relationship with the intensity of the use of inorganic fertilisers (refer to Table 4.4). This finding was consistent with the basic economics law of demand which postulates less use of a resource with increasing cost of the resource.



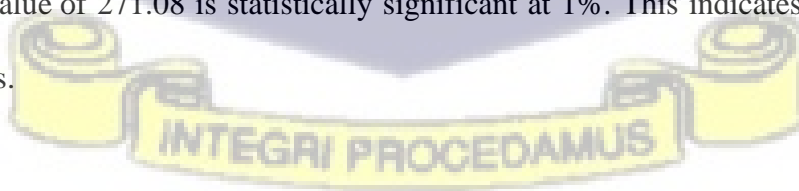
Table 4.4: Factors influencing farmers decision to use inorganic fertiliser and intensity of utilisation

Factor	Model 1			Model 2		
	The decision to apply fertiliser			Rate of fertiliser application		
	Coef.	Std. Err.	P>z	Coef.	Std. Err.	P>z
Sex	-0.089	0.184	0.630	-10.297	37.912	0.786
Age	-0.007	0.006	0.241	-0.265	1.288	0.837
Major crop (maize)	0.625***	0.157	0.000	56.722	37.998	0.135
Off-farm work	0.468***	0.143	0.001	-13.793	29.843	0.644
Extension access	0.685***	0.16	0.000	36.099	31.387	0.250
Agroecological zone	0.669***	0.167	0.000	108.021***	37.163	0.004
Scale of production	-0.166	0.157	0.290	45.797	30.962	0.139
Very fertile land	-1.83***	0.263	0.000	98.713*	52.119	0.058
Fertile land	-0.980***	0.214	0.000	26.671	32.402	0.410
Education (formal)	0.011	0.014	0.431	1.065	2.647	0.688
Production purpose	0.416**	0.181	0.022	66.846*	38.198	0.080
Credit access	0.203	0.167	0.224	-19.83	31.613	0.530
Home-farm distance	0.018	0.014	0.192	-6.008**	2.892	0.038
Own land	-0.227	0.155	0.144	-55.346*	29.49	0.061
FBO	-0.024	0.169	0.886	-61.67*	32.882	0.061
Use of improved seeds	-0.023	0.148	0.877	67.037**	29.545	0.023
Fertiliser unit price				-140.108***	15.728	0.000
Constant	-0.038	0.519	0.942	658.702***	130.894	0.000
Sigma	5.193***	0.064	0.000			
Number of observations	448			267		

Notes

***, ** and * indicate 1%, 5% and 10% statistical significance levels respectively.

The chi-square value of 271.08 is statistically significant at 1%. This indicates the fitness of the estimated models.



4.8 Factors Influencing Maize Productivity

Table 4.5 provides the results of the multiple linear regression analysis of the factors influencing the productivity of maize farms, measured in kg per hectare. The independent variables explicitly included the methods of fertiliser application. The estimated regression model was checked for correct specification based on the Ramsey Reset test and it was found to be adequately specified with the computed p value of 0.595, much greater than the 0.10 maximum critical p value used in this study. Further, the model had no significant heteroscedasticity based on the use of the Glejser test; the computed p value of this test was 0.109, above the critical p value of 0.10. The power of the estimated model was high with the R^2 of 0.701; this indicated that the independent variables explained around 70% of the variation in the dependent variable (the yield per hectare).

The outcomes from the regression analysis indicated that employing the top-dressing technique with inorganic fertilisers resulted in significantly higher yields per hectare compared to not using this method. The parameter estimate, equivalent to that of a semi-logarithmic dummy variable, was 0.201, signifying that utilizing the top-dressing method increased maize productivity by approximately 22.3% ($(\exp(0.201)-1)$) compared to not using this approach.

In contrast, the use of the basal method of inorganic fertiliser did not exhibit a significant increase compared to non-use. However, the regression analysis clearly illustrated that when combining the basal method with improved seeds, there was a notable increase in productivity.

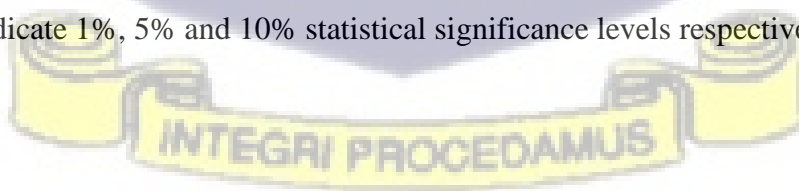
While an increase in the age of the farmer was associated with a decrease in productivity, the conjunction of increasing age and farm experience led to an increase in productivity. Additionally, a larger size of the maize farm was linked to decreasing productivity, suggesting evidence of diminishing returns to scale.

Table 4.5: Factors influencing maize productivity

Explanatory Variable	Parameter Estimate	Standardised Estimate	Student t Test Value	Significance Probability	VIF
Intercept	7.099	0.000	35.725	0.000***	0.000
Natural logarithm maize farm size	-0.948	-0.817	-22.135	0.000***	1.936
Family labour per hectare	-0.015	-0.025	-0.763	0.446	1.517
Hired labour per hectare	0.005	0.013	0.452	0.652	1.165
Seed expenditures per hectare	0.019	0.095	3.370	0.001***	1.119
Top-dressing fertiliser	0.201	0.093	2.408	0.016**	2.121
Basal fertiliser	-0.060	-0.028	-0.744	0.457	1.943
Basal fertiliser * use of improved seed	0.252	0.099	3.097	0.002***	1.459
Frequency of use of pesticides	-0.010	-0.053	-1.929	0.054*	1.062
Age of farmer	-0.009	-0.105	-2.473	0.014**	2.580
Age of farmer* farm experience	0.000	0.085	1.987	0.048**	2.569
Formal education	0.076	0.035	1.252	0.211	1.141
Sex of farmer	0.103	0.040	1.350	0.178	1.234
R ²	0.701				
Adjusted R ²	0.692				
Probability significance level of Ramsey Reset test of correct model specification	0.505				
Probability significance level of Glejser test of heteroscedasticity	0.109				

Notes

***, ** and * indicate 1%, 5% and 10% statistical significance levels respectively.



4.9 Effect of Inorganic Fertiliser Use on Maize Commercialisation

About 32.1% of the respondents were into subsistence maize farming while about 61.6% and 6.25% of them were engaged in partial and full maize commercialisation respectively. This finding suggested that most farmers were into partial maize commercialisation. Farmers cultivated maize for household consumption and sold surplus when there was a bumper harvest.

A Tobit regression model was used to determine the factors of the level of maize commercialisation. Table 4.6 contains the findings of this investigation. These results indicated that the five significant positive drivers of maize commercialisation were quantity of inorganic fertiliser applied, production purpose, sex, farm-market distance, and the availability of a community market centre. The three identified significant negative drivers were agroecological zone, age of the farmer, and household size.

With respect to inorganic fertilisers, the positive significant effect implies that access to inorganic fertiliser by applying the right quantity of inorganic fertiliser boost farmers' capacity to intensify maize commercialisation. With access to inorganic fertiliser, farmers can increase maize production to meet household consumption, and participate in markets to make food available to non-farm households. In Ethiopia, a study was conducted and found that the adoption of green technologies has a positive relationship with agricultural commercialisation (Asfaw et al., 2010). Similarly, Tesfy (2020) study concluded that the application of inorganic fertiliser has a strong positive association with smallholder household commercialisation and productivity in Ethiopia.

Production purpose was found to have a positive significant effect on maize commercialisation at the 1% significance level. This result indicated that farmers whose objective was more in tune with household consumption were more likely to practice maize commercialisation. The agroecological

zone was found to have an inverse relationship with maize commercialisation, which was statistically at the 1% significance level. This meant that farmers in the Guinea Savannah zone were less likely to practice maize commercialisation compared to those in the transitional zone in Ghana. This was possible since farmers in the Guinea Savannah zone were subsistence farmers who held less than two hectares in Ghana (MoFA, 2021).

The farmers age had a negative association with maize commercialisation at a 1% significance level indicating that increasing age led to declining probability to practice maize commercialisation. Older farmers were more into maize production at the subsistence level while young farmers tended to see maize farming as a business. When compared to older farmers, younger farmers were much more business oriented. The finding was consistent with the result established by Otekunrin et al. (2022) and different from the result produced by Tafesse et al. (2020).

Sex was observed to have a positive significant effect on maize commercialisation at a 10% level. That is to say, male farmers, were more likely to practice maize commercialisation than female farmers. Male farmers tended to have greater access to production resources such as farm technologies, credit and extension services more than female farmers. Lack of land tenure security coupled with insufficient access to other production inputs reduced the likelihood of female farmers practicing commercialisation.

Farm size is another indicator found to have a positive significant effect on maize commercialisation at the 5% significance level. A farmer with a relatively large farm area is more likely to practice maize commercialisation than another farmer with smaller farm size. Farmers with relatively large farm plots can allocate a portion of the land to practice commercialisation

while other portions for subsistence farming. This finding is consistent with the literature that farm plot size promotes agricultural commercialisation (Ele et al., 2013). The study further demonstrated that access to formal education has a positive effect on maize commercialisation at the 5% significance level. That is as farmers' years of formal education increase, the probability of such farmers practicing maize commercialisation will increase in the same direction.

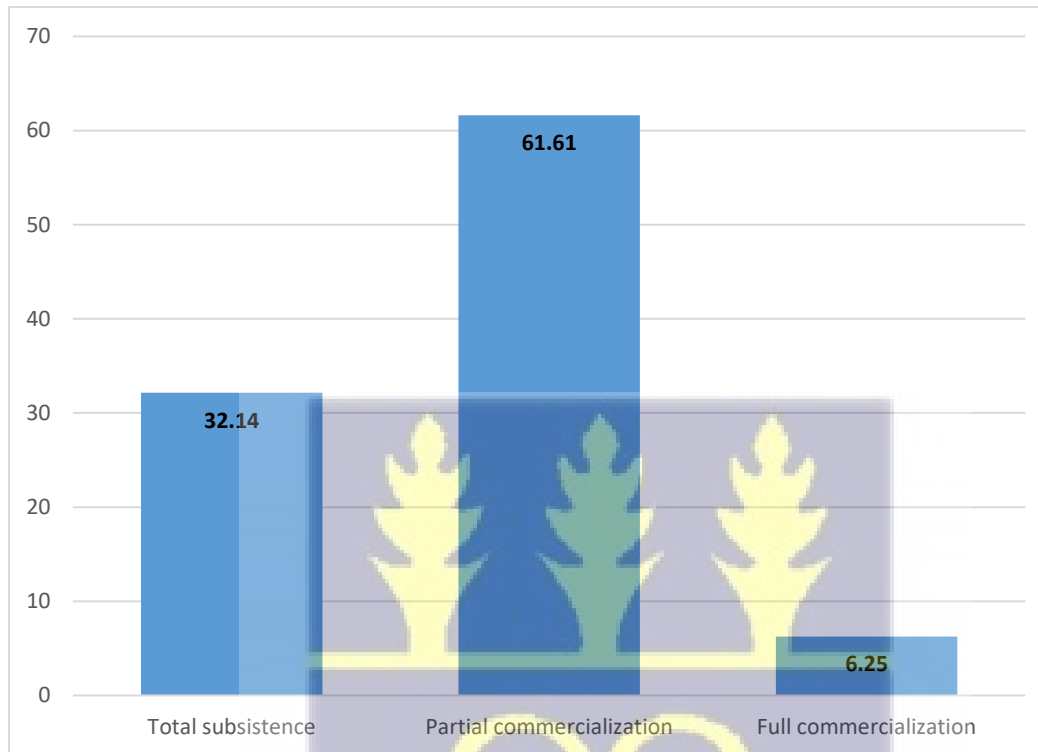
Education is a socioeconomic capital empowering farmer to access farm production resources in formal institutions to intensify the commercialisation of agriculture, including maize production. With formal education, farmers can read, understand, and able to apply information accessed at the farm level. Formal education assists farmers to access both inputs and output price information which are motivational drivers for maize commercialisation. Some studies have concluded that educational level has a direct relationship with smallholder agriculture commercialisation (for example, refer to Mulwafu et al., 2013; Ele et al., 2013; Sylvester et al., 2014, Aderemi et al., 2014). Nonetheless, Dube and Guveya (2016) found education to have a negative relationship with smallholder commercialisation.

Household size has a positive significant effect on maize commercialisation at the 1% significance level, meaning that a farmer with a large household size is likely to practice maize commercialisation. Maize commercialisation is labour-demanding activity; hence a small household size might not be able to have the human resource to practice maize commercialisation. The finding of the positive significant effect of household size with maize commercialisation is consistent with Agwu et al. (2012), Aderemi et al. (2014) and Dube and Guveya (2016).

Market access is one of the key drivers to maize commercialisation. Access to farm inputs and outputs markets empower farmers to participate in market through commercialisation. This study

illustrated that communities with market centres and increasing farm-market distance have a positive significant effect on maize commercialisation at 5% and 1 % significance levels, respectively. These findings suggest that farmers living in a community with market centres and a longer distance from farm to market centre were more likely to practice maize commercialisation. The presence of markets in communities motivates farmers to practice maize commercialisation as they have access to farm inputs and output markets through value chain actors. Farmers' access to markets for farm produce has been acknowledged in the literature as a critical factor in commercialisation and market integration.





Mean	Std. Dev.	Min	Max
41.7	37.7	0	100

Figure 4.5: Distribution of Household Commercialisation Index (HCI)



Table 4.6: Estimates of Tobit model for drivers of maize commercialisation

Variable	Coef.	Std. Err.	T-Value	P>t
Fertiliser quantity	0.039***	0.007	5.21	0.000
Production purpose	22.766***	3.577	6.36	0.000
Major crop	5.134	3.214	1.60	0.111
Credit access	-1.264	3.273	-0.39	0.700
Agroecological zone	-25.018***	3.542	-7.06	0.000
Off-farm activity	1.912	2.892	0.66	0.509
Age	-0.477***	0.154	-3.10	0.002
Sex	6.283*	3.755	1.67	0.095
Farm size	1.274**	0.586	2.17	0.030
Extension	-0.145	3.071	-0.05	0.962
FBO	0.708	3.242	0.22	0.827
Experience	0.181	0.153	1.19	0.237
Education	0.572**	0.277	2.07	0.039
Household size	-1.075***	0.286	-3.76	0.000
Community market	6.473**	3.244	2.00	0.047
Farm-market distance	0.256***	0.096	2.67	0.008
Own land	4.195	3.000	1.40	0.163
Maize price information	1.216	3.213	0.38	0.705
Constant	37.243	9.997	3.73	0.000
Model summary				
Observations =	448			
LR chi2(18) =	244.13			
Prob > chi ² =	0.0000			
Pseudo R ² =	0.0540			
Log-likelihood =	-2139.5249			

Notes:

***, ** and * indicate 1%, 5% and 10% statistical significance levels respectively.



4.10 Effect of Inorganic Fertiliser Use on Maize Profitability

The Value Cost Ratio (VCR), a typical tool for analysing the financial incentives to use inorganic fertiliser, was used to estimate the profitability of inorganic fertiliser use. Generally, the greater the VCR, the higher the additional value of yield obtained from fertiliser use per the cost of the fertiliser used. Although a VCR of one suggest a profit maximizing point where the value of the marginal product per marginal factor cost is one, the lack of perfect knowledge in prices by farmers and the high production and price risks, the generally used rule of thumb is that a VCR of plus two ($VCR > 2$) should be considered as the minimum requirement for fertiliser use. From Figure 4.6, only 22% of the maize farmers had a VCR of more than two, therefore, were profitable from using inorganic fertilisers for maize production. Thus, only 22% of the farmers are able to obtain two Ghana cedis from an additional one Ghana cedis spent on fertiliser purchase. This is low and also indicates that most farmers are not able to obtain the best returns on their investment from inorganic fertiliser use in maize production.

Furthermore, the results of inorganic fertiliser user and other socioeconomic factors on maize profitability among farmers are presented in Table 4.7. The Wald Chi² value was 30.45 which was highly significant at 1% level. The significance of the Wald Chi² value implies that the null hypothesis is rejected, that all the parameters of the independent variables (inorganic fertiliser use and other socioeconomic factors) were jointly equal to zero. This demonstrates that the probit model provided the greatest fit for the analysis.

The results of the analysis indicated that the commercialisation index (HCI) had a positive association with profitability at the 5% significance level. This finding suggested that as HCI increased, maize profitability increased. When participating in market is high coupled with moderate output prices with minimum inputs costs, it is expected that the profit margin of farmers

would increase. In Ghana, Zakaria et al. (2021) study conclude that commercialisation enhances rice profitability. Similarly, Azumah et al. (2020) found that the adoption of climate-smart production practices is beneficial in Ghana.

Farm experience was found to have a negative significant effect on the profitability of inorganic fertiliser utilisation at the 10% significance level. Thus, more experienced maize farmers were less likely to get high profits compared to less experienced maize farmers. It was anticipated that the profitability of users of inorganic fertilisers would increase as a result of experience in maize farming, but the study found a contradictory result. The reason for such a finding could be that more experienced farmers could be more risk averse and would avoid activities with high-risk potential even though these activities could give them higher returns. This result has been found in other studies. For example, Masuku (2011) found that the experience had an inverse relationship with the farm profitability of sugarcane farmers in Swaziland.

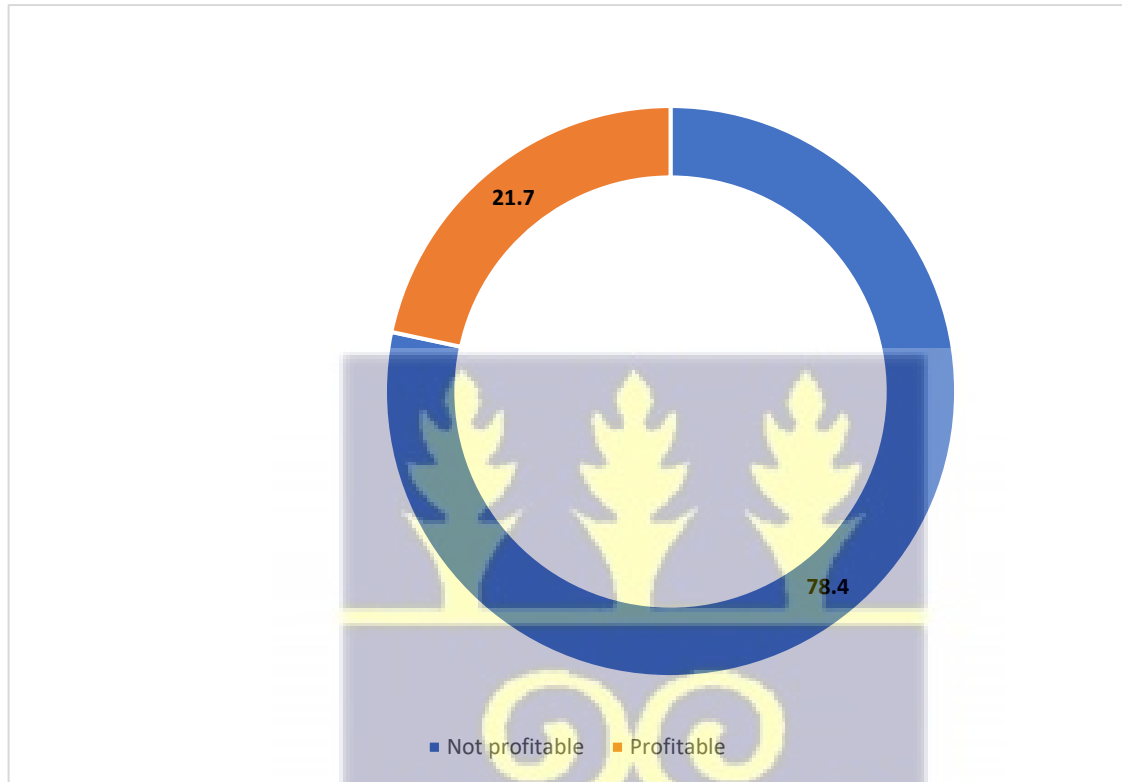
The study further demonstrated that scale of production has a negative correlation with maize profitability for inorganic fertiliser users suggesting that farmers cultivating maize with more than two hectares were less likely to increase maize profit. The other interpretation is that farmers operating less than two hectares of maize farm were more likely to increase maize profit. That is, smallholder farmers turned out to be more profitable than their large holder counterparts. Large-scale farming did not necessarily lead to higher profit.

Production credit was observed to have a direct effect on the maize profitability of inorganic fertiliser users at a 5% level in the study area. Farmers with access to production credit were more likely to increase profit compared to those who did not have credit access. Credit access assisted farmers to invest in the maize production business. As farmers invested in maize production, it

was expected that productivity and income would increase which then would lead to higher profits. This result was similar to another study which established that production credit allowed farmers to adopt productivity-enhancing technologies with direct impacts on profitability (Ehiakpor et. al., 2019).

The parameter of the location variable was significant when examining factors influencing the maize profitability of inorganic fertiliser users. This parameter was significant at 5% level. This implied that farmers located in the Guinea Savannah zone were more likely to have higher profitability than farmers in the Transitional zone.





Note: Profitable if the VCR is greater than 2

Figure 4.6 Level of profitability among fertiliser users

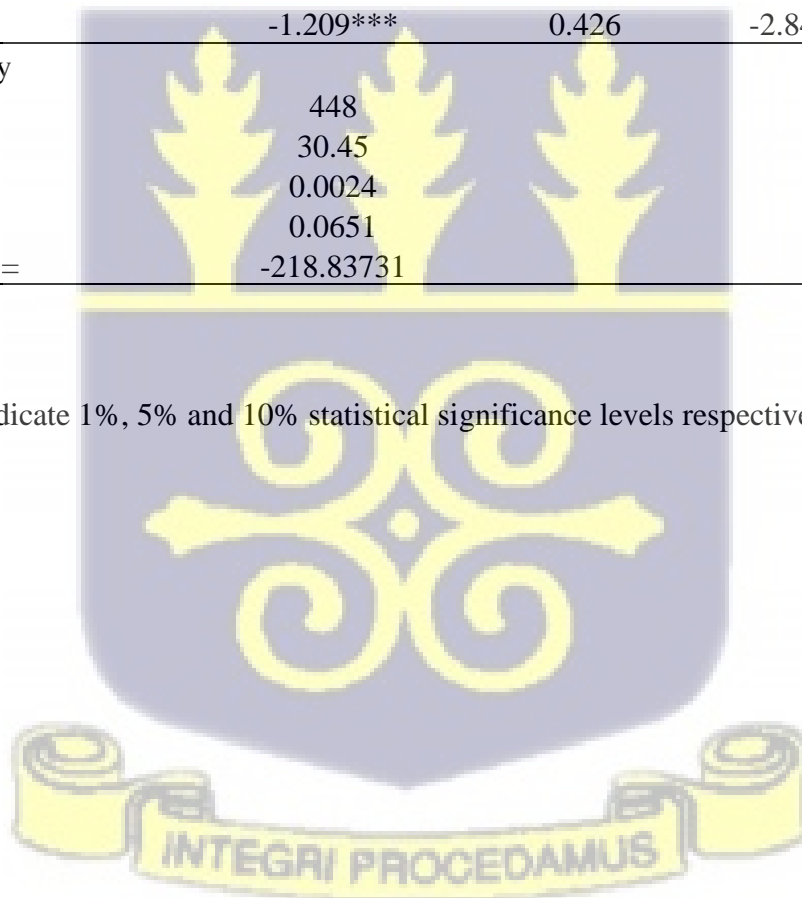


Table 4.7: Factors influencing the profitability of inorganic fertiliser use by maize farmers

Variable	Coef.	Std. Err.	z	Mfx
HCI	0.004**	0.002	1.98	0.001
Fertiliser use	0.0012**	0.0006	2.18	0.0007
Age	0.005	0.008	0.70	0.002
Education	0.001	0.014	0.10	0.004
Experience	-0.014*	0.008	-1.82	0.002
Production scale	-0.371***	0.146	-2.55	0.044
Credit access	0.351**	0.155	2.26	0.049
Ready market	0.060	0.159	0.38	0.044
FBO	0.165	0.150	1.11	0.044
Agroecological zone	0.376**	0.172	2.19	0.044
Farm-market	0.0001	0.005	0.02	0.001
Off-farm	0.011	0.145	0.08	0.041
Extension	-0.002	0.007	-0.31	0.002
Constant	-1.209***	0.426	-2.84	
Model summary				
Observation =	448			
LR chi2(12) =	30.45			
Prob > chi2 =	0.0024			
Pseudo R2 =	0.0651			
Log-likelihood =	-218.83731			

Notes:

***, ** and * indicate 1%, 5% and 10% statistical significance levels respectively.



CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary of the Study

This study employed a multistage sampling technique to randomly select 448 maize farmers. A semi-structured questionnaire was used to solicit primary information from maize farmers. Descriptive statistics were used to analyse inorganic fertiliser utilisation and rate of utilisation as well as the socioeconomic characteristics of the sampled farmers. The double hurdle model (Cragg model) was employed to assess the drivers of inorganic fertiliser utilisation and intensity of application; the multiple linear regression model was employed to examine the drivers of maize productivity, as indicated by the yield per hectare. The drivers of maize commercialisation were examined using Tobit regression model. Finally, a probit model was used to analyse the effect of inorganic fertiliser and other factors on maize profitability for only those farmers who used inorganic fertilisers in their maize production.

The results of the descriptive statistics shows that about 60% of the maize farmers used inorganic fertiliser with an application rate of 169.56kg/Ha. Inorganic fertiliser users were high in the Upper West region (98%), Northern region (80%), Bono East region (77%) and North East region (71%) It was lower in Ahafo region (7%), Savannah region (39%) and Bono region (48%). Farmers mostly apply NPK 15:15:15 (42.6%) as basal application and SoA (41.5%) as top-dressing application. About 88% of the maize farmers applied inorganic fertiliser using the side placement method. About 32.1%, 61.6%, and 6.3%, of the maize farmers were into subsistence, partial commercialisation, and full commercialisation respectively.

The empirical results of the double hurdle model revealed that the agroecological zone, production purpose, and land with highly fertile soil all had a positive significant effect on a farmers' decision

to use inorganic fertiliser and the rate of utilisation. Factors like maize as a major crop, off-farm activity, and extension services were observed to have a positive association with farmers' decision to use inorganic fertiliser and fertile land was observed to have a negative association with farmer decision to use inorganic fertiliser. While improved seeds had a positive correlation with the rate of inorganic fertiliser application, farm distance to market, own land, membership to FBO, and inorganic fertiliser unit price had a negative correlation with the rate of inorganic fertiliser application.

Furthermore, the fertiliser top-dressing application method and interaction of fertiliser basal application with improved seeds had a positive significant effect on maize productivity. Similarly, the interaction of improved seed with experience, and age and experience interaction were found to have positive benefits to maize production while age, farm size, and frequency of pesticide use were found to have negative effects on maize productivity.

The quantity of inorganic fertiliser was observed to have a positive significant effect on maize commercialisation. Additionally, maize production purpose, sex, farm size, education, community market, and farm-to-market distance were found to have a positive relationship with maize commercialisation, yet agroecological zone, age, and household size were found to have a negative relationship with maize commercialisation.

The study found five factors influencing maize profitability for inorganic fertiliser users. Those observed to have a positive significant effect on maize profitability include commercialisation index, access to production credit, and agroecological zone while experience and production scale had a negative significant effect on maize profitability.

5.2 Conclusions of the Study

The study concludes that farmers' decisions to use inorganic fertiliser and the intensity of their application are significantly influenced by socioeconomic characteristics and their perceptions of soil fertility. Particularly, in the Guinea Savannah zone of Ghana, there is a high probability of farmers jointly deciding to use and intensively apply inorganic fertilisers.

Furthermore, the study emphasizes the significance of inorganic fertiliser use in maize production, highlighting its positive impact on maize productivity. It further establishes that integrating basal fertiliser application with improved seeds enhances overall maize productivity.

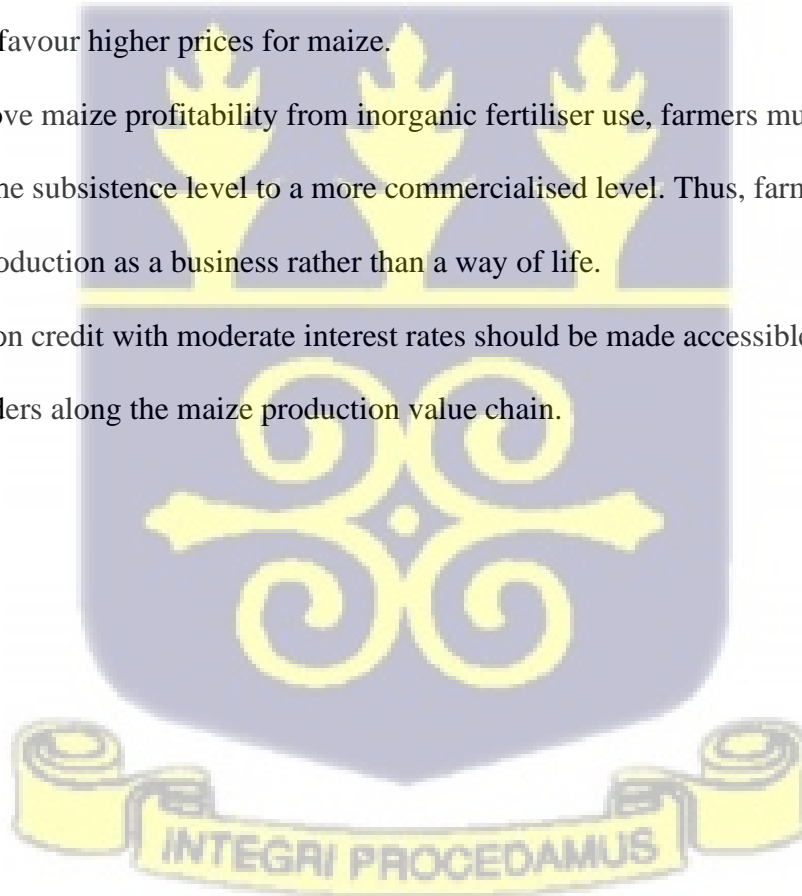
Despite approximately 32% of farmers still producing maize solely for subsistence (home consumption), there is a notable trend of commercialisation among farmers. The use of inorganic fertilisers emerges as a key factor contributing to increased levels of commercialisation. This suggests that using inorganic fertilisers can play a crucial role in raising maize yield over the level needed for subsistence.

However, the profitability of using inorganic fertilisers appears to be low, with 78% of maize farmers unable to achieve optimal returns on their investment. Notably, factors such as maize commercialisation, access to production credit, and farmers in the Guinea Savannah zone positively impact maize profitability. On the other hand, more experienced farmers and those cultivating more than two hectares tend to reduce maize profitability.



5.3 Recommendations

1. Given the beneficial impact of inorganic fertiliser on maize production, farmers are advised to utilize sufficient amounts of it.
2. Government extension agents, NGOs and the private sector should intensify visits and trainings to farmers and farmer-based organisations to educate them on the right types and rates of inorganic fertilisers recommended for use by maize farmers.
3. The fertiliser use profitability is low among maize farmers. To correct this, fertiliser prices must be reduced, or output prices must increase. Considering that Ghana is a price taker of fertiliser, the Government of Ghana must improve the output market conditions that will favour higher prices for maize.
4. To improve maize profitability from inorganic fertiliser use, farmers must produce beyond the subsistence level to a more commercialised level. Thus, farmers must view maize production as a business rather than a way of life.
5. Production credit with moderate interest rates should be made accessible to farmers by stakeholders along the maize production value chain.



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APPENDIX 1: COPY OF THE SURVEY QUESTIONNAIRE USED FOR THE STUDY

STRICTLY CONFIDENTIAL

DEPARTMENT OF AGRICULTURAL ECONOMICS AND AGRIBUSINESS

UNIVERSITY OF GHANA, LEGON, ACCRA, GHANA

SURVEY QUESTIONNAIRE FOR THE STUDY ON THE USE OF FERTILISERS

INVESTIGATOR'S INTRODUCTION AND STATEMENT OF INFORMED CONSENT

My name is **Mr. Opoku Mensah Gyasi, MPhil** candidate of the Department of Agricultural Economics and Agribusiness, University of Ghana, Legon, Accra. My phone number is Email address:

The objective of this study is to elicit views from you on your farm practices. I am an enumerator contracted by IFDC, a public research organisation with a sub-regional office in Accra, Ghana. This interaction with you would help the organisation to better understand your farming practices, the yields obtained and what interventions must be recommended to all stakeholders including the government to better improve your yields. The information you provide shall not be shared with anyone unless we ask for your permission. Therefore, please feel free and let us have a good discussion.

May I begin the interview now? **1.** Respondent **agrees** to be interviewed..... **2.** Respondent does not **agree** to be interviewed.....

DISTRICT/CONSTITUENCY:

ADDRESS OF RESPONDENT (NAME NOT REQUIRED):

TELEPHONE NUMBER:

DATE OF SURVEY:

TIME

OF STARTING THE INTERVIEW:

SURVEY QUESTIONNAIRE NUMBER:

SECTION A: BASIC INFORMATION

1. Name of Enumerator:
2. Region: (1) Northern (2) North East (3) Upper West (4) Savannah (5) Upper East (6) Bono (7) Bono East (8) Ahafo (9) Ashanti
3. District:
4. Community.....
5. What is your position/status in the household? (1) Head (2) Spouse to head (3) Child to head (4) Others

1. How many people are in your household?
2. How many of your household members are not working and therefore depend on you?.....
3. How many household members have their own farms?
4. Apart from crop production do you engage in any of the following economic activities?

Economic activity	Response (1) Yes (0) No	If yes, income per year (GHC)
Livestock production		
Agro-processing		
Marketing/trading		
Artisanry		
Private sector employee		
Public sector employee		
Other crops apart from maize, rice and soybean		

5. Do you belong to a farmer group (FBO)? (1) Yes (0) No
6. If you are a member of FBO, has your membership helped you in your crop production in the 2021 cropping year? (1) Yes (0) No
7. If yes in Q13, in what way(s)? (1) Input acquisition (2) Finance (3) Technical support/training (4) Marketing (5) Others [*Multiple choice*]
8. What is your level of participation in the activities/events of the FBO? (1) Very active (2) Active (3) Less active (4) No participation
9. Have you had extension service contact in the 2021 cropping year? (1) Yes (0) No
10. If yes in Q16, how many times were you visited/contacted?
11. If Yes in Q16, what is your level of trust on the extension service(s)? (1) Very high (2) High (3) Low (4) Very low (5) No trust
12. If yes in Q16, has it had any effect on your crop production? (1) Yes (0) No
13. If yes in Q19, in what way(s) did this help your crop production?

Effect of access to extension	Response (1) Yes (0) No
Easy access to farm inputs like fertiliser and seeds	
Easy access to credit	
Information on good production practices	
Training on good production practices	
Information and linkage to produce buyers or markets	

14. Did you apply for credit in 2021? (1) Yes (0) No
15. If no, why didn't you apply for farm credit?
16. If yes, did you have access to the credit in the 2021 production year? (1) Yes (0) No
17. If no, why was your application rejected?
18. If yes, what was the source of the credit? (1) Banks (2) Friends/relatives
(3) Contracts (4) Cooperative/credit unions (5) Others:
19. If Yes in Q23, did you receive the exact amount you requested? (1) Yes (0) No
20. If yes in Q23, what was the form of the credit received? (1) Cash (2) Input or in-kind credit (3) Both
21. Have you had any form of training (e.g training on good agronomic practices) in the past three years? (1) Yes (0) No

Section B: Crop production

22. Please provide the following information on your 2021 farm

Question	Maize	Rice	Soybean
Was this crop cultivated under contractual agreement? (1) Yes (0) No			
If yes, has it improved your adoption of good production practices? (1) Yes (0) No			
What was the source of land under which this crop was cultivated? (1) Own (2) Family (3) Communal (4) Rent/Lease			
Under what farming system was this crop produced? (1) Intercropping (2) Monocropping (3) Mixed farming (4) Crop rotation (5) Mixed cropping			
Since you started farming, for how many years have you cultivated this crop?			
What is the MAIN reason for cultivating this crop? (1) Domestic use (2) Sale (3) Both (4) Undecided (5) Others:.....			
What is the total farm area cultivated to this crop (acres)			
What is the distance from the home to the farm? (#miles)			
Is the road to the farm motorable? (1) Yes (0) No			
Did you cultivate this same farmland in 2020? (1) Yes (0) No			
If yes, with which crop? (1) Maize (2) Rice (3) Soybean (4) Other crops (Specify)			

Section C: Inputs usage

23. Kindly provide information on the inputs you used in the cultivation of each cultivated crop.

Input	Maize	Rice	Soybean
Improved seeds(bowls)			
Local seeds (bowls)			
Herbicides (litres)			
Organic fertiliser such as manure/crop residue			
Family labour (# of persons)			

Hired labour (# of persons)			
Pesticides (litres)			

24. Kindly provide the following information on the fertiliser(s) applied as first fertiliser (basal) on each crop

Fertiliser type	Maize (#50kg bag)	Rice (#50kg bag)	Soybean (#50kg bag)	Unit cost (GHS)
NPK 15:15:15				
NPK 15:20:20 + 0.7Zn				
NPK 12:30:17+0.4 Zn				
NPK 17:10:10				
NPK 20:10:10 3S+2MgO				
NPK 25:10:10				
NPK 21:10:10 +2S				
NPK 23:10:5 + 4MgO + 2Zn				
Urea				
SoA				
Other (Specify)				

25. What fertiliser application method did you use for your basal application? (1)

Broadcasting (2) Side placement (3) Injection into soil

26. How many days after planting did you apply your first or basal fertiliser?

27. Have you applied fertiliser for the second time after the first application? (1) Yes (0) No

28. If yes in Q34, how many days after the first (basal) fertiliser application did you apply the second fertiliser?

29. If yes in Q34, what fertiliser application method did you use during top-dressing application? (1) Broadcasting (2) Side placement (3) Injection into soil

30. If yes in Q34, what type and quantity of the fertiliser did you apply?

Fertiliser type	Maize (#50kg bag)	Rice (#50kg bag)	Soybean (#50kg bag)
NPK 15:15:15			
NPK 15:20:20 + 0.7Zn			
NPK 12:30:17+0.4 Zn			
NPK 17:10:10			
NPK 20:10:10 3S+2MgO			
NPK 25:10:10			
NPK 21:10:10 +2S			
NPK 23:10:5 + 4MgO + 2Zn			
Urea			
SoA			
Other (Specify)			

31. Have you applied the right quantity of fertiliser to your crops? (1) Yes (0) No.
 32. If No in Q38, what prevented you from applying the right quantity? (1) Unavailability of the fertiliser (2) High cost of the product (3) Other (specify).....
 33. If a farmer have not used fertiliser at all, why?

Reasons	Response (1)Yes (0) No
Limited credit/finances	
Limited reach of subsidised fertiliser in adequate quantities	
High cost of unsubsidised fertiliser	
Lack of fertiliser at the right time/	
Lack of confidence/trust in fertiliser quality	
Lack of labour to use fertiliser	

34. After applying fertiliser(s), what must you do to ensure that the fertilisers will help the crops grow well and produce higher output?
 35. For how long have you been using inorganic fertilisers?# of years
 36. What are the major challenges with the use or application of fertiliser?
 37. Have you (will) you use fertiliser for crop production in 2022? (1) Yes (0) No
 38. If YES/NO, Why?

Section D: Crop output

39. Kindly provide the following information on your total harvest and distribution

Question	Maize (#100kg bag)	Rice (#100kg bag)	Soybean (#100kg bag)
How many bags did you harvest from your farm?			
What quantity of your harvest did you consume or reserve for consumption?			
What quantity of your harvest did you sell?			
What is the price per bag of the produce sold? (GHS per bag)			
How did you harvest this? (1) Manual (2) Mechanical			



Section E: Adoption of Sustainable Agricultural Practice (SAP)

40. Which of the following methods do you use to determine the fertility status of your soil or farmland?

Method	Did you use this method? (1) Yes (0) No
Types of weeds growing on land	
Cultivation of land for previous year(s)	
Crop yield on land from previous year(s)	
Visual assessment of the soil colour	
Digging to assess the topsoil	
Availability of soil micro-organisms like earthworm	
Others_Specify	

41. Which of the following sustainable agricultural practices did you adopt on your farm?

Sustainable agricultural practices	Maize (1) Yes (0) No	Rice (1) Yes (0) No	Soybean (1) Yes (0) No	# of years adopted
<i>Soil and water conservation</i>				
Mulching				
Minimum/zero tillage				
Agroforestry				
Contour farming				
Earthing up				
<i>Integrated soil fertility management</i>				
Use of organic manure				
Use of inorganic fertiliser				
Crop rotation with legume				
Intercropping or Mixed cropping				
Fallowing				

<i>Integrated pest management</i>				
Use of pesticides or insecticides				
Mechanical pest control (e.g scare crows)				
Manual pest control (e.g Hand picking of pests)				
Use of weedicides/herbicides				
Weeding when weeds are tender/young				
<i>Other strategies</i>				
Improved seeds				
Row planting				
Planting with recommended spacing				
Planting at recommended time				

42. What is the effect of the adoption of sustainable agricultural practices on improving your soil health, crop yield and environmental sustainability? [*level of effect= (1) Very high (2) High (3) Low (4) Very low (5) Not at all*]

Sustainable agricultural practices	Effect on soil health	Effect on crop yield	Effect on environmental sustainability
Soil and water conservation			
Mulching			
Minimum/zero tillage			
Agroforestry			
Contour farming			
Earthing up			
Integrated soil fertility management			
Use of organic manure			
Use of inorganic fertiliser			
Crop rotation with a legume			

Intercropping or Mixed cropping			
Fallowing			
Integrated pest management			
Use of pesticides or insecticides			
Mechanical pest control (e.g scare crows)			
Manual pest control (e.g Hand picking of pests)			
Use of weedicides/herbicides			
Weeding when weeds are tender/young			
Other strategies			
Improved seeds			
Row planting			
Planting with recommended spacing			
Planting at recommended time			

43. Have you had any training on any of these sustainable agricultural practices in the past three years? (1) Yes (0) No

44. Please rank the following constraints hindering the adoption of sustainable agricultural practice.

Constraints	Rank (1=Most severe...9=less severe)
High cost associated with the adoption of sustainable agricultural practices	
Inadequate information on the sustainable agricultural practices	
Unavailability/Inaccessibility of sustainable practices	
High complexity of the sustainable agricultural practices	
Low understanding of the sustainable agricultural practices	
Low personal income	
Lack of credit	
Poor land tenure systems	
High labour requirement	

Section G: Agricultural Technology Transfer Modes and Farmers Preference

TECHNOLOGY TRANSFER MODES

45. Did you receive any information on sustainable agricultural practices through the following media?

Source	Response: (1) No (2) Sometimes (3) Often (4) Very often
MoFA (Extension agents)	
NGOs (e.g., IFDC)	
Researchers (e.g., SARI)	
Colleague farmers and family members	
Radio	
TV	
Marketers/aggregators	
Mobile platforms (e.g SMS, whatsapp)	

46. Rank the following technology transfer modes in order of how often farmers in your community receives information on sustainable agricultural practices through it. **NB: 1 represents most used mode through to 12 being least used mode of transfer.**

Technology transfer approaches	Rank
Farmer-to-farmer	
Household extension	
Individual extension/farm visit	
Demonstration plots	
Group extension (lectures/discussions)	
TV programme	
Radio	
Newspaper	
Mobile platforms (e.g SMS, whatsapp)	
Video Screens/projectors	
Posters	
Marketers/aggregators	

PERCEIVED EFFECTIVENESS OF THE MODES OF TRANSFER OF AGRICULTURAL TECHNOLOGIES

47. What is the level of effectiveness of each of the following information transfer approaches on your adoption of improved agricultural practices? [Level of effectiveness =1 – Very effective; 2 – Effective; 3 – Neutral; 4 – Ineffective; 5 – Very ineffective]

Technology transfer approaches	Accurate adoption	Sustainability of adoption
Farmer-to-farmer		
Household extension		
Individual extension/farm visit		
Demonstration plots		
Group extension (lectures/discussions)		
TV programme		
Radio		

Newspaper		
Mobile platforms (e.g SMS, whatsapp)		
Video Screens/projectors		
Posters		
Marketers/aggregators		

48. What is the level of severity of the following challenges on your crop production?

Challenge	Response: (1) Very severe (2) Severe (3) Less severe (4) No effect
High cost of inputs	
Lack of access to credit	
Lack of access to improved planting materials	
Soil degradation	
Pest and diseases prevalence	
Lack of access to market	
Poor prices for maize produce	
Poor rainfall	
Unavailability of labour	
Lack of machinery for production	
Lack of extension service	

Section H: Commercialisation and Profitability of Fertiliser Use by Maize Farmers in Guinea and Transitional Zones of Ghana

Cost of production

49. How much money did you invest into the following activities on your maize farm in 2021?

Activity	Item	Cost (GHS)
Land preparation	Labour	
	Tractor and other machinery	
Planting	Labour	
	Labour	
Weed management	Herbicides	
	Labour	
Insect/pest management	Pesticides	
	Labour	
Soil fertility management	Transporting fertiliser from input source to the farm	
	Labour	
Harvesting	Harvester	
	Threshing	

Transportation of output from farm to home		
Transportation of output from home to market		
Equipment (e.g hoe)		
Storage		
Sum of any other costs		

Market access

- 50. Do you have a market in this community? (1) Yes (0) No
- 51. If yes, do you sell your crop output in this community market? (1) Yes (0) No
- 52. If NO, what is the distance between your home and the nearest market where you buy inputs and sell outputs?miles
- 53. What is the cost of transportation from home to the nearest market where you buy inputs and sell outputs?GHS
- 54. Do you think there is a ready market for your farm produce? (1) Yes (0) No
- 55. Do you personally own any of the following? {multiple choice} (1) Bicycle (2) Motorbike (3) Motorking [aboboya] (4) Donkey (5) Car
- 56. Which of them do you use for carting your farm produce? {multiple choice} (1) Bicycle (2) Motorbike (3) Motorking [aboboya] (4) Donkey (5) Car
- 57. Do you consider access to market before producing the maize? (1) Yes (0) No
- 58. Where did you sell most of your maize produce? (1) Home (2) Community market (3) District market (4) Other markets outside the district.
- 59. Have you had access to information on the following during and post 2021 production season?

	Have you had access to this information? (1) Yes (0) No
Information type	
Where to sell output	
Price of output	
Source of agro inputs	
Prices of agro inputs	
Storage facilities and procedures	
Desired qualities of the products by actors (e.g moisture content, packaging)	

- 60. Do you think the application of fertiliser have an effect on your maize output? (1) Yes (0) No
- 61. If yes, how many bags of output would you have gotten if you were not to apply fertiliser? ...#100kg bags
- 62. Do you think your application or non-application of fertiliser influence your decision to sell your maize output? (1) Yes (0) No
- 63. If yes, has it influenced the quantity of maize sold? (1) Yes, to a high extent (2) Yes, to a low extent (3) Not at all
- 64. Do you think selling more of your output will influence your decision to use fertiliser in 2022? (1) Yes (0) No

65. If YES, will it influence the quantity of fertiliser to use? (1) Yes, to a high extent (2) Yes, to a low extent (3) Not at all
66. What are some of the major challenges faced in marketing your maize produce? ...

Section I: Assessment of Agricultural Value Chain Development Programs in Ghana

(a) Effect of VCD Programs on the Performance of Farmer

1. Are you a rice farmer (control question)? (1) Yes (0) No
2. Did you participate in any agricultural project? (1) Yes (0) No
3. If yes, what is the name of the project?
 - (1) Savannah Zone Agricultural Productivity Improvement Project (SAPIP)
 - (2) Market Oriented Agriculture Programme (MOAP)
 - (3) Agricultural Development and Value Chain Enhancement Program (ADVANCE)
 - (4) Northern Rural Growth Program (NRGP)
 - (5) USAID Ghana Inclusive Agricultural Transformation Program (GIAT)
 - (6) Planting for Food and Jobs Program (PFJ)
 - (7) Others (Specify)
4. How did you hear of the project? (1) FBO (2) Friend (3) Family (4) Extension agent (5) Others_ Specify.....
5. Why did you join the project?

Reason	Response (1) Yes (0) No
Extension service	
Input support	
Better market for produce	
No reason	
Others (specify)	

6. Do you think you would have had similar benefits if not for participating in the project? (1) Yes (0) No
7. If yes, from where will you get such benefits? (1) Other projects (2) MoFA (3) Input dealers (4) Community buyers (5) others _ Specify
13. What is the source of your seed? (1) Own seed (2) Input dealers/shops (3) Open market (4) MoFA (5) Friend/Neighbour
14. Where do you get your fertiliser? (1) MoFA (2) Projects (3) Market (4) Others (Specify).....

15. Who do you sell your rice to? (1) Processor (2) Aggregators (3) Traders in the Market (4) Others (specify)
16. What is the level of agreement on the effect of participating on the following livelihood outcomes? **Response** (1=Strongly agree 2=Agree 3=Neutral 4=Disagree 5= Strongly disagree)

Impact of project participation	Response
I am able to get more bags on an acre due to my participation in the program	
I am able to make more profit from my farm due to the program.	
My income level have increased due to my participation in the program	
I am able to meet my food needs (especially basic needs) easily due to the program.	
I am able to meet my non-food needs (especially basic needs) easily due to the program.	
I am able to access market easily due to my participation in the project/program	
I am able to obtain quality inputs like seeds for production due to my participation in the program.	
I am able to access inputs like seed and fertiliser easily due my participation in the project/program.	
Your expectations about the project were met	
Farmers would not be able to continue with the interventions after the project	
The duration of the project is not long enough to impact the lives of many farmers	
Farmers did not learn anything new from the project	

17. Do you have a particular fixed (Regular) buyer? (1) Yes (0) No
18. Do you have a particular fixed (Regular) buyer for your other crops? (1) Yes (0) No
19. Do you clean/sort your rice before selling? (1) Yes (0) No
20. What was the price per bag the previous season?
21. Who defines the price for the rice you sell? (1) Buyers (0) Farmers
22. Were you satisfied with the price of rice last season? (1) Yes (0) No

(b) Perception of Agricultural Interventions in Ghana

1. Which of the following benefits did farmers obtain from participating in the project?

Benefit	Response (1) Yes (0) No
Access to technical assistance	
Access to farm inputs	
Purchase of farm inputs at low cost	
Access to financial or in-kind credit	
Access to market	
Better price for produce	

8. What are the challenges you faced when participating in the project?

Challenge	Response (1) Yes (0) No
Training times were not suitable	

Difficulty in practising the new technologies	
Delay in supply of input	
Inadequate quantity of inputs	
Stringent food safety and quality standards	
Difficulty in meeting project requirements	
Other challenges. Specify	

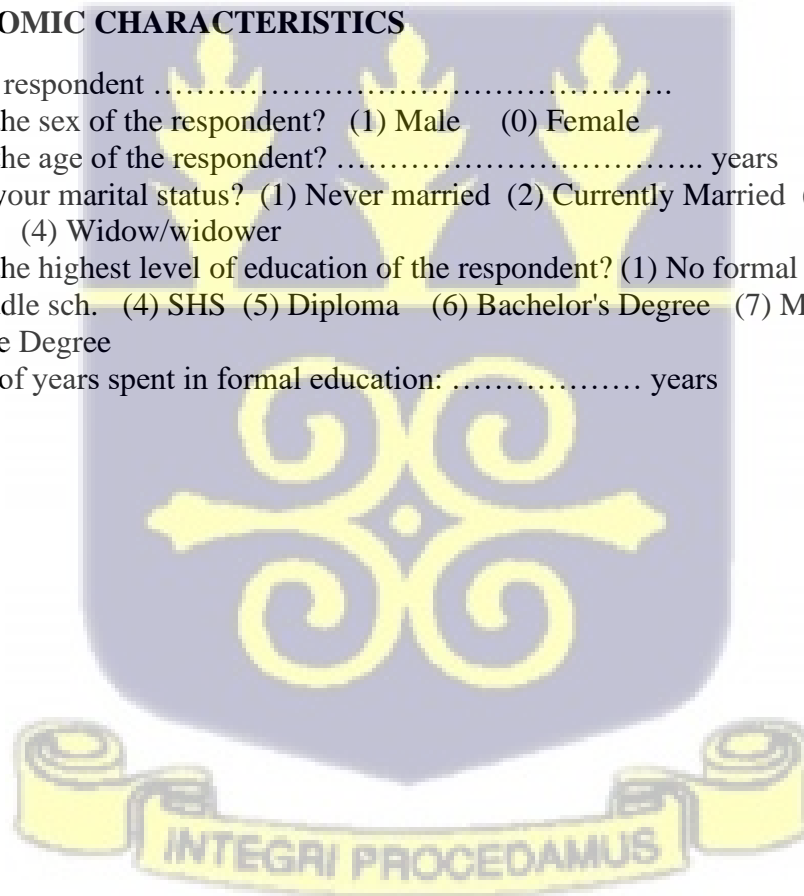
9. What do you think can be done to improve future projects?

Telephone number of respondent:

GPS:.....

SOCIO-ECONOMIC CHARACTERISTICS

1. Name of respondent
2. What is the sex of the respondent? (1) Male (0) Female
3. What is the age of the respondent? years
4. What is your marital status? (1) Never married (2) Currently Married (3) Married but divorced (4) Widow/widower
5. What is the highest level of education of the respondent? (1) No formal (2) Primary (3) JHS/Middle sch. (4) SHS (5) Diploma (6) Bachelor's Degree (7) Masters Degree (8) Doctorate Degree
6. Number of years spent in formal education: years



EXTENSION PERSONNEL QUESTIONNAIRE

Dear valued farmer. We appreciate your efforts in the agricultural sector and your role in providing food for the entire country. Well done! I have come to solicit some views from you on your farm practices. I am an enumerator contracted by IFDC, a public research organisation with a sub-regional office in Accra, Ghana. This interaction with you would help the organisation to better understand the approaches used to provide extension services/information to farmers and the effect on farmers adoption of sustainable agricultural practices. The information you provide shall not be shared with anyone unless we ask for your permission. Therefore, please feel free and let us have a good discussion. **Do you agree to participate? (1) Yes (0) No**

Thank you!

GENERAL INFORMATION

Name of Enumerator:
 Region: (1) Northern (2) North East (3) Upper West (4) Savannah (5) Upper East
 (6) Bono (7) Bono East (8) Ahafo
 District:
 Zone:
 Name of Respondent:

1. How long have you been an extension personnel? years
2. What institution/organisation do you work for?
3. How many farm communities are within your zone?
4. On average, how many farmers are in each community?
5. How many farm communities were you able to visit in the 2021 cropping year?

6. On average, how many farmers per the communities visited?
7. On the average, how many times did you visit each of these farmers?
8. What were some of the information given to the farmers?

9. Which of the following approaches did you use to provide your extension services to the farmers?

Modes of transfer	Response (1) Yes (2) No
One on one visit (individual farm visit)	
Demonstration plots	
Group extension (lectures/discussions)	
TV programme	
Radio	
Newspaper	
Mobile platforms (SMS, whatsapp)	
Video screens/projectors	
Posters	

10. What is the level of effect of the following approaches on farmers' adoption of sustainable agricultural practices appropriately?

Modes of transfer	Response (1) Very high (2) High (3) Low (4) Very low (5) Not at all
Farmer-to-farmer	
Household extension	
Individual training/farm visit	
Demonstration plots	
Group extension (lectures/discussions)	
TV programme	
Radio	
Newspaper	
Mobile phone	
Video screens/projectors	
Posters	

11. Did you provide training on the usage of inorganic fertilisers to maize farmers during 2021 cropping year? (1) Yes (2) No

12. If no, why:

13. If yes, which of the modes of transfer listed below did you use to transfer information on the use of inorganic fertiliser?

14. What are some of the challenges associated with transferring improved technologies to farmers?

15. In your own opinion, what needs to be done to enhance crop production in the district and region at large?

.....
.....

Telephone number of respondent:

GPS.....

SOCIO-ECONOMIC CHARACTERISTICS

1. Age of extension agent:

2. Sex of extension agent: (1) Male (2) Female

3. Highest level of education: (1) SSS/SHS (2) A-Level (3) Diploma (4) Bachelor's degree (5) Masters degree (6) PhD

4. Number of years spent in formal education? years