DETERMINANTS OF FERTILIZER USE BY SMALLHOLDER ARABICA COFFEE FARMERS IN BUGINYANYA SUB-COUNTY, BULAMBULI DISTRICT

BABRA BIIRA ALIGANYIRA

J22M43/008

A DISSERTATION SUBMITTED TO THE FACULTY OF AGRICULTURAL SCIENCES IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF SCIENCE IN AGRICULTURE AND RURAL DEVELOPMENT OF UGANDA CHRISTIAN UNIVERSITY

September,2025

UGANDA CHRISTIAN UNIVERSITY

A Centre of Excellence in the Heart of Africa

DECLARATION

I, BIIRA BABRA ALIGANYIRA, declare that this dissertation entitled "***Determinants of Fertilizer Use by Smallholder Arabica Coffee Farmers in Buginyanya Sub-County, Bulambuli District***" is my original work, and has not been presented to any institution for any award.

Signed: 8th .September.2025

BIIRA BABRA ALIGANYIRA

J22M43/008

Approval

This is certify that this dissertation entitled *"Determinants of fertilizers use by smallholder arabica coffee farmers in buginyanya sub-county, bulambuli district."* Is hereby approved for sub-mission to the Faculty of Agricultural Sciences in partial fulfilment of the requirements for the a ward of a master of science in Agriculture and Rural Development of Uganda Christain University.

Supervisor

Signed:

Dr. John Livingstone Mutyaba

08th September, 2025

DEDICATION

This dissertation is dedication to my family, friends and relatives for their invaluable encouragement and sacrifices during this study.

ACKNOWLEGMENT

I am profoundly grateful to Almighty God for His continuous guidance, wisdom, and provision throughout my academic journey and during the course of this research. I extend my deepest appreciation to my supervisor, Dr. John Livingstone Mutyaba, whose constructive guidance, patience, and encouragement provided the foundation upon which this dissertation was built. I also acknowledge the collective contribution of my lecturers at Uganda Christian University, whose mentorship has greatly enriched my academic growth, as well as my course-mates in the 2022 cohort for their collegial support and encouragement. My heartfelt thanks further go to my family for their unwavering love, prayer, and moral support that sustained me through this process.

I am equally indebted to the smallholder Arabica coffee farmers in Buginyanya Sub-County, Bulambuli District, who willingly participated in this study and shared their experiences, without which this research would not have been possible. I gratefully acknowledge the assistance of extension agents, district agricultural officers, farmer cooperatives, and coffee associations whose support in farmer mobilization and provision of contextual insights significantly enriched the quality of this study. Special thanks also go to the government institutions and development partners working in the coffee sector, whose policy frameworks and initiatives informed the contextual understanding of input use. To all individuals, institutions, and organizations that directly or indirectly contributed to this work, I remain sincerely appreciative.

ABSTRACT

The persistent decline in Arabic coffee production annually in Buginyanya Sub-county has necessitated smallholder farmers to adopt the use of fertilizers to improve coffee production. This study evaluated farmers' perception, knowledge, and socio-economic factors that affect fertilizer use in arabica coffee production in Buginyanya sub-county, Bulambuli district. The study adopted a mixed-methods approach to provide a comprehensive analysis of the survey data of 240 respondents. Chi Square statistics was used to determine the relationship between agronomic practices and arabic coffee production (Output) while ordered logit model was used to determine the level of fertilizer usage among smallholder Arabic coffee farmers in Buginyanya Sub- County. The impact of perception, socioeconomic factors, and institutional features on fertilizer use adoption was then examined using a multivariate probit model. The finding revealed varying degrees of the influence of recommended agronomic practices on Arabica coffee output in the study area. The Variance Inflation Factor (VIF) values (*Fertilizer use, 1.65; weed control, 1.52; Use of improved seed, 1.38; others, <1.8*) below the commonly accepted threshold of 10 confirmed reliability of the regression coefficients. Furthermore, multiple linear regression analysis indicates that use of improved coffee seed varieties, application of inorganic fertilizers, proper plant spacing, pruning, and weed control were statistically significant predictors of coffee output. The study also showed that both socio-economic characteristics and institutional factors play a significant role in shaping fertilizer adoption behaviour among Arabica coffee farmers. Education level ($p = 0.014$; $\beta = 0.081$), access to extension services ($p = 0.001$; $\beta = 0.628$), availability of credit access ($p = 0.002$; $\beta = 0.452$), farm size ($p = 0.023$; $\beta = 0.319$) and income from coffee ($p = 0.022$; $\beta = 0.0002$) with fertilizer use. Positive perception of Fertilizer use on yield (93.52%, n = 231), very risky on microflora (89.88%, n = 222), high risk on livestock (88.66%, n = 219), very risky on water quality (89.88%, n = 222) and very risky on food safety (85.43%, n = 211). Agricultural extension services should be expanded and better resourced to provide consistent and context-specific training on best agronomic practices. Furthermore, policymakers and development partners should promote inclusive access to financial services, such as input credit schemes and agricultural subsidies, particularly for resource-constrained farmers

Table of Contents

List of figures

List of Tables

List of Abbreviations

UCDA	Uganda Coffee Development Authority
FAOSTAT	Global Food and Agricultural Statistics of FAO
DLG	District Local Government
GoU	Government of Uganda
MAAIF	Ministry of Agriculture, Animal Industry and Fisheries
DAP	Di-ammonium Phosphate
CAN	Calcium Ammonium Nitrate
TSP	Triple Super Phosphate
ICO	International Coffee Organization
NPK	Nitrogen, Phosphorus, Potassium
IPM	Integrated Pest Management
FAO	Food and Agricultural Organization of the United Nations
UBOS	Uganda Bureau of Statistics

CHAPTER ONE
INTRODUCTION

1.1 Background of the study

Global coffee production is estimated at 169.34 million bags (World Data Atlas, 2020). Brazil accounts for around one-third of global coffee production, establishing itself as the preeminent producer, succeeded by Vietnam, Colombia, Indonesia, and Ethiopia (Voora *et al.*, 2019). In Africa, coffee production is estimated at 18.7 million 60kg bags (World Data Atlas, 2021). Ethiopia and Uganda lead the region in coffee production, collectively representing 62% of Sub-Saharan Africa's coffee volume (Ogundeji et al., 2019). In East Africa, notable coffee-producing nations comprise Ethiopia, Kenya, Tanzania, Uganda, Rwanda, and Burundi (Lemma and Megersa, 2021). In this East African region, smallholder farmers predominate in the coffee sector, enabling the area to excel in coffee production compared to the rest of Africa (FAOSTAT, 2020). In 2020, East Africa's coffee production represented 82% of Africa's total output and roughly 10% of global production (Ferreira, 2019).

Although coffee is the country's highest-earning export cash crop, Uganda is ranked eighth in world for coffee production, second in Africa and first in East Africa (Lemma and Megersa, 2021). It is one of the most significant cash crops, contributing immensely to the livelihoods of numerous smallholder farmers and serving as a significant source of foreign exchange earnings for Uganda (Nyamuhumuza, 2021). According to the Uganda Coffee Development Authority (UCDA), the government organization in charge of the industry, estimates that approximately 500,000 households rely on coffee production (Muratori, 2016). Apart from Robusta coffee, Uganda also produces Arabica coffee in the East of the country (on Mount Elgon which borders Kenya) and in the Western part of the country (on the border of the Congo) (Jun, 2020). Arabica coffee of Uganda originates from Ethiopia and was naturally grown on Mount Elgon's slopes (Tembrock, 2021). Due to its superior quality, Arabica coffee is more competitive on the global market (Morjaria, 2018). However, Arabica coffee makes up an average production of only 15% annually as compared to 85% Robusta in Uganda (FAOSTAT, 2020).

Uganda's coffee production dropped by 7.02 % from 312,601 tonnes in 2019 to 290,668 tonnes in 2020 (FAOSTAT, 2021). Since the 24.27 % jump in 2017, coffee production decreased by 3.77 % in 2020 and the arabica coffee annual production is as low as 15% (FAOSTAT, 2020). According to the study conducted by Nyamuhumuza, (2021) in Kenya showed that, the decline in production of coffee was attributed but not limited to; limited extension services, lack of awareness and knowledge on fertilizer use in the coffee gardens, farmers income level, employment status, costs of out puts, access to information about coffee production, land size, and failure to apply proper crop agronomic practices like fertilizer which have gone a long way to cause the country's pathetic arabica coffee production decline.

Good nutrition is necessary for coffee to grow vigorously with reduced susceptibility to pests and infections (Piato, 2020). Larger, bolder beans that are of higher grade and price are linked to an adequate supply of nitrogenous fertilizer (Mulatu, 2019). According to Antonious (2018), the best way to boost Arabica coffee productivity and improve the industry's competitiveness internationally is to adopt and apply fertilizers to Arabica coffee farms and gardens. This strategy preserves the primary source of livelihood for the rural farming community in areas that produce a lot of coffee, like Bulambuli district (Nyamuhumuza, 2021). Similarly, fertilizer use helps enhance and translates high soil fertility into healthy coffee plants and higher yields (Mulatu, 2019).

Although coffee can be produced at an average minimum annual rainfall of 1200 to 1600 mm without too long hot dry season, water and nutrient stress significantly affect its growth and overall yield (Etefa *et al.*, 2019). Meerburg *et al.*, (2019) reported that arabica coffee yield increases with an increase in nutrient availability and with no effects of water stress. However, according to Hatfield and Prueger (2015), and Lobell *et al.* (2018) noted a 1% reduction in nutrient availability to coffee plant per day even under optimal rain-fed conditions which causes a great effect to the yield in the long run. Studies have shown that fertilizers can increase the coffee farm yield through improvement of soil fertility (Mayanja, 2018). Lack of water for coffee plants can result in physiological issues and a significant drop in productivity since coffee are not immune to water shortages. Certainly, some fertilizers also serve as water reservoirs and could improve the physical properties of soil, which increase coffee productivity and, consequently, production (Lemma & Megersa, 2021).

Although fertilizers have a great impact on coffee yield due to high supply of nutrients needed by coffee plants, it's estimated that only 20% of smallholder arabica coffee farmers in Elgon region especially Bulambuli district have embraced the use of fertilizers in arabica coffee production (Mayanja, 2018). According to Bulambuli district annual report, (2021) indicated that although coffee farmers in the region have tried to increase coffee production by increasing its acreage, its production has continued to decrease per year. This is attributed to the soils under arabica coffee production continually being depleted of nutrients without replenishment (Mutanyagwa *et al.*, 2018). Additionally, socio-economic factors such as; farmers' age, education level, land size, culture and norms, employment, and farmers' income greatly determine the crop's production and yield Guzman and Javier Santos, (2018), and these factors affect the adoption of an innovation Mutanyagwa *et al.*, (2018) which equally may affect fertilizers' usage in Arabica coffee production in the Elgon region (Mayanja, 2018).

Considering the importance of fertilizers in coffee production, on the other hand, their use by farmers ought to be growing; yet this has not worked in Bulambuli district as expected (Mayanja, 2018). Therefore, soil fertility management is a considerable key factor in addressing increasing soil fertility depletion in arabica coffee-producing areas such as Bulambuli district, Buginyanya sub-county in the Elgon region of Uganda through adoption and use of fertilizers is paramount. Thus, the study assessed famers' perception, knowledge and socio-economic factors that affect fertilizer use in Arabica coffee production in the Buginyanya sub-county, Bulambuli district.

1.2 Problem statement

Although fertilizer use in Arabica coffee production, has a great effect on the yield (Coffee Research Institute. 2019). In Bulambuli District especially Buginyanya Sub-

County, the available literature indicates that only 20% of smallholder farmers have embraced the fertilizer use (Musoni, 2020). In addition, the persistent decline in Arabic coffee production in the area is attributed to the low usage of fertilizers and changes in climatic conditions (Wanyama *et al.*, 2017). In the past two decades, Arabic coffee production in Buginyanya Sub- County, has persistently dropped by 5% annually (DLG, 2020). More efforts have been deliberately beefed up to address the problem of increasing soil fertility depletion in coffee production by farmers adopting the use of fertilizers to improve arabica coffee production. Presently, there is no study done in the Bulambuli district to document farmers' knowledge, perception, and socio-economic factors that affect the adoption and use of fertilizers among arabica coffee farmers in the Buginyanya sub-county, Bulambuli district. Thus, it is pertinent to assess farmers' perception, knowledge, and socio-economic factors that affect fertilizer use in arabica coffee production in Buginyanya sub-county, Bulambuli district.

1.3 Objectives of the study

1.3.1 The main objective

To evaluate farmers' perception, knowledge, and socio-economic factors that affect fertilizer use in arabica coffee production in Buginyanya sub-county, Bulambuli district.

1.3.2 Specific Objectives

1) To determine the relationship between agronomic practices and Arabic coffee production among smallholder farmers in Buginyanya Sub-County.
2) To determine socioeconomic and institutional factors that influence the level of fertiliser usage among smallholder Arabic Coffee farmers in Buginyanya Sub-County.
3) To determine the role of perception, socio-economic and institutional factors on the uptake of fertiliser use among smallholder Arabic Coffee farmers in Buginyanya Sub-County.

1.4 Research questions

1) What is the relationship between agronomic practices and Arabic coffee production among smallholder farmers in Buginyanya Sub-County?
2) What are the socioeconomic and institutional factors that influence the level of fertiliser usage among smallholder Arabic Coffee farmers in Buginyanya Sub-County?
3) What is the role of perception, socioeconomic and institutional factors on the uptake of fertiliser use among smallholder Arabic Coffee farmers in Buginyanya Sub-County?

1.5 Justification of the study

Contemporary agriculture is characterized by extensive overuse of inorganic fertilizers in order to boost yields. This has created increasing campaigns by the key stake holders in the agricultural sector (GoU/MAAIF, 2020; FAO, 2019). Coffee is one of the most significant cash crops in Uganda, contributing significantly to the livelihoods of many impoverished people while also being a significant source of foreign exchange earnings (FAOSTAT, 2018). According to UCDA, (2020) estimates that about 500,000 households depend on coffee production. Arabica coffee is more competitive on the international market because of its superior quality (FAOSTAT, 2018).

However, its annual production is very low and estimated on average at 15% as opposed to 85% Robusta coffee (UCDA, 2020). Although its production is very low, it has continued to worsen, and its estimated reduction is at 3.77% per year in the Elgon region (Mutanyagwa *et al.*, 2018). The decline in production is attributed to poor agronomic practices (Mulatu, 2019). Given that arabica coffee is the primary source of income for the rural farming population in areas that produce a lot of coffee, like Bulambuli district, using fertilizer is one way to boost the crop's productivity and production and improve its ability to compete internationally (Nyamuhumuza, 2021). The use of fertilizers is known to increase crop productivity Lemma and Megersa (2021) but equally could improve physical soil characteristics to enhance coffee productivity (Lobell *et al.*, 2018).

Additionally, literature on level of fertilizer usage among smallholder Arabica coffee farmers in this region is scanty. Due to its impact on farmers' behavior and decision-making process, farmers' perception is crucial when choosing which fertilizer to use. Consequently, this may lead to reduced crop yields due to reduced soil fertility and climatic changes in the region. Hence, leading to increased yields, increased farm incomes, improved livelihoods and better living standards. Moreover, findings from this study will enable policy makers to formulate intervention and strategies that promote appropriate fertilizer use in coffee production and conservation of the environment.

1.6 Significance of the study

The study is of significance to the following stakeholders.

Farmers: The findings shall equip farmers with knowledge of fertilizer and its importance in arabica coffee production to improve arabica coffee yields in the area. This is under the pretext that local knowledge is vital for preserving biodiversity, while at the same time practicing farming, which is considered a vital strategy.

Agricultural Extension staff: Extension practitioners may be acquainted with knowledge about the socio-economic factors that affect arabica coffee production in the Bugisu sub-region and the farmers' knowledge and perception of the use of fertilizers.

Policymakers: The study may help policymakers such as the Ministry of Agriculture technocrats understand the socio-economic factors that affect fertilizers' usage in arabica coffee production in the region and farmers' knowledge about the use of fertilizers in arabica coffee production in the region which would help in the development and promotion of fertilizer's use in arabica coffee production in the area.

Researchers and academicians: Findings from the study may help researchers and academicians to identify research gap for further research.

1.7 Scope and limitation of the study

The study was limited to smallholder Arabic coffee farmers of Buginyanya Sub-County, Bulambuli District. The selected main issues in this study included relationship between agronomic practices and Arabic coffee production among smallholder farmers, the level of fertilizer usage and role of perception, socio-economic and institutional factors on the uptake of fertilizers among smallholder farmers. The findings in this study though useful were limited in that farmers interviewed hardly keep records on fertilizer use. Consequently, most of the answers to questions were based on the farmer's understanding and memory. However, thorough probing was undertaken to ensure respondents give accurate data.

1.8 Operational definition of terms

Fertilizer: As used in this study, Fertilizer refers to synthetic compounds used by farmers in boosting crop growth and yields. Some examples of fertilizer include DAP, UREA, CAN and TSP among others.

Agronomic Practices: Refers to activities that are associated with field crop production, including soil-water management, land preparation, weeding, pruning and row cropping among others.

Smallholder farmer: Refers to a farmer whose area under Arabic coffee production is not more than five acres.

Household: Refers to an individual plus her/his dependents who have lived together for a duration of six months or more. The members are answerable to one person as the head and share a meal together.

Weed: As used in this study, weed refers to plant or organism that is considered to be undesirable or destructive and compete with crops for resources such as water, light, and nutrients in crop production.

CHAPTER TWO
LITERATURE REVIEW

2.1 Arabic Coffee Production in Uganda

Arabica coffee (*Coffea arabica*) is not native to Uganda, it was introduced in the early 20th century and has since become an important cash crop for the country (Smith, 2010). Over the past decade, Uganda's Arabica coffee production has witnessed substantial growth (ICO, 2021). Arabica coffee in Uganda is one of the chief beverage crops mainly grown in high altitudes and cold areas. It is cash crop and grown for export purposes mainly (UCDA, 2019). It is mainly grown in the highland areas of Uganda, such as the slopes of Mount Rwenzori, Mount Elgon, and southwestern region of the country. According to Uganda Coffee Development Agency, output of Arabica coffee of Uganda has increased progressively from nearly 1.2 million bags in 2010 to an estimated 2.8 million bags in 2022 (UCDA, 2022). This steadfast progression can be attributed to various factors, including augmented investments, favorable weather conditions and improved farming practices among others (MinAg, 2018). Arabica coffee production in Uganda provides a significant employment opportunity to over 1.7 million smallholder farmers and foreign exchange earnings, offsetting unfavorable balance of trade (UG Gov, 2019). Coffee exports brings a substantial share of Uganda's foreign earnings, with Arabica coffee being the leading contributor (Johnson, 2021).

In recent years, coffee has remained Uganda's top agricultural exports, maintaining a strong significance in driving the economy (UCDA, 2019). This is due to tremendous growth in interest and investment in Arabica coffee production (UCDA, 2019). Accordingly, initiatives such good quality coffee, training and support to farmers, and establishment of direct trade relationships with international buyers facilitated the growth (Johnson, 2021). These initiatives were aimed at promoting sustainable practices, improve processing methods, and enhance the overall value chain of Arabica coffee in Uganda (UCDA, 2022). The trend in coffee production in Uganda is a factor of weather conditions, market demand, and government policies. Some of the major Arabic producing areas in Uganda as shown in (Table 1) below.

Table 1: Some of the major Arabica coffee producing areas in Uganda

Region	Arabica coffee producing Areas
Western Uganda	areas around the Rwenzori Mountains and in the districts of Mbarara, Ibanda, Kasese and Bushenyi
Eastern Uganda	Bugisu around Sipi Falls on the western slopes of Mount Elgon in the district of Manafwa, Mbale, Bududa, Bulambuli, Kapchorwa and Sironko

(Primary Data, 2022)

2.2 Fertilizer use in Arabic Coffee Production in Uganda.

Arabica coffee, also known as Coffea arabica, is a profitable cash crop in many coffee-producing regions around the world. Majorly, its production is undertaken by smallholder farmers particularly in Middle East, Africa and Latin America. As a prerequisite, smallholder farmers should correctly implement recommended Good Agronomic Practices timely, such as soil and water conservation, pruning, fertilization, and the control of pests and diseases among others to maximize crop productivity and profitability.

Studies have shown a strong positive correlation between improved arabica coffee production outcomes and the implementation of these good agronomic practices. For instance, properly prepared land involving both appropriate cultivation and harrowing to break soil clogs for better aeration is associated with better coffee growth and increased yield (Nakiganda et al., 2019). According to Wekesa et al. (2018), effective land preparation incorporates organic materials into the soil to improve its fertility and raise yields. High-yielding and disease-resistant coffee varieties increase productivity due to lower chances of yield losses (Alves et al., 2018). Therefore, smallholder farmers should concentrate on using coffee varieties designed to withstand particular agro-climatic conditions and disease resistant (Smith, 2019).

Soil and water conservation has been shown to influence coffee production and productivity according to Jones *et al.* (2020). Soil and water Conservation integrates use of organic matter and other techniques that improves soil structure, adds nutrients into the soil and improves water retention (DaMatta *et al.*, 2018). Soil retention mechanisms like mulching not only improves soil fertility through decomposition but helps maintain soil moisture into the soil by reducing evaporation according to Montagnon *et al. (*2021). Alves *et al.* (2019) revealed that NPK (nitrogen, phosphorus, and potassium) fertilizers is associated with health coffee plats growth and better fruiting of high quality. This was confirmed by Chaparro-Giraldo *et al.* (2020) in Colombia that the use of chemical pesticides like NPK has the ripple effect of 34% increase in the yield on productivity.

Plant density significantly influence coffee plant yields. It has been shown that high plant density is associated with high coffee yields. This is because at close spacing weeds suppressed and more fruiting points due to higher plants (Avelino *et al.*, 2019). At close spacing light interception that facilitate the process of photosynthesis is enhanced, and this enables higher fruit setting and increased coffee production.

Canopy management practices are critical for maintaining vigorous coffee plant growth, controlling disease spread, and facilitating penetration of light (Montagnon *et al.,* 2021). Practices such as pruning facilitates growth of multiple new shoots and rejuvenates plants with increased flowering and fruit production (Zullo Jr *et al.,* 2020; Green *et al.,* 2021). Regular pruning therefore helps removes infected branches especially for fungal infections and intensifies air circulation within the canopy (Brown, 2018). The canopy management practice like appropriate pruning has proven to positively impact coffee production especially increasing coffee yield and quality (Abiyu, 2020; Alves *et al.,* 2019). Johnson (2008) further demonstrated that proper pruning increases light penetration, facilitates air circulation, reduces disease incidence, and enhances yield. Shade Management significantly affects plant physiology and growth. Research by Somarriba *et al.* (2004) demonstrates that appropriate shade management is associated with enhanced photosynthetic efficiency, reduced temperature stress and improved overall coffee quality.

Effective management of pest and diseases helps to mitigate yield losses and maintain healthy coffee plants (Abiyu, 2020). Such management practices include use of Integrated Pest Management (IPM) strategies, which integrate chemical, biological, and cultural control techniques. Integrated Pest management strategies have demonstrated positive result in lowering pest populations (Bisseleua *et al.,* 2022). Diseases such as coffee leaf rust and coffee berry disease can be prevented by using disease-resistant coffee variety and good field hygiene practices, elements of Integrated Pest Management. Abiyu, (2020) indicated that shade management and intercropping have the potential to control pests and diseases in coffee fields and improve coffee yields. More directly, using chemicals i.e. pesticides and fungicides to manage pests and diseases also increase coffee yields (Chaparro *et al.,* 2020). However, the yields are greater when organic fertilizers are used (Abiyu, 2020). Use of fertilizers in Arabica coffee production is crucial to realize better outcomes (Chaparro *et al.,* 2020). The only considerations while using fertilizer are type and application rate. In Colombia and Brazil, Alves *et al.,* 2019 and Chaparro-Giraldo *et al.,* 2020 demonstrated that using of fertilizers in coffee plantation enhances coffee yields and quality.

2.3 Socioeconomic factors influencing the level of fertilizer usage among smallholder Arabica Coffee farmers

Fertilizer usage in agricultural production has been associated with improved crop yields and profitability. Fertilizer's usage is influenced by socioeconomic factors. Some of these socioeconomic factors and their influence on fertiliser use are as discussed below;

Johnson *et al.* (2017) revealed that farm size is a major determinant of fertilizer usage among smallholder farmers globally. For instance, large amount of fertilizers are required in large farms and consequently better returns on investment (Smith *et al.,* 2018). Silva et al. (2020) affirmed that commercial farms often have higher fertilizer application rates than those with low landholdings. In other related studies, income of the farmers which relates to purchasing power influence the ability to acquire fertilizers (Smith, 2018; Jones et al., 2019; Al-Wadei et al. (2017).

Education level of the farmers affect their ability to utilize and adhere to farming principle such as application of fertilizers (Chen & Li, 2018). For instance, knowledgeable farmers are more likely to utilize fertilizers and carefully adhere to the application rate than the illiterate ones (Silva et al., 2020). Another study in Uganda affirmed that farmers with greater education level are more motivated to apply fertilizer (Asenso-Okyere et al., 2015). These studies revealed that adherence to agronomic practice including fertilizer use could be determined by level of education (Johnson et al., 2016). Research affirms that knowledgeable farmers are awareness of the advantages of using fertilizers in coffee plants (Gupta et al., 2017). Shiferaw et al. (2014) acknowledged that adoption behavior of smallholder farmers in Ethiopia was influenced by education. Particularly, farmers who were aware of the importance of fertilizers and their proper application were more likely to ignorant ones (Silva et al., 2020).

Another determinant of utilization of agricultural practices such as fertilizer is age factor (Smith, 2018). As revealed, older farmers tend to use traditional farming practices than the younger farmers who were more receptive to new technologies including use of fertilizers (Brown & Jones, 2019).

Furthermore, gender of the farmers also determine use of modern agronomic practices such as use of fertilizers. For instance, female farmers in some societies in Zimbabwe lack access to productive resources including fertilizers due to limitedness in decision-making power and control over agricultural inputs as opposed to male farmers (Anderson & Johnson, 2021; Gupta et al., 2017)

Household size also affect adoption of farming technologies like fertilizer usage. Lopez et al. (2019) demonstrated that bigger size of the household often have ready labor and resources to support farming activities. However, larger households often have greater financial needs and this inhibit investment in fertilizers (Wilson, 2020). Access to financial resources has been confirmed to affect fertilizer usage according to Huang & Wang (2020).

The experience of the farmers also affects fertilizer use, according to Thompson et al. (2015). As noted by Roberts & Johnson (2019), greater experiences are linked to better understanding of technical knowledge including advantages of fertilizers and application methods and rates.

2.4 The institutional factors influencing the level of fertilizer usage among smallholder Arabica Coffee farmers

Several factors attributed by several institutions influence the level of fertilizer usage among smallholder Arabica coffee farmers. One notable institution is the cooperative organization. As learned, the strength of a cooperative organization is purposely demonstrated in the bargaining power to access improved agricultural inputs, such as fertilizers cheaply, since they are usually in bulk (Smith, 2019; Jones 2020). Cooperatives also provide avenue to acquire knowledge and information exchange major farming practices including proper use of fertilizers (Brown, 2018). Farmers organize themselves in groups and receive tailored trainings. For instance, agricultural cooperatives in Ethiopia support farmers with credit facilities, negotiating better prices and training and extension services (Anderson, 2022; Johnson, 2021; Garcia, 2020). Such programs promote sustainable use of fertilizer among smallholder farmers, which raises their income levels through improved coffee productivity (Lee, 2017).

Regulatory frameworks and policy guidelines regarding the use of agrochemicals is another institutional factor. In most cases, government through various initiatives subsidize prices of agro inputs such as fertilizers, which makes fertilizers more affordably (Smith 2018; Brown & Johnson 2020). For example, the Government of Yemen has introduced subsidy program on fertilizers and that greatly reduced financial burden on coffee farmers (Jones, 2022). Relatedly, some governments have set up initiatives to educate farmers on fertilizers usage, choices and how to apply through agricultural extension programs (Wang et al., 2019). In the extension programs, farmers are guided on proper practice and rate of fertilizers application and soil management practices and that significant increased investments in agricultural extension services (Smith, 2018). These initiatives raise awareness and understanding of the benefits of using fertilizers on the productivity of Arabic coffee farming among smallholder farmers, consequently leading to higher adoption rates (Wang et al., 2019).

Another institutional element that significantly affects fertilizer use is the availability of credit facilities to farmers. The credit facilities assist farmers to access agro inputs such as fertilizers during the difficult period of planting, weeding, fertilization harvesting and post-harvest handling. According to Johnson et al. (2020), smallholder farmers are faced with financial challenges when buying fertilizer for their coffee plants. One practical way is the use of coupons instead of real money up to the set maximum credit level to purchase fertilizers from cooperatives or microfinance institutions (Brown & Jones, 2019). Farmers are more likely to adopt fertilizers and use them at recommended rates when they have better access to credit, according to Adams & White (2021). In Colombia, coffee farmers are certified with standardized farming practices such as sustainable smart farming in order to receive incentives such as fertilizers either organic or inorganic, etc. (Garcia et al., 2022). According to Robinson & Smith (2019), these certification programs guarantee these farmers markets at premium prices for their products. The availability of a premium market and the financial benefits associated with certification encourage farmers to adopt fertilizers and comply with sustainable practices (Sánchez et al., 202; Gutierrez & Martinez, 2020).

2.5 The role of perception, socio-economic and institutional factors on fertilizer use among smallholder Arabic Coffee farmers

Smallholder farmers are the basis of sustainable agriculture globally especially in developing nations (FAO, 2020). These smallholder farmers through various mechanisms including adoption of fertilizers' usage impact productivity and livelihoods (Johnson et al., 2021). For sustainable and effective fertilizer use, Arabica coffee farmers should understand the roles of perception, socioeconomic factors, and institutional frameworks, as explained below:

Perception Factors: Perception reflects a subjective process where individuals interpret and organize information about the usage of fertilizers. Therefore, perception can be influenced by various factors including personal experiences, cultural background and emotions. Among others. There is a direct relationship between perception and adoption of fertilizers usage by smallholder farmers. For example, Silva et al. (2019) found that farmers who had a favorable opinion of fertilizers were more likely to adopt the use of fertilizers than the counterparts. The possible advantages and cost-effectiveness of using fertilizers influenced this opinion.

Socioeconomic Factors: The ability of farmers to adopt fertilizer use is significantly influenced by socioeconomic factors. Studies continuously demonstrate that the adoption of agricultural inputs, such as fertilizers, is influenced by farmers' income, credit availability, and resource endowments. According to Nyanga et al. (2016), for instance, farmers who earn more money are more likely to use fertilizers because they can afford to buy and apply them. Likewise, Gebremedhin et al. (2018) showed that farmers can purchase fertilizers by having access to credit facilities.

Institutional Factors: Institutional factors that influence the adoption and usage of fertilizers among smallholder farmers include but not limited to favorable government policies and regulations, access to extension services and market infrastructure among others. For example, a supportive institutional framework facilitates better access and usage of agro inputs such as fertilizer uptake among smallholder farmers. Also, availability of extension services in an area enables farmers to be aware of the likely methodology of improving their productivity. A study by Rijal et al. (2017) in Nepal found that the availability of extension services positively influenced farmers' adoption decisions. Relatedly, Deressa et al. (2014) reported that well-functioning input markets with reliable supply chains and competitive prices enhance farmers' access to fertilizers.

2.6 Conceptual Framework

The conceptual framework below illustrates how perceptions, institutional factors, and socioeconomic factors, affect farmers' decisions regarding the use of fertilizer. Education level, age, gender, household size, farming experience, and perceptions of farm size are examples of socioeconomic factors. Institutional factors such as credit availability, extension services, training programs, social networks, and information availability influence farm productivity and pest management technique selection. Farmers' decisions about pesticide use are heavily influenced by these perception, institutional, and economic factors, which also affect their decisions to utilize fertilizer. The expected outcomes from the adoption of fertilizer use will be the changes in the crop yields, income and improvement livelihood. Figure 1 indicates interactions among these factors and how they influence farmer`s decision to adopt fertilizer use as well as the level of usage.

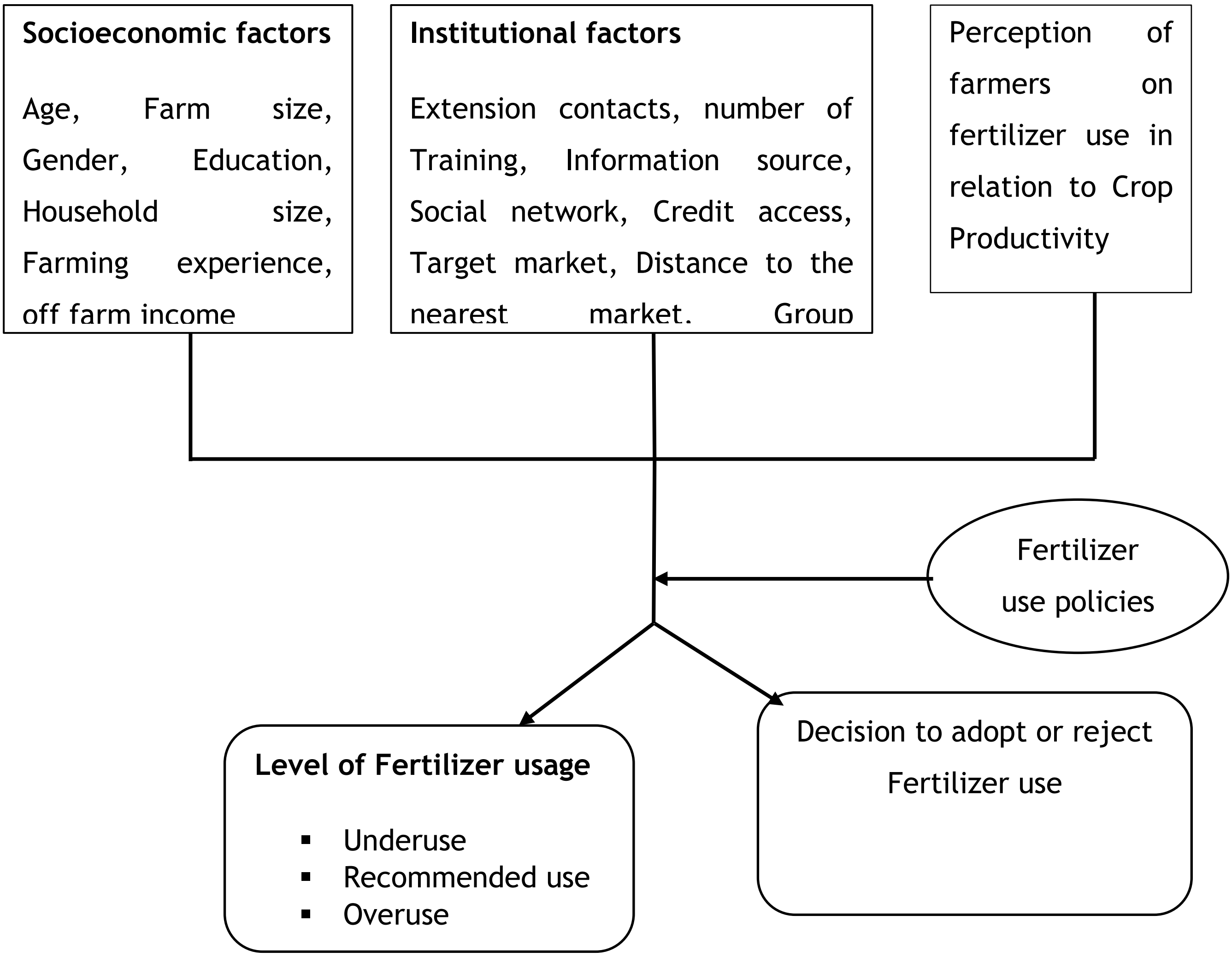

Figure 1: Conceptual framework on determinants of fertilizer usage and uptake

CHAPTER THREE

METHODOLOGY

3.1 Study area

The study was conducted in Buginyanya Sub-County, Bulambuli District, which is one of the leading Arabic coffee producing areas in Uganda, situated in a close proximity to the Border of Kenya, which is the biggest coffee market in East Africa. The Sub-County lies within the Great MT. Elgon with volcano soils. It is located at latitude 1.21333^0 and 34.39306^0 longitude (1°12' 48" North, 34°23' 35" East) and at an elevation of 1,877 meters above the sea level. Buginyanya Sub- County borders with Bukhalu and Bulago Sub-Counties. Buginyanya Sub- County covers an area of 4,859 Km^2 with a population of 3700 males and 3,600 females (UboS, 2020). This Sub-County is situated in a region that receives bimodal rainfall with long rains ranging from March to June, with the shortest rains occurring from October to November (Bulambuli LG, 2019). The temperature ranges from an average of 12^0C to 29.3^0C. The county has three parishes namely Buginyanya, Kirwali and MT. Elgon National Park. Agriculture is the major economic activity in this region with major crops including Arabic coffee, bananas, maize, beans, carrots and vegetables among others. Some of the livestock bred kept include; cattle, local poultry, sheep donkeys as well as bees (Bulambuli DLG, 2019).

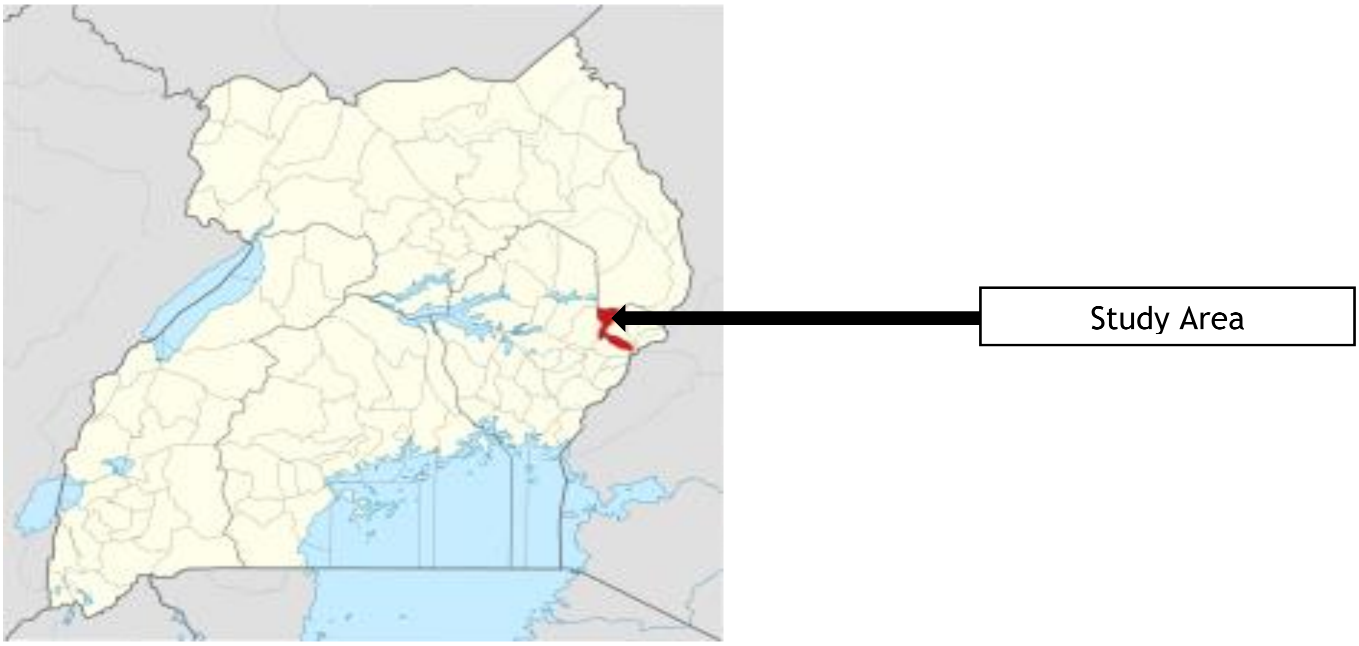

Figure 2: map showing study area

Source: www.bulambuli.go.ug

3.2 Sampling Procedure

The study adopted a multi-stage sampling procedure to select respondents. First, Buginyanya Sub- County was purposively selected. Second, the three parishes were purposively selected since they are one of the major coffee producing areas in the sub-county. Subsequently, random selection of villages in the three parishes was carried out. Simple random sampling was used to select the required number of farmers from the selected villages. A list of farmers generated by an agricultural extension officer of the area and that acted as a sampling frame from which respondents were drawn. The sample was proportionately allocated to smallholder farmers growing Arabic coffee with assistance from agricultural extension officer in the selected villages.

3.3 Sample size determination

The sample size for respondents were determined using Yamane's formula (1967:886) as shown in the equation 1 below:

$$n = \frac{N}{1+N(e)^2} \text{...(1)}$$

"n" is the sample size, "N" is total population, "e" is error (0.05) or level of confidence 95% "N" (population) = 500

$n = \frac{540}{1+540(0.05)^2}$ $n = \frac{540}{1+540(0.0025)}$ $n = \frac{540}{2.25}$ **n = 240**

Therefore, the study considered **240 respondents** from Buginyanya Sub-County

3.4 Data collection and Analysis

The research employed both primary and secondary sources of information. Qualified enumerators presented semi-structured questions to respondents in order to gather primary data through in-person interviews. Journals on fertilizer use and government publications among others, were sources of secondary data. Data was coded before being analyzed using STATA (version 15) software.

3.4.1 Analytical framework

Objective one: To determine the relationship between agronomic practices and Arabic coffee production among smallholder farmers in Buginyanya Sub- County.

Chi Square statistics was used to determine the relationship between agronomic practices and arabic coffee production (Output) among smallholder farmers in Buginyanya Sub- County. Agronomic practices examined include: Training/bending coffee trees, weed control/management, managing soil fertility, Pruning and de-suckering, Stumping, Mulching, Soil and water conservation practices. This involved use of percentage, mean, tables and graphs.

Objective two: To determine socioeconomic and institutional factors that influence the level of fertilizer usage among Arabic coffee farmers in Buginyanya Sub-county.

Ordered logit model was used to determine the level of fertilizer usage among smallholder Arabic coffee farmers in Buginyanya Sub-county. The dependent variable (Y_i) was the level of fertilizer usage measured in kilogram per acre applied where, 0 = under dose, 1= recommended dose and 2= overdose. Fertilizer overdose refers to the amount of fertilizer applied in excess of recommended dosage as indicated on the manufacturer's manual or product label. Fertilizer under dose refers to the amount of fertilizer applied which is less than the recommended dosage as specified on the product label. When fertilizer is administered in quantities below the recommended dosage listed on the product label, it is referred to as fertilizer under dose. The amount of fertilizer applied per acre is calculated by multiplying the farmers' reported application rate by the treated area, and is expressed in kilogram of the fertilizer per acre (Kg/acre).

Subsequently, the sum of the amounts determined for each application during a season was used to determine the total amount of fertilizer applied per acre. Ordered logit model can be formulated as follows (Mellisa and Bryman, 2004);

$$Ln\Omega_{y\leq m}(x) = \alpha_m - x\beta$$

$$Ln\left[\frac{pr[y \leq m \mid x]}{pr[y > m \mid x]}\right] = \alpha_m - x\beta \text{ .... (2)}$$

The benefit of this model is that it eliminates the limitation of parallel regression assumption by allowing estimated coefficient β to vary for each of J-1 alternatives. Hence, that can be written as follows;

$Ln\Omega_{y\le m}(x)=\alpha_m - x\beta$ For m=1… J-1

Equation 2 can be rewritten in terms of likelihoods as

$Ln\Omega_{y\le m}(x)=\exp[\alpha_m - x\beta]$ For m=1... J-1.. (3)

The predicted likelihoods can be calculated as follows

$$pr[y=1\,|\,x]=\frac{\exp(\alpha_1 - x\beta_1)}{1+\exp(\alpha_1 - x\beta_1)}$$

$$pr[y=j\,|\,x]=\frac{\exp(\alpha_j - x\beta_j)}{1+\exp(\alpha_j - x\beta_j)}-\frac{\exp(\alpha_{j-1} - x\beta_{j-1})}{1+\exp(\alpha_{j-1} - x\beta_{j-1})} \quad \text{For J=2,.., J-1}$$

$$pr[y=j\,|\,x]=1-\frac{\exp(\alpha_{j-1} - x\beta_{j-1})}{1+\exp(\alpha_{j-1} - x\beta_{j-1})} \quad \text{.. (4)}$$

Consequently, $\alpha_j - x\beta_j \ge \alpha_{j-1} - x\beta_{j-1}$ so that $pr[y=j\,|\,x]$ lies between zero and one (Mellisa and Bryman, 2004).

Description of the variables and their expected signs as used in the model are presented in Table 2. The variables were derived from the reviews of the previous studies (Ajayi, 2000; Alam and Wolff, 2016; Amoabeng *et al.*, 2017; Dasgupta, 2007; Hashemi, 2012; Jallow *et al.*, 2017; Jin *et al.*, 2017; Macharia *et al.*, 2013; Murendo *et al.*, 2015; Schreinemachers *et al.*, 2017; Wang *et al.*, 2017).

Table 2: Description of variables in the Ordered Logit model

Variables	**Description**	**Expected signs**
Dependent		
Level of fertilizer usage	Quantity of fertilizer in (kgs) (Underdoes, recommended dose and overdose)	
Explanatory		
Age HH	Age (years) of the household head	+/-

Gender HH	Gender of the respondent where 1=male and 0=female	+/-
Education HH	Number of years of schooling of household head	-
Farming experience	Farming experience in years	-
Farm size	Farm size in acres	-
Exten contact	Number of contacts with extension services	-
ProductivityPerc	Attitude towards pesticide use on productivity where 1=strongly agree 2= agree, 3=uncertain, 4=disagree, 5= strongly agree.	+/-
Off Farm Inc.	Participation in off farm activities	+
Traingfert	Number of training on fertilizer use	-
Information source	Dummies of main primary information source for fertilizer use in general.	-/+
Creditacc	Access to credit 1= yes,0= otherwise	
Arabica production	Nature of production system 1= recommended spacing 0=Otherwise	+
Distance fertilizer	Distance to the nearest fertilizer market measured in walking minutes and Km	+
Target to Market	Dummies of different coffee markets (Exporters, processing companies, cooperatives, local traders/middlemen)	+/-

(Primary Data, 2022)

Objective three: To determine the role of perception, socio-economic and institutional characteristics on the uptake of fertilizers among smallholder coffee farmers in Buginyanya Sub- County

The study recognized that farmers use a variety of methods in crop production. They faced with a variety of production strategies that can be used as complements, substitutes, or supplements either concurrently or sequentially. This indicated that the quantity of tactics used may be interconnected rather than independent. As a result, a farmer could select a combination of tactics to optimize the anticipated utility. As a result, the adoption decision was multivariate, and using a multivariate approach could leave out important details from concurrent and interdependent adoption decisions (Kassie *et al.*, 2013).

First, production strategies were divided into two groups: scientific methods and conventional ways. The impact of perception, socioeconomic factors, and institutional features on fertilizer use adoption was then examined using a multivariate probit model. The model permitted the error term to be flexibly correlated while simultaneously estimating the impact of a collection of independent factors on each of the several strategies (Belderbos et al., 2004; Lin et al., 2005). In contrast, univariate probit models disregard the association between the adoption of various fertilizer use practices and the correlation of disturbance terms. This might lead to bias and inefficient estimates. Kassiea *et al.* (2013) formulated multivariate regression as follows;

$Y_{ji}^{*} = \beta_j X_{ji}^{`} + \varepsilon_{ji}, j = 1 \ldots M$ .... (5)

And

$Y_{ji} = \{1 if Y_{ji} > 0, 0 otherwise\}$.. (6)

Where j=1...M represents available Arabic coffee production strategies.

Y_{ji}^{*} = Latent variable which captures the unobserved preferences.

$X_{ji}^{`}$ = A set of independent variables (perception, socioeconomic and institutional characteristics)

ε_{ji} = Random error term

Y_{ji} = Observable binary discrete variable denotes whether or not a farmer adopts a certain strategy.

Equation 6 was used for estimation due to the latent nature of the variable. Assuming that the disturbance term has a multivariate normal distribution with a zero conditional mean and variance normalized to unity, multiple strategies can be adopted (Kassiea *et al.*, 2013). That is, ε_{ji} ~ {0,Σ} where the covariance matrix is given by the following:

$$\begin{bmatrix} 1 & \rho_{12} & \rho_{13} & \cdots & \rho_{1M} \\ \rho_{12} & 1 & \rho_{23} & \cdots & \rho_{2M} \\ \rho_{13} & \rho_{23} & 1 & \cdots & \rho_{3M} \\ \cdots & \cdots & .. & 1 & \cdots \\ \rho_{1M} & \rho_{2M} & \rho_{3M} & \cdots & 1 \end{bmatrix}$$

Variables used in the models and their expected signs are described in Table 3. They were derived from review of previous relevant studies (Ajayi, 2000; Hashemi and Damalas, 2011; Kassiea *et al.*, 2013; Khan, 2008; Khan and Damalas, 2015; Mengestie *et al.*, 2015; Murendo *et al.*,2015; Rahman, 2013; Riwthong *et al.*, 2016; Sharif *et al.*, 2017; Zyoud *et al.*, 2010).

Table 3: Description of variables in the Multivariate Probit model

Variables	Description	Expected sign
Dependent		
Adoption	Decision to adopt a production strategy (Traditional or Scientific) (dummy)	
Independent		
Farmexpe	Farming experience in years	+
Age of House Hold	Age of the household head in years	+
Education House Hold	Years of schooling	+
Gender House Hold	Gender of the household head 1=male, 0=otherwise	+/-
Extencont	Number of contacts with extension services	+
ProductivityPerc	Attitude towards fertilizer use on productivity where 1=strongly agree, 2= agree, 3= uncertain, 4= Disagree, 5= Strongly disagree.	+/-
Offfarminc	Participation in off farm activities	+
Traingfert	Number of training on fertilizer use	+
Arabic coffee production	Nature of production system where 1=use fertilizer 0=otherwise	+/-

Distance to fertilizer market	Distance to the nearest fertilizer market measured in walking minutes and Km.	+/-
Target to Market	Dummies of different coffee market, (Exporters, processing companies, cooperative, local traders)	+/-

(Primary Data, 2022)

3.5 Ethical consideration

First, because the study included farmers as participants, an ethical letter was sought from Uganda Christian University's research ethics committee.

Second, an introduction letter was issued in order to secure authorization from Uganda Christian University's course coordinator. The DPO received the letter, which accepted and assisted the researcher in conducting the study.

Thirdly, participants' rights were protected by granting them the appropriate liberty to choose whether or not to take part in the study. Confidentiality and privacy were preserved throughout the study. The subjects were guaranteed the confidentiality of any information they provided. The researcher ensured that there was confidentiality about the respondents and respected their views given.

Consent was obtained from the respondents at the beginning of the research, after understanding the objectives, purpose as well as the assurance that the study is only for academic purposes. Each of the chosen study sites' focal persons (chairpersons) was contacted at the start of the study to obtain consent and any additional information.

CHAPTER FOUR
RESULTS AND DISCUSSIONS

4.1 Descriptive Statistics

A mixed-methods approach was used in the study, and this combines qualitative and quantitative research techniques to provide a detailed analysis of the survey data. A semi-structured questionnaire with both closed-ended and open-ended questions was used to gather this research data. This necessitated capturing qualitative data to improve interpretation and further generate quantitative data for statistical analysis.

Key socio-demographic factors included in study were age, gender, education level, marital status, and household size, were crucial for understanding the composition of population and spotting trends that could affect the findings.

4.1.1 Demographic Characteristics of Respondents

The demographic characteristics of the respondents are shown in the table below.

Table 4.1: Distribution of Demographic characteristics of respondents

Variable	Obs	Mean	Std. Dev.	Min	Max
AGE	247	50.7	14.6	18	81
HH_Size	247	5.3	1.5	1	9
Experience in coffee	247	18.9	10.2	5	55
Land Size	247	1.9	0.9	0.5	4
Acreage under coffee	247	1.8	0.8	0.5	4
Dist. Nearest Mkt	247	1.7	1.0	0.5	5
Coffee Harvest S1 (Kgs)	247	1313.9	631.4	233	3544
Coffee Harvest S2 (Kgs)	247	1571.6	695.5	180	2944
Farmer group Size (Members)	247	10	7	3	30

(Primary Data, 2025)

According to the findings, the average age of the respondents was 50.7 years (SD = 14.6). The combined experience of older people in coffee production, farm management, and marketing are the likely cause of this age distribution. Although most coffee farming in the region is primarily carried out by older farmers, other seasoned farmers are also represented with minimum of 18 years.

The majority of households had at least five people, as indicated by the average household size of 5.3 members (SD = 1.5) among respondents. Given the labor-intensive nature of coffee production, family labor availability is essential to coffee farm management. This confirms the smallholder coffee producers' observed reliance on family labor as their main source of farm labor in the area.

In regard to land ownership, the average respondents owned 1.9 acres of land (SD = 0.9), and the average area of land used exclusively for coffee production was 1.8 acres (SD = 0.8). These results show that respondents frequently diversify their land use to include the production of food crops for both market and household subsistence, and that landholding sizes are generally modest. This consequently reduces the amount of land that is solely used for coffee production.

In terms of production output, the farmers reported an average harvest of 1,314 kilograms (SD = 631) of coffee in the first season and 1,572 kilograms (SD = 696) in the second season, yielding a total annual average of approximately 2,886 kilograms. This level of productivity reflects the combined influence of experience, labour availability, and land allocation practices.

Moreover, the findings indicate that the majority of farmers were affiliated with farmer groups. These groups serve as platforms for knowledge sharing, capacity building, and collective action aimed at improving production and marketing activities. On average, each farmer group consisted of approximately 10 members (SD = 7), indicating small, manageable group sizes conducive to effective interaction and cooperation among members.

4.1.2 Farmers' Socioeconomic and Institutional Characteristics

Table 4.2 presents the distribution of socioeconomic and institutional characteristics of the sampled coffee farmers.

Education Levels of Coffee Farmers

The results indicate that the majority of the respondents had attained formal education. Only 6 respondents (2.43%) had informal education, implying limited representation of this group. The highest proportion of respondents had attained primary education, with 142 farmers (59.92%) reporting completion of this level. Additionally, 73 respondents (29.55%) had attained secondary education, while 26 farmers (10.53%) had completed tertiary education. These findings indicate that most coffee farmers in the study area had access to basic or formal education, which may influence their adoption of agricultural technologies and participation in market activities.

Table 4.2: Distribution categorical characteristics of the sampled respondents (n=247)

Variable	Attribute	Freq.	Percent	Cum.
Gender	Male	186	75.30	75.30
	Female	61	24.70	**100.00**
Level of Education	Informal level	6	2.43	2.43
	Primary	142	57.49	59.92
	Secondary	72	29.55	89.47
	Tertiary/University	26	10.53	**100.00**
Primary Occupation	Farming	224	90.69	90.69
	Business	23	9.31	100.00
	Causal	0	0.00	**100.00**
Main coffee buyers	Cooperatives	18	7.29	7.29
	Processors	159	64.37	71.66
	Local dealers	69	27.94	99.60
	others	1	0.40	**100.00**
Membership fees	Yes	190	76.92	76.92
	No	57	23.08	**100.00**
Reason for Association	Production & Marketing	23	9.31	9.31
	Saving & Credit	164	66.40	75.71
	Welfare	3	1.21	76.92
	Others	57	23.08	**100.00**
Access to credit	Yes	108	43.72	43.72
	No	139	56.28	**100.00**
Purposes for credit	Domestic	5	2.02	2.02

	Farm workers	1	0.4	2.42
	School fees	14	5.67	8.09
	Farm inputs purchases	62	25.1	33.19
	Acquire property	26	10.53	43.72
	Not Specified	139	56.28	**100.00**
Sources of credit	Commercial bank	6	2.43	2.43
	Farmers' group	53	21.46	23.89
	Informal lenders	2	0.81	24.70
	Microfinance Institutions	9	3.64	28.34
	SACCOs	39	15.76	44.10
	Others	138	55.9	**100.00**
Reasons for Not Using Credit	Previous loan Defaulting	2	0.81	0.81
	High interest rate	118	47.78	48.59
	Lack of collateral security	46	18.64	67.23
	Lack of awareness	3	1.21	68.44
	Not Interested	78	31.56	**100.00**
Sources of information	Fellow farmers	118	47.78	47.78
	Local leaders	11	4.45	52.23
	CBOs	93	37.65	89.88
	Gov't Ext. Officers	25	10.12	**100.00**

(Primary Data, 2025)

Coffee Marketing Channels

The same table also highlights the market channels through which coffee producers sold their products. A total of 18 respondents (7.29%) reported selling their produce to coffee cooperative societies. This indicates that cooperatives may offer better prices and stable markets; however, membership often requires adherence to strict rules and quality standards. The majority of respondents, 159 farmers (64.37%), sold their coffee-to-coffee processing companies. Another 69 respondents (27.94%) sold to private coffee dealers, while only 1 farmer (0.40%) reported selling to other unspecified buyers.

Group Membership and Payment of Membership Fees

Regarding group membership, 190 respondents (76.92%) reported paying membership fees to belong to a farmers' group, while 57 respondents (23.08%) did not. Among those who paid fees, all 190 (76.92%) indicated that they could afford the payments. Conversely, the 57 respondents who did not pay membership fees cited unaffordability as the main reason for not joining a group.

Reasons for Joining or Not Joining Farmers' Groups

When asked about the purpose of group membership, 23 respondents (9.31%) stated that they joined for production and marketing benefits. These farmers believed that group membership improved access to farm inputs, enhanced production management, and provided easier access to markets. The majority (164 respondents, 66.40%) reported that they joined groups primarily for savings and credit services, indicating that these groups act as financial support systems for their members. A smaller proportion of respondents—3 (1.21%)—cited welfare reasons, while 57 respondents (23.08%) indicated other unspecified reasons.

Among those who were not members of any group, the main reason cited was a lack of trust in group members, reported by 190 respondents (76.92%). Other reasons included high membership fees (20 respondents, 8.10%), unmet expectations from the groups (3 respondents, 1.21%), quality standards not being met (4 respondents, 1.62%), and lack of time to attend group meetings (3 respondents, 1.21%). The remaining 27 respondents (10.93%) reported other unspecified reasons.

Access to Credit and Its Utilization

On average, the number of groups per respondent was 9.79. Regarding credit access, 108 respondents (43.72%) reported receiving credit from their group, while 139 respondents (56.28%) had not. Among those who accessed credit, 5 respondents (2.02%) used it for domestic expenses, 1 respondent (0.40%) used it to pay farm workers, and 14 (5.67%) paid school fees. A larger proportion—62 respondents (25.10%)—used the credit to purchase farm inputs, and 26 (10.53%) used it to acquire property. The remaining 139 respondents (56.28%) did not specify how they used the credit.

Sources of Credit

Credit sources varied among respondents. A small proportion (6 respondents, 2.43%) reported obtaining credit from commercial banks. Farmer groups were a significant source of credit for 53 respondents (21.46%). Informal lenders were mentioned by 2 respondents (0.81%), while 9 respondents (3.64%) obtained credit from microfinance institutions. Additionally, 39 respondents (15.76%) sourced credit from Savings and Credit Cooperative Organizations (SACCOs), while 138 respondents (55.87%) did not disclose their credit sources.

Reasons for Not Using Credit

Respondents who did not utilize credit provided several explanations. Two respondents (0.81%) cited defaulting on previous loans. A larger portion (118 respondents, 47.77%) attributed it to high-interest rates, while 46 respondents (18.64%) reported lack of collateral. Another 3 respondents (1.21%) were not aware of credit facilities. The remaining 78 respondents (31.58%) did not provide specific reasons.

Training Attendance and Providers

Training attendance among respondents was high, with 239 farmers (96.76%) reporting participation in agricultural training sessions, while only 8 (3.24%) had not. Regarding payment for training, 246 respondents (99.60%) reported receiving the training for free, while only 1 respondent (0.40%) paid for the service. The sources of training were diverse: 4 respondents (1.62%) received training from fellow farmers, 88 (35.63%) from government extension officers, and the majority—151 respondents (61.13%)—from NGO personnel. The remaining 4 respondents (1.62%) did not specify their training providers.

Training Topics

The main training topics reported by respondents were focused on agronomic practices. Specifically, 208 respondents (84.24%) received training in Arabica coffee agronomic practices, while 6 respondents (2.43%) were trained in fertilizer application. Eight respondents (3.24%) received training in coffee marketing, and 21 were trained in post-harvest handling. Four respondents did not mention the training topics.

Sources of Agricultural Information

Information dissemination among coffee farmers was varied. Ninety-four respondents (38.06%) reported receiving information from fellow farmers. In contrast, 228 respondents (92.31%) reported receiving information from extension officers, and 142 respondents (57.49%) received information from input suppliers. Similarly, 228 respondents (92.31%) received information from coffee-purchasing companies.

Relationships with Information Sources

When asked about their relationship with information providers, 118 respondents (47.78%) identified fellow farmers as their main source. Eleven respondents (4.45%) received information through local leaders, 93 (37.65%) through community organizations (COs), and 25 respondents (10.12%) reported receiving information from extension officers.

4.1.3 Descriptive Statistics of Agronomic Practices Used in Coffee Production

Table 4.3 presents the mean scores of the key agronomic practices employed by coffee farmers in the study area, namely pruning, mulching, weeding, uprooting, and intercropping. The results indicate that these practices were applied at varying levels of frequency among the respondents.

Table 4.3: Distribution of agronomic practices used by sampled farmers

Variable	Mean	Std. Dev
Pruning	1.98	0. 30
Mulching	2.04	0.40
Weeding	2.08	0.38
Uprooting	1.31	0.50
Intercrops	1.09	0.32

(Primary Data, 2025)

Pruning had a mean score of 1.98 (SD = 0.30), indicating that it is moderately practiced by farmers. This practice is primarily undertaken when a coffee tree is dry, diseased, infested with pests, broken, dead, or deemed unproductive. According to Bunn et al. (2015), pruning is essential for keeping coffee trees robust and fruitful because it eliminates unwanted branches, which encourages rapid growth and slows the spread of pests and diseases. Mulching scored a mean of 2.04 (SD = 0.40). Therefore, coffee farmers frequently mulch their farmers to maintain soil moisture, control soil temperature and enhance soil fertility. Especially after harvest, mulching is frequently done with crop residues, cover crops, or shade trees (Jassogne et al., 2013).

Coffee growers viewed weed control (2.08; SD = 0.38) as an essential part of farm management. Weeding is often performed to lessen competition for nutrients, water, and light and increase yields. Regular weeding lowers production costs and enhances coffee produce quality (Kiyimba et al., 2021). Uprooting, on the other hand, showed a lower mean of 1.31 (SD = 0.50). The high expense of replacing coffee trees is probably the cause of this. As a result, most farmers pick alternative methods of managing contaminated or unproductive trees.

Intercropping had the lowest mean score of 1.09 (SD = 0.32). The lack of awareness of the possible advantages of intercropping, such as increased resource efficiency and pest control, is primarily the reason for this slow adoption. Consequently, many farmers in the region opt for monocropping systems, possibly due to traditional practices or lack of extension support. These findings underscore the need for enhanced extension services and farmer training programs to promote the adoption of sustainable agronomic practices that can improve coffee productivity and profitability.

4.2 Relationship between Agronomic practices and Arabic Coffee Production

Table 4.4 shows the distribution between agronomic practices in terms of use of improved coffee seedlings, fertilizer usage, organic manure, mulching, pest control, shade management, plant spacing and weed control among others and coffee production in the study area.

Table 4.4: Distribution of agronomic practices and coffee output

Variable	Obs	Mean	Std. Dev.	Min.	Max.
Coffee_Output (Kgs)	247	1,443	664	207	3244

Use_Improved Coffee seed	247	120	98	9	238
Inorganic Fertilizer_use	163	82	73	0	163
Organic Fertilizer_use	84	42	34	0	84
Mulching	247	120	60	13	225
Pruning	247	116	88	18	242
Pest_control	247	150	66	11	236
Shade_management	247	112	72	23	240
Plant_spacing	247	110	56	66	238
Weed_control	247	76	69	54	232

(Primary Data, 2025)

Table 4.4 presents the descriptive statistics of selected coffee farming practices among the sampled respondents. On average, the respondents reported a coffee harvest of approximately 1,430 kilograms (M = 1,430, SD = 664). The average number of improved coffee varieties used was 120 (SD = 98), indicating moderate variability in adoption across respondents.

The use of Inorganic fertilizers had a mean value of 82 kilograms (SD = 73), while the application of organic manure averaged 42 kilograms (SD = 34), indicating a relatively lower use of organic fertilizers compared to inorganics fertilizers. Additionally, an average of 120 respondents (SD = 60) practiced mulching, and 116 (SD = 88) engaged in pruning activities to maintain the health and productivity of their coffee plants.

Shade management, which involves the planting of shade trees in coffee fields, was practiced by an average of 150 respondents (SD = 66). Moreover, an average of 110 respondents (SD = 56) adhered to proper plant spacing during coffee establishment, and 76 respondents (SD = 69) practiced periodic weeding using hoes. These findings reflect the varying degrees of integration of recommended agronomic practices among coffee farmers in the study area.

4.2.1 Multicollinearity Diagnostics

The results presented in Table 4.5 indicate that all the selected explanatory variables including; *Fertilizer use*, *Weed control*, *Use of improved seedlings*, among others, exhibited Variance Inflation Factor (VIF) values below the commonly accepted threshold of 10. This indicates the absence of multicollinearity among the independent variables, thereby confirming the reliability of the estimated regression coefficients (Gujarati & Porter, 2009).

Table 4.5: Multicollinearity Test

Variable	VIF	Tolerance
Fertilizer_use	1.65	0.606
Weed_control	1.52	0.658
Use_improved_seed	1.38	0.725
Others	<1.8	>0.55

(Primary Data, 2025)

4.2.2 Econometric Analysis

The results from the multiple linear regression analysis indicate that several agronomic practices significantly influenced Arabica coffee production at the 5% significance level ($p < .05$). Specifically, the use of improved coffee seed varieties, application of inorganic fertilizers, proper plant spacing, pruning, and weed control were found to be statistically significant predictors of coffee output.

The model showed a strong (69.2%) power in the variation in Arabica coffee production levels (R2 = 0.692) as confirmed by the robustness and reliability of the diagnostic tests. The model fit the sampled coffee farmers indicating that the chosen agronomic practices are important factors influencing their productivity.

Table 4.6: Multiple linear regression Analysis

Variable	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
Use_improved_seed	2.764	0.582	4.09	**0.000**	1.340	3.554
Inorganic_Fertilizer_use	1.788	0.516	3.42	**0.001**	1.040	2.496
Organic_manure	0.566	0.494	1.15	0.432	0.206	2.224
Mulching	0.349	0.313	0.86	0.422	0.148	1.789
Pruning	1.287	0.468	2.65	**0.008**	0.205	2.064
Pest_control	0.404	0.396	1.33	0.345	-0.054	1.532
Shade_management	0.312	0.405	0.54	0.653	0.080	1.630
Plant_spacing	1.124	0.542	2.48	**0.014**	0.172	1.874
Weed_control	1.378	0.470	2.82	**0.002**	0.426	2.192

_Cons	2.969	1.278	2.34	0.024	0.011	5.636

Obs = 247; **F(9,247)** = 15.68; **Prob>F** = 0.000; **R-squared** = 0.692; **Root MSE** = 3.462

(Primary Data, 2025)

The econometric analysis indicate a number of statistically significant agronomic practices that affect coffee productivity. As noted in the table 4.6 above, the use of improved coffee seeds showed a significant effect on coffee yield (coefficient = 2.764, p-value = 0.000). This reveals that farmers who used improved coffee varieties harvest about 2.8 kilograms more coffee per tree than their counterparts who used traditional seed varieties, under normal conditions. This result is consistent with findings that better seed technology boosts agricultural output (Abro et al., 2021; Mwaura et al., 2020).

The use of inorganic fertilizer was also found to have statistically significant on yield (coefficient of 1.800, p-value = 0.000). For instance, coffee yield increases by about 1.8 kilograms for every additional unit of inorganic fertilizer applied. This is supported by other empirical research showing that crop yield and fertilizer application are positively correlated in smallholder farming systems (Kassie et al., 2018; Tambo & Wünscher, 2017).

According to the analysis, coffee production is significantly impacted by the practice of pruning coffee shrubs (p = 0.008, coefficient = 1.287). as shown above, yield increases by approximately 1.3 kilograms as a result of regular pruning. According to ICO (2023), pruning improves air circulation and light penetration and this improves growth and development of beans. Likewise, plant spacing was statistically significant (p = 0.014) and positively associated with coffee output, with a coefficient of 1.124. Proper spacing allows for better resource utilization, including sunlight and nutrients, thereby improving yields (Worku et al., 2019).

Weed control also emerged as a statistically significant practice (p = 0.002), with a coefficient of 1.378. This finding indicates that effective weed management can lead to an increase in coffee yield by approximately 1.4 kilograms. Weeds compete with coffee plants for nutrients, water, and light, and their management is therefore essential for maximizing productivity (FAO, 2022).

Conversely, some agronomic practices were found to be statistically insignificant at the 5% level of significance. These include the use of organic manure (p = 0.260), mulching (p = 0.402), pest control measures (p = 0.304), and shade management (p = 0.603). Although these practices did not show significant statistical effects in this analysis, they remain important components of sustainable coffee production systems. Their benefits, such as improving soil health, moisture retention, and microclimate regulation, have been widely documented in agronomic literature (DaMatta et al., 2022; Jha et al., 2014). Thus, farmers should not disregard these practices, but rather incorporate them alongside those with immediate yield impacts for long-term sustainability.

4.3 Socio-economic and institutional factors influencing fertilizer usage

The descriptive statistics presented in Table 4.7 reveal key characteristics of the sampled households engaged in coffee production. The average age of respondents was approximately 51 years (SD = 15), indicating that the majority were older adults. Household sizes were generally large, with a mean of five members (SD = 2), indicating a prevalence of extended or moderately sized families among coffee producers in the study area.

Table 4.7: Distribution of factors influencing fertilizer usage

Variable	Obs	Mean	Std. Dev.	Min	Max
AGE (years)	247	50.7	14.6	18	81
HH_Size (number)	247	5.3	1.5	1	9
Experience in coffee (years)	247	18.9	10.2	5	55
Farm_Size (acres)	247	1.9	0.9	0.5	4
Acreage under coffee (acres)	247	1.8	0.8	0.5	4
Coffee_income (million_UGX)	247	1.7	1.3	1.1	5.6
Categorical variables	**Attribute**	**Freq.**	**Percent**	**Cum.**	
Inorganic_Fertilizer_use	1=yes	185	74.90	74.90	
	0=no	62	25.10	**100.00**	
Gender	1=male	186	75.30	75.30	
	0=female	61	24.70	**100.00**	

Level of Education	0=informal	6	2.43	2.43
	1=primary	142	57.49	59.92
	2=secondary	72	29.55	89.47
	3=tertiary/university	26	10.53	**100.00**
Extension_access	1=yes	226	91.50	91.50
	0=no	21	8.50	**100.00**
Credit_access	1=yes	244	98.79	98.79
	0=no	3	1.21	**100.00**

(Primary Data, 2025)

The descriptive statistics presented in Table 4.7 reveal key characteristics of the sampled households engaged in coffee production. The average age of respondents was approximately 51 years (SD = 15), indicating that the majority were older adults. Household sizes were generally large, with a mean of five members (SD = 2), indicating a prevalence of extended or moderately sized families among coffee producers in the study area.

In terms of gender distribution, male respondents comprised a significant majority (75.3%), while females accounted for only 24.7%. This disparity points to a male-dominated coffee farming landscape in the study region. Educational attainment varied among respondents: 2.43% had no formal education, 57.49% had completed primary education, 29.55% had secondary education, and 10.53% had attained tertiary or university-level qualifications.

Regarding agricultural experience, respondents reported an average of 19 years (SD = 10) in coffee farming, reflecting a well-established familiarity with the enterprise. On average, the respondents owned about 2 acres of land (SD = 1), a size mirrored in the average area allocated specifically to coffee plantations, also estimated at 2 acres (SD = 1). In terms of income, households reported an average annual revenue of approximately 1.7 million Ugandan Shillings from coffee production (SD = 1.3 million), indicating variability in economic returns across households.

Institutionally, the findings demonstrate that a substantial majority of farmers (91.5%) had access to agricultural extension services, indicating strong outreach support in the area. Conversely, only 8.5% reported lacking such access. Similarly, financial accessibility appeared to be widespread, with 98.79% of respondents indicating that they received financial assistance related to coffee farming, whereas a minimal proportion (1.21%) reported not receiving any financial support.

4.3.1 Multicollinearity Diagnostics

Table 4.8 presents the Variance Inflation Factor (VIF) values for all explanatory variables included in the logistic regression model. VIF is a diagnostic statistic used to assess the presence of multicollinearity among independent variables. As a general rule, a VIF exceeding 10 may indicate problematic multicollinearity (Gujarati, 2004).

The VIF values for all variables in the model ranged from 1.16 (age) to 1.44 (Coffee_income), with a mean VIF of 1.011. These values are well below the critical threshold, indicating that multicollinearity is not a concern in the dataset. Consequently, all predictor variables were retained in the final model, as they do not distort the estimation of coefficients due to collinearity.

Table 4.8: Multicollinearity test of Socio-economic and institutional factors influencing fertilizer usage

Predictor	VIF	1/VIF
Coffee_income	1.44	0.694
Education_level	1.36	0.735
Credit_access	1.23	0.813
Extension_access	1.28	0.781
Farm_size	1.24	0.806
Household_size	1.22	0.819
Gender	1.18	0.847
Age	1.16	0.862
Mean VIF	**1.011**	

(Primary Data, 2025)

4.3.2 Econometric Analysis

The results of the logistic regression model, as summarized in Table 4.9, reveal a chi-square value of 7.65 with 8 degrees of freedom and an associated p-value of

0.472. Given that the p-value is greater than the commonly accepted threshold of 0.05, the null hypothesis of good model fit cannot be rejected. This indicates that the model is well-calibrated and appropriately reflects the observed data.

Table 4.9: Analysis of logistic regression on Socio-economic and institutional factors influencing fertilizer usage

Fertilizer_use	**Coef.**	**Std. Err.**	**Z**	**P>|Z|**	**[95% interval]**	**Conf.**
Age	-0.016	0.006	-1.66	**0.021**	-0.032	0.002
Gender	0.314	0.205	1.42	0.231	-0.066	0.817
Education_level	0.081	0.032	2.44	**0.014**	0.014	0.841
Household_size	0.034	0.054	0.86	0.427	-0.055	0.541
Farm_size	0.319	0.066	2.04	**0.032**	0.006	0.027
Extension_access	0.628	0.253	3.12	**0.001**	0.276	1.918
Credit_access	0.452	0.222	2.08	**0.002**	0.032	0.988
Coffee_income	0.0002	0.0001	2.23	**0.022**	0.001	0.004

Obs=247; LR chi^2 (8) = 7.65; Prob>chi^2 = 0.000; Pseudo R^2 = 0.7935.

(Primary Data, 2025)

Furthermore, the classification results indicate that the model accurately predicted the fertilizer use status of approximately 79.35% of the respondents. This level of predictive accuracy demonstrates that the model is reasonably effective in distinguishing between users and non-users of fertilizer among smallholder Arabica coffee producers in Buginyanya Sub-County. Therefore, these findings affirm the suitability of the logistic regression model in examining the influence of socio-economic and institutional factors on fertilizer adoption.

The possibility of using inorganic fertilizer was found to negatively impact age variable of the respondents (p = 0.021; ß = -0.016). This suggests that coffee growers in Buginyanya Sub-County are less likely to use inorganic fertilizers in their coffee gardens as they get older. This result is consistent with findings that older farmers are typically more risk averse and therefore mostly rely on traditional farming methods (Ntakyo & van den Berg, 2019). Older farmers in Buginyanya may also have limited investment horizons or physical limitations that limit their willingness or capacity to apply labor-intensive or capital-intensive inputs like fertilizers.

There was a statistically positive correlation between fertilizer use and education level ($p = 0.014$; $\beta = 0.081$). It indicates that inorganic fertilizers are more frequently used on Arabica coffee farms by Buginyanya's better-educated farmers. The ability of farmers to access and understand agronomic information is improved by education, particularly in areas like Buginyanya where training programs and extension services frequently demand a minimum level of literacy in order to be beneficial. In smallholder agriculture, this finding is in line with earlier research that found that education raises the likelihood of technology adoption (Asfaw & Admassie, 2004; Ogunniyi et al., 2021).

Fertilizer use was found to be significantly impact access to extension services ($p = 0.001$; $\beta = 0.628$). This demonstrates the importance of agricultural extension services in encouraging Arabica coffee growers in Buginyanya to use modern inputs. Government and non-governmental organizations have been more active in the region, encouraging good agricultural practices (GAPs), particularly through programs run by the district's coffee cooperatives and production and marketing department. Regular interaction with extension agents increases the likelihood that farmers will be knowledgeable about when and how to apply fertilizer, which improves adoption rates (Feder, Murgai, & Quizon, 2004; Mango et al., 2017).

Additionally, there was a positive correlation between the adoption of inorganic fertilizers and the availability of credit access ($p = 0.002$; $\beta = 0.452$). This indicates that having access to agricultural credit sources boosts the capacity of farmers to spend money on pricey agricultural inputs including fertilizers. Credit availability allows smallholder farmers to buy inputs during Arabica coffee's busiest planting and flowering seasons. Studies revealed the value of rural financial services in raising agricultural productivity (Simtowe & Zeller, 2006; Sinyolo et al., 2017) and are consistent with this finding.

The regression analysis reveals a positive relationship between farm size and fertilizer use ($p = 0.023$; $\beta = 0.319$). For instance, larger coffee farms in Buginyanya are likely to have more diversified revenue streams and higher expected returns from input investments than the smaller ones. This is particularly relevant in the sub-county where landholding sizes vary, and larger farms often have better access to market channels and agricultural services (Abdulai & Huffman, 2014).

Finally, income from coffee production was observed to associate positively with fertilizer use (p = 0.022; β = 0.0002). This implies that farmers who derive higher incomes from coffee are more likely to reinvest their earnings into buying fertilizers for subsequent growing seasons. In Buginyanya, coffee is the main cash crop and a critical source of livelihood. Higher coffee revenues reduce liquidity constraints and enable timely procurement of inputs. This supports the assertion that household income plays a central role in sustaining input adoption and intensification in perennial crops (Alene & Hassan, 2006).

In line with this study, the econometric results from Buginyanya Sub- County showed that both socio-economic characteristics (age, education, income) and institutional factors (extension and credit access) play a significant role in shaping fertilizer adoption behaviour among Arabica coffee farmers. These findings have practical implications for policy and development programs that enhance productivity and sustainability of Arabica coffee systems in Eastern Uganda. Efforts to strengthen rural education, improve access to financial services, and scale up extension coverage are key to promoting input use and increasing yields in the region.

4.4 Role of perception on the fertilizer usage

Table 4.10: Perception of Fertilizer uses on Yields

Perception	Frequency	Percentage (%)
Very bad	1	0.40
Slightly bad	9	3.64
Slightly good	6	2.42
Very good	231	93.52

(Primary Data, 2025)

The findings in Table 4.10, indicate that perceptions of fertilizer use on coffee yields varied among respondents. A small proportion, 0.40% (n = 1), perceived the effect of fertilizer on coffee yields as very bad, while 3.64% (n = 9) reported it as slightly bad. Additionally, 2.42% (n = 6) of respondents considered the effect to be slightly good. Notably, the majority of respondents, 93.52% (n = 231), perceived the impact of fertilizer use on coffee yields as very good.

Table 4. 11: Perceived fertilizer risks on Macroflora

Perception	Frequency	Percentage (%)
Not Risky	3	1.21
Slightly Risky	12	4.86
Moderately Risky	10	4.05
Very Risky	222	89.88

(Primary Data, 2025)

As presented in Table 4.11, respondents expressed differing perceptions regarding the potential risks of fertilizer use on soil microflora. A small proportion of respondents (1.21%, n = 3) indicated that fertilizer use posed no risk to microflora, while 4.86% (n = 12) perceived the risk as slight. Another 4.05% (n = 10) regarded fertilizers as moderately risky to microflora. Notably, the majority of respondents (89.88%, n = 222) perceived fertilizer use as very risky to the microflora. These findings indicate a widespread concern among farmers about the adverse effects of fertilizer on soil microbial health, highlighting the need for awareness and promotion of environmentally sustainable soil fertility practices.

Table 4.12: Perceived fertilizer risks on livestock

Perception	Frequency	Percentage (%)
Not Risky	2	0.81
Slightly Risky	14	5.67
Moderately Risky	12	4.86
Very Risky	219	88.66

(Primary Data, 2025)

Table 4.12, presents results on perceptions regarding the risks of fertilizer use on livestock varied among respondents. A small fraction (0.81%, n = 2) believed that fertilizers posed no risk to livestock. Additionally, 5.67% (n = 14) considered the risk to be slight, while 4.86% (n = 12) viewed it as moderate. The overwhelming majority of respondents (88.66%, n = 219), however, perceived fertilizer use as very risky to livestock health. These findings reflect a general concern within the farming community about the potential harmful effects of chemical fertilizers on animal well-being, underscoring the importance of promoting safe handling and environmentally conscious application practices.

Table 4. 13: Perceived risk of fertilizer on water quality

Perception	Frequency	Percentage (%)
Not risky	1	0.40
Slightly risky	12	4.86
Moderately risky	12	4.86
Very risky	222	89.88

(Primary Data, 2025)

As indicated in Table 4.13, respondents held varying perceptions regarding the potential risks of fertilizer use on water quality and, by extension, food safety. A very small proportion (0.40%, n = 1) believed that fertilizer posed no risk to water quality. An additional 4.86% (n = 12) of respondents perceived the risk to be slight, while an equal proportion (4.86%, n = 12) regarded the risk as moderate. The vast majority of respondents (89.88%, n = 222), however, perceived fertilizer use as posing a significant risk to water quality. These perceptions indicate growing awareness among farmers of the environmental and food safety implications associated with fertilizer runoff, particularly it's potential to contaminate water sources used in agricultural production.

Table 4. 14: Perceived risks of fertilizer use on food safety

Perception	Frequency	Percentage (%)
Not risky	5	2.02
Slightly risky	18	7.29
Moderately risky	13	5.26
Very risky	211	85.43

(Primary Data, 2025)

Table 4.14 presents the respondents' perceptions regarding the potential risks of fertilizer use on food quality. A small percentage of participants (2.02%, n = 5) indicated that fertilizer use posed no risk to food quality. Another 7.29% (n = 18) perceived the risk as slight, while 5.26% (n = 13) considered the risk to be moderate. The majority of respondents (85.43%, n = 211) viewed fertilizer use as highly risky to food quality. These findings reflect a strong concern among the farming community about the possible negative impacts of chemical fertilizers on the quality and safety of food products, emphasizing the need for safer and more sustainable input use in agricultural practices.

4.5 Analysis of the level of inorganic fertilizer usage in coffee production.

In an effort to assess the determinants influencing the intensity of inorganic fertilizer use among smallholder farmers, an ordered logit model was employed. Fertilizer application levels were grouped into three categories; Low, Medium, and High.

In the model, every indicator provides information about fertilizer usage trends. For example, farm size, perceptions of soil fertility, proximity to input markets, access to extension services, and farmer education level were quantifiable in influencing the amount of fertilizer applied. These results are consistent with the emphasis that institutional and socioeconomic factors as important determinants of the intensity of input use (Martey et al., 2020; Kassie et al., 2018).

The estimated coefficients and marginal effects offer a more realistic comprehension of variations of these variables on the fertilizer usage. For instance, there was a significant increase in moving from low to higher usage categories when access to extension services increased. This is in line with research by Ogada et al. (2019), which discovered that farmers who have greater access to extension services are more likely to embrace input-intensive technologies because they are better informed and see the advantages.

Furthermore, a higher likelihood of medium and high fertilizer usage was linked to proximity to agro-input dealers, as market access often lowers transaction costs and enhances input availability (Sheahan & Barrett, 2017). Similarly, due to economies of scale enjoyed by larger farms, fertilizer intensity tend to positively correlate with farm size as a result of greater capital investment (Liverpool-Tasie et al., 2019).

These results contribute to existing studies on sustainable input use and this study offers supporting perspectives that are pertinent to policy for focusing interventions that support effective and ecologically friendly fertilizer practices. Among the strategic recommendations to improve smallholder farmers' balanced fertilizer use in the study area include boosting farmers' education, fortifying extension systems and enhancing market infrastructure.

Table 4. 15: Ordered Logit Analysis of inorganic fertilizer usage levels in Arabic coffee

fert.level_usage	**Coef. (β)**	**Std. Err.**	***z*_value**	***p*_value**	**Marginal Effect (Low)**	**Marginal Effect (Medium)**	**Marginal Effect (High)**
Age_HH	0.016	0.006	1.876	0.161	0.001	-0.003	-0.002
Gen_HH	-0.212	0.163	-1.274	0.404	-0.046	0.030	0.014
Educ_HH	-0.034	0.016	-2.400	**0.001**	0.006	0.004	0.003
Farm_Exp.	-0.026	0.012	-2.800	**0.002**	-0.024	0.016	0.008
Farm_Size	-0.104	0.058	-1.823	**0.004**	-0.033	0.230	0.014
Ext_con	-0.154	0.032	-2.422	**0.012**	0.027	-0.016	-0.011
RiskperHealth	0.126	0.047	-3.256	**0.001**	0.012	-0.007	-0.033
RiskperEnviro	0.068	0.054	2.461	0.303	0.046	-0.032	-0.015
ProductivperCoff	0.214	0.046	1.524	**0.002**	-0.015	0.010	0.007
Off_farm_income	-0.082	0.103	2.086	0.305	0.031	-0.012	-0.022
TrainingSoil	-0.145	0.033	-2.670	**0.001**	0.077	-0.056	-0.035
InforSource	0.341	0.075	1.943	0.204	0.004	-0.040	-0.001
Creditacc	0.028	0.091	3.587	**0.004**	-0.018	0.012	0.004
DistFarmSupply	-0.083	0.005	2.766	**0.008**	0.011	-0.006	-0.003
Targetcoffmkt	0.056	0.042	2.362	**0.016**	0.021	-0.012	-0.027
Threshold 1	-1.542	0.448	-3.606	**0.000**	-	-	-
Threshold 2	2.134	0.519	4.198	**0.000**	-	-	-

Obs = 247; Log Likelihood =-321.75; Pseudo R^2 = 0213; LRChi^2 (17) =122.45; Prob>Chi^2=0.000

(Primary Data, 2025)

Table 4.15, presents the ordered logit regression model was employed to examine the factors influencing the intensity of inorganic fertilizer use among Arabica coffee farmers, where fertilizer usage was categorized into three ordinal levels: Low, Medium, and High. The model was estimated using a sample of 247 observations.

The log likelihood value of -321.75 indicates the model's fit relative to a null (intercept-only) model. The pseudo R-squared value of 0.213 indicates that approximately 21.3% of the variation in the levels of fertilizer use is explained by the explanatory variables included in the model. While pseudo R^2 values in limited dependent variable models are not directly comparable to R^2 in linear regressions, a value above 0.20 is generally considered acceptable in cross-sectional studies involving behavioural responses (McFadden, 1974).

The likelihood ratio (LR) Chi-square statistic of 122.45 with 17 degrees of freedom is statistically significant ($p < .001$), as indicated by the Prob > Chi^2 value of 0.000. This result confirms that the model as a whole is statistically significant and provides a better fit than a model without any predictors.

In summary, the model demonstrates good explanatory power and statistically significant overall fit. This implies that the independent variables included in the regression collectively contribute to explaining the variation in fertilizer usage levels among the Arabic coffee farmers surveyed.

Education Level

Additionally, Table 4.15 indicate that the education level of the respondent is a statistically significant determinant of inorganic fertilizer usage among Arabica coffee farmers in the study area. The education variable yielded a p-value of 0.001, demonstrating strong statistical significance at the 1% level, however, the estimated coefficient was -0.034, indicating a negative relationship between education level and the likelihood of belonging to the low fertilizer usage category. The marginal effects further reveal that a one-unit increase in education (measured in years of formal schooling) is associated with a 0.6% decrease in the probability of low usage, alongside a 0.4% and 0.3% increase in the likelihood of medium and high usage, respectively.

This inverse relationship between education and low fertilizer use implies that more educated farmers are less likely to underutilize fertilizers and are instead more inclined to apply them at optimal or higher levels. One plausible explanation is that education enhances farmers' capacity to access, interpret, and apply agronomic information regarding input use and soil fertility management. Asfaw and Admassie (2004) and Kassie et al. (2018), noted that farmers with higher levels of education were more likely to interact with extension agents and look for market information than their counterparts.

The findings are in consistent with several studies conducted from other developing nations, including South Asia and sub-Saharan Africa, which found education to have positive impact on the intensity and adoption of input use, including fertilizers (Khonje et al., 2015; Mishra et al., 2018). In Buginyanya Sub-County, where access to agro-inputs and extension services is constrained, education becomes essential for closing the knowledge gap and promoting better agronomic practices.

Experience in Coffee farming

Farming experience yielded a p-value of .002, indicating strong statistical significance at the 1% level. The negative coefficient of -0.026 indicates that as the number of years of experience in coffee farming increases, the likelihood of being categorized under low fertilizer usage decreases. This relationship is further clarified by the marginal effects, which reveal that an additional year of farming experience reduces the probability of low fertilizer usage by 2.4%, while increasing the probabilities of medium and high usage by 1.6% and 0.8%, respectively.

These findings imply that more experienced farmers are better positioned to make informed decisions regarding fertilizer application. Through years of practice, they acquire practical knowledge of soil nutrient demands, seasonal variations, and cost-benefit considerations of fertilizer use. Such farmers are also more likely to have observed long-term trends in productivity and may understand the diminishing returns associated with under- or overuse of chemical inputs. This aligns with previous evidence from Ethiopia, where experience in farming was found to be positively associated with the adoption and intensity of fertilizer use (Mekonnen & Kohlin, 2017; Tura et al., 2021).

In line with this study in Buginyanya Sub-county, experiential learning could shape agronomic behavior of the farmers. As noted above, experienced farmers often are considered as informal sources of knowledge within rural communities, and their adoption of appropriate fertilizer practices greatly contribute to broader diffusion of such practices among peers. This therefore indicates the importance of leveraging local farming knowledge in policy interventions aimed at enhancing sustainable coffee production.

Farm Size

Farm size was found to have inversely significance with fertilizer use (p = .049, Coefficient = -0.004). This indicates that a larger farm size is linked to a 3.3% decrease in the possibility of fertilizer low usage and a 2.3% and 1.4% increase in the probabilities of medium and high usage, respectively. This finding proposes that greater fertilizer application intensity is encouraged by larger farm size. Coffee growers with larger plots probably see more financial gains from increasing production per acre and may also have better access to credit or capital for input purchases (Holden & Lunduka, 2014). To maintain soil productivity and profitability, larger farm management require implementing more modern and efficient farming techniques, such as the use of fertilizers.

Kassie et al. (2015) argue that land size has a positive impact on the intensity and adoption of agricultural inputs, such as inorganic fertilizers. According to economic theory, farmers who own larger farms are more likely to take advantage of economies of scale and invest in technologies that increase yields and maximize agricultural profits than the counterparts.

Access to Extension Services

Access to agricultural extension services was found to be statistically significant with fertilizer use (Coefficient -0.154, p =.012). Based on the coefficient, farmers who regularly interact with extension agents are 2.7% less likely to use fertilizer in the low category and more likely to use it in the medium (1.6%) and high (1.1%) categories. This research emphasizes that extension services help people make well-informed decisions about the use of agricultural inputs.

Extension services offer holistic resources for sharing information on sustainability, input efficiency, and agronomic best practices (Anderson & Feder, 2007). Having access to timely and appropriate advice greatly improves the ability of smallholder coffee farmers to apply fertilizers at recommended rates in Buginyanya Sub-county. This confirms earlier research showing that consistent interaction with extension agents enhances farmers' understanding of input use, ultimately increasing input-use efficiency and productivity (Ragasa et al., 2016).

These findings indicate the importance of investing in extension infrastructure and supporting farmer training programs to address the needs of smallholder coffee producers. In addition to facilitating greater fertilizer use, improved access to agricultural information encourages more sustainable and logical farming methods.

Perceived Health Risks from Fertilizer Use

There was statistical significance at the 1% level (p =.001) in the perception of health risks related to the use of inorganic fertilizers. With marginal effects of 0.012 for low fertilizer usage, -0.007 for medium fertilizer usage, and -0.033 for high fertilizer usage, the ordered logit regression yielded a positive coefficient of 0.126.

These results show a somewhat paradoxical relationship: farmers are more likely to apply medium or high amounts of fertilizer and less likely to apply low amounts when they perceive greater health risks. One explanation is that farmers might put short-term financial gains ahead of long-term health consequences even though they are aware of the possible health risks. This is particularly possible in areas like Buginyanya Sub-county, where subsistence constraints, market pressure and the absence of affordable organic alternatives may compel farmers to maintain or increase fertilizer application levels, even at perceived personal health costs.

This phenomenon is consistent with behavioral findings in agricultural economics, which show that risk perception does not always translate into risk-averse behavior, especially when perceived benefits exceed costs (Liu et al., 2019). Policy interventions in such situations should take into account improving access to safer inputs, supporting sustainable farming systems, and increasing public awareness of the health risks.

Perceived Coffee Productivity Due to Inorganic Fertilizer Use

Additionally statistically significant (p =.002) was the perception that inorganic fertilizers increase coffee productivity. In terms of marginal effects, the variable showed a positive coefficient of 0.214, -0.015 for low usage, 0.010 for medium usage, and 0.007 for high usage.

According to these findings, farmers who believe that using inorganic fertilizer increases coffee yield are more likely to use medium and high application levels rather than low amounts. This suggests a logical decision-making process where the alleged increases in productivity are greater than the costs of inputs or possible environmental hazards. Because Arabica coffee farmers in Buginyanya Sub-county rely largely on crop production for their livelihoods, the prospect of higher yield serves as a major inducement to invest in fertilizer.

This conclusion is supported by earlier research. Positive expectations about productivity gains, for example, have a significant impact on smallholders' decisions to adopt inputs in Eastern and Southern Africa, according to research by Kassie et al. (2015).

Training in Soil Fertility Management

According to table above, participation in soil fertility management training programs was found to have a statistically significant impact on their decisions about fertilizer use (p =.001, coefficient = -0.145). The variable showed that low fertilizer usage is inversely correlated with receiving such training. Marginal effects indicated a 0.077 possibility increase for low usage, a 0.056 decrease for medium usage, and a 0.035 decrease for high fertilizer usage.

These findings propose that training initiatives considerably move farmers away from applying very little fertilizer and toward more ideal levels of use. For instance, soil fertility education improves farmers' knowledge of nutrient needs and optimal input application techniques. Evidence-based agronomic decision-making is promoted by this kind of knowledge transfer, which eventually leads to more productive agriculture and more effective use of inputs. Study by Mwangi & Kariuki (2015), acknowledged that informed farmers are more likely to use scientifically supported and sustainable farming methods than the less informed farmers.

In line with this study in Buginyanya, the findings establish the effectiveness of extension services and training initiatives in providing farmers with the technical skills required for effective fertilizer management. The technical skills improve the overall farm performance and encourage use of sustainable inputs.

Access to Financial Support

Fertilizer use was found to be significantly correlated with their access to financial support (p =.004, coefficient = 0.028). The marginal effects analysis showed that the likelihood of medium (0.012) and high fertilizer usage levels (0.004) increased while the likelihood of low fertilizer usage (-0.018) decreased.

Access to financial services such as agricultural credit, subsidies, or input financing, improves ability of farmers to invest in inputs that increase productivity. Financial support facilitates the timely acquisition and application of fertilizers, which is necessary for better crop performance. Holden and Lunduka (2013) affirmed that financial constraints possesses a major limitation in smallholder systems and that expanding access to capital substantially influence input use behavior and agricultural productivity.

Given the financial constraints that many farmers in Buginyanya face, the availability of credit facilities or focused input support programs may be a vital tool for boosting fertilizer adoption. The aforementioned findings show the significance of incorporating financial inclusion tactics into more comprehensive agricultural development initiatives to improve input adoption and facilitate sustainable intensification initiatives among farming households with limited resources.

Distance to Nearest Farm Input Supply Outlet

The use of fertilizer by coffee farmers in Buginyanya was statistically significantly influenced by the distance to the closest agricultural supply outlet (p =.008). With a negative coefficient of -0.083, the variable showed a negative correlation between fertilizer application intensity and proximity to input sources. The calculated marginal effects for low, medium, and high fertilizer usage were 0.011, -0.006, and -0.003, respectively.

Based on this pattern, the likelihood of low fertilizer use increases with the distance to input sources. The negative correlation illustrates the logistical difficulties smallholder farmers encounter in isolated and mountainous regions, where access to agricultural inputs is frequently hampered by lower infrastructure, higher transportation costs, and time constraints. These obstacles may deter prompt and sufficient application of inputs, which could impact output levels. Minten et al. (2013) urge policy interventions targeted at enhancing the density and distribution of agro-dealer networks in underserved areas, highlighting the prevalence of such spatial constraints in rural farming systems.

Investment in rural input delivery systems is vital, as demonstrated by the findings in the Buginyanya case. In order to support more sustainable and productive farming methods, strengthening the local agro-dealer infrastructure could reduce transaction costs and improve farmers' access to necessary agricultural inputs, such as fertilizers.

Access to Targeted Coffee Markets

Access to targeted coffee markets—such as contract-based buyers, agricultural cooperatives, and specialty or premium outlets—was found to be statistically significant in influencing fertilizer use decisions among smallholder coffee farmers in Buginyanya ($p = .016$). The regression analysis yielded a positive coefficient of 0.056, indicating a direct relationship between market access and fertilizer use. Further analysis of marginal effects revealed differentiated impacts across fertilizer usage levels: 0.021 for low usage, -0.012 for medium usage, and -0.027 for high usage.

These findings indicate that farmers who engage with structured and quality-sensitive market channels are more inclined to optimize input use, particularly fertilizers, in order to meet stringent quality requirements and secure higher market premiums. This observation aligns with the theoretical assertions of Barrett (2008), who noted that market-oriented production systems incentivize investment in productivity-enhancing technologies and inputs. In the context of Buginyanya, improved access to premium coffee markets appears to encourage more intensive and strategic fertilizer application, contributing to both yield enhancement and product quality improvement.

CHAPTER FIVE
CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This study employed a mixed-methods research design, integrating both quantitative and qualitative approaches to explore the agronomic practices and determinants of fertilizer use among smallholder Arabica coffee farmers in Buginyanya Sub- County. Primary data were collected through a semi-structured questionnaire, enabling the generation of both measurable statistics and contextual insights. The analysis revealed that farmers commonly practiced agronomic techniques such as pruning, mulching, weeding, uprooting, and intercropping, although the frequency of these practices varied. Descriptive statistics highlighted moderate levels of adoption for improved coffee varieties, inorganic fertilizers, and organic manure, indicating opportunities for scaling up productivity-enhancing inputs.

The findings demonstrated several statistically significant relationships between key factors and fertilizer usage intensity. Notably, the adoption of improved coffee seeds was associated with a substantial increase in yield, confirming their critical role in boosting productivity. Additionally, education level, farming experience, and farm size were all significant predictors of fertilizer application, with more educated, experienced, and better-resourced farmers more likely to adopt medium to high levels of fertilizer use. These outcomes support the broader literature emphasizing the influence of human capital and farm resource endowments on agricultural input decisions.

Important determinants also included market-related and institutional factors. Access to extension services was linked to increased fertilizer use, highlighting the significance of information sharing in shaping farmer behavior. Likewise, market access, especially through specialty markets and contract agreements, encouraged farmers to increase their input investments in order to meet quality standards. All of these findings show that decisions about fertilizer use are multifaceted and that, in order to achieve sustainable productivity gains in smallholder coffee systems, integrated interventions are required that improve farmer education, fortify extension systems, increase market opportunities, and improve input accessibility.

5.2 Recommendations

According to the results of the study, improving access to inputs among smallholder farmers is imperative in order to increase productivity. Secondly, improving access to agricultural extension services is necessary to offer regular, situation-specific training on the best agronomic techniques, such as intercropping, pruning, and managing soil fertility, Furthermore, since farmers with less formal education were less likely to apply fertilizer optimally, special educational programs may assist them. These measures are expected to raise household incomes and increase food security by increasing coffee yields in both quantity and quality.

Additionally, policymakers and development partners should support equitable access to financial services like input credit programs and agricultural subsidies especially for farmers with limited resources. In order to lower the logistical obstacles related to fertilizer acquisition, particularly in isolated and mountainous regions like Buginyanya, the results also emphasize the necessity of enhancing rural infrastructure and input distribution networks. Priority should be given to establishing connections with premium coffee buyers and cooperatives, as these markets encourage increased input use and adherence to quality standards. Interventions should also guarantee that smallholders have equal access to productive resources while providing larger farm operators with scalable input delivery systems. The agricultural sector in Uganda can sustainably boost coffee productivity and farmer resilience by tackling these multifaceted constraints.

5.3 Research Gap further study

The current study has provided valuable insights into the agronomic practices and socioeconomic factors influencing coffee productivity among smallholder farmers in Buginyanya Sub-county; however, several critical gaps remain. While the determinants of fertilizer use were established, the analysis did not account for the long-term economic and environmental sustainability of varying fertilizer regimes, particularly the interplay between organic and inorganic inputs. Similarly, the study emphasized the frequency of agronomic practices but overlooked their quality, timing, and intensity, dimensions that may exert nuanced effects on productivity. Moreover, although market access was shown to influence fertilizer usage, the specific attributes of coffee markets—such as certification standards, traceability mechanisms, and pricing models—were not examined, despite their potential to shape farmers' input decisions. Addressing these dimensions would generate a more comprehensive understanding of the drivers of productivity and sustainability within the coffee value chain.

Methodologically, the cross-sectional design employed limits causal inference and obscures the temporal dynamics of technology adoption, input utilization, and productivity outcomes. A longitudinal or panel-based approach would better capture the trajectories of agronomic decision-making and the sustained adoption of improved practices. In addition, the study did not explore intra-household dynamics, such as gender roles, labour allocation, and decision-making processes, which are known to influence agricultural input use in smallholder contexts. While extension services emerged as important in shaping fertilizer adoption, the study did not interrogate the quality, frequency, or delivery modes of such services. Future research should therefore adopt a holistic, gender-responsive, and time-sensitive approach that integrates market dynamics, social structures, and extension modalities to inform more effective and sustainable interventions in Uganda's coffee sector.

REFERENCES

Abdulai, A., & Huffman, W. E. (2014). The adoption and impact of soil and water conservation technology: An endogenous switching regression application. *Land Economics*, *90*(1), 26-43. https://doi.org/10.3368/le.90.1.26.

Abro, Z. A., Alemu, B. A., & Abay, K. A. (2021). Adoption and impacts of improved maize varieties on productivity and welfare: Evidence from Uganda. *Food Policy, 100*, 102019. https://doi.org/10.1016/j.foodpol.2020.102019.

Akello, S., Turyahabwe, N., Sseguya, H., & Agea, J. G. (2017). Devolution policy and its implication on watershed restoration in eastern Uganda. African Journal of Rural Developement, 2(3), 403-415.

Alene, A. D., & Hassan, R. M. (2006). The efficiency of traditional and hybrid maize production in eastern Ethiopia: An extended efficiency decomposition approach. *Journal of African Economies*, *15*(1), 91–116. https://doi.org/10.1093/jae/eji017.

Anderson, J. R., & Feder, G. (2007). Agricultural extension. In R. Evenson & P. Pingali (Eds.), *Handbook of Agricultural Economics* (Vol. 3, pp. 2343–2378). Elsevier. https://doi.org/10.1016/S1574-0072(06)03086-1.

Asenso-Okyere, K., Asante, F. A., Tarekegn, J., Andam, K. S., & Thangata, P. H. (2015). The Role of Education in Agricultural Productivity: Evidence from Smallholder Rice Farmers in Northern Ghana. Journal of Agricultural Education and Extension, 21(4), 347–361.

Asfaw, A., & Admassie, A. (2004). The role of education on the adoption of chemical fertiliser under different socio-economic environments in Ethiopia. *Agricultural Economics, 30*(3), 215–228. https://doi.org/10.1111/j.1574-0862.2004.tb00190.x.

Asfaw, S., Shiferaw, B., Simtowe, F., & Lipper, L. (2012). Impact of modern agricultural technologies on smallholder welfare: Evidence from Tanzania and Ethiopia. Food Policy, 37(3), 283–295.

Babigumira, R., Batte, M. T., & Wambugu, S. (2019). The role of farmer organizations in coffee production and marketing in Rwanda. African Journal of Agricultural and Resource Economics, 14(4), 280–292.

Barrett, C. B. (2008). Smallholder market participation: Concepts and evidence from eastern and southern Africa. *Food Policy, 33*(4), 299-317. https://doi.org/10.1016/j.foodpol.2007.10.005.

Cheptoyek, S. (2018). The relationship between agronomic practices and productivity of Barley in Kwosir Sub-County Kween District.

Coffee Research Institute. (2019). Coffee industry status report. Kampala, Uganda: National Coffee Research Institute.

DaMatta, F. M., Ronchi, C. P., Maestri, M., & Barros, R. S. (2022). Ecophysiology of coffee growth and production. *Brazilian Journal of Plant Physiology, 34*(3), 255–274. https://doi.org/10.1007/s40626-021-00208-2.

Feder, G., Murgai, R., & Quizon, J. B. (2004). The acquisition and diffusion of knowledge: The case of pest management training in farmer field schools, Indonesia. *Journal of Agricultural Economics, 55*(2), 221-243. https://doi.org/10.1111/j.1477-9552.2004.tb00104.x.

Fischer, E. F., Victor, B., & Asturias de Barrios, L. (2021). Quality versus solidarity: Third Wave coffee and cooperative values among smallholding Maya farmers in Guatemala. The Journal of Peasant Studies, 48(3), 640-657.

Food and Agriculture Organization (FAO). (2022). *Weed management for sustainable agriculture*. Rome: FAO. https://www.fao.org.

Gujarati, D. N., & Porter, D. C. (2009). *Basic econometrics* (5th ed.). McGraw-Hill/Irwin.

Holden, S. T., & Lunduka, R. (2013). Who benefits from Malawi's targeted farm input subsidy program? *Forum for Development Studies, 40*(1), 1–25. https://doi.org/10.1080/08039410.2012.688858.

Holden, S. T., & Lunduka, R. (2014). Input subsidies, cash constraints and timing of input supply. *American Journal of Agricultural Economics, 96*(1), 290–307. https://doi.org/10.1093/ajae/aat053.

ICO (International Coffee Organization). (2021). Coffee Market Report 2021. Retrieved from https://ico.org/resources/coffee-market-report-statistics-section

International Coffee Organization (ICO). (2023). *Best practices for coffee cultivation: A farmer's guide*. London: ICO.

Jalata, D. H. (2021). Competitiveness and Determinants of Coffee Export in Ethiopia: An Analysis of Revealed Comparative Advantage and Autoregressive Distributed Lag Model.

Jha, S., Bacon, C. M., Philpott, S. M., Rice, R. A., Méndez, V. E., & Läderach, P. (2014). Shade coffee: Update on a disappearing refuge for biodiversity. *BioScience, 64*(5), 416-428. https://doi.org/10.1093/biosci/biu038.

Johnson, L. (2021). Modern Agricultural Technologies and Coffee Production in Uganda. International Journal of Agricultural Sciences, 15(2), 201-215.

Kassie, M., Teklewold, H., Jaleta, M., Marenya, P., & Erenstein, O. (2015). Understanding the adoption of a portfolio of sustainable intensification practices in eastern and southern Africa. *Land Use Policy, 42*, 400–411. https://doi.org/10.1016/j.landusepol.2014.08.016.

Kassie, M., Teklewold, H., Jaleta, M., Marenya, P., & Erenstein, O. (2018). Understanding the adoption of a portfolio of sustainable intensification practices in eastern and southern Africa. *Land Use Policy, 75*, 1–13. https://doi.org/10.1016/j.landusepol.2018.03.020

Kassie, M., Teklewold, H., Marenya, P., Jaleta, M., & Erenstein, O. (2015). Measuring farm and market-level pathway impacts of sustainable intensification innovations: Evidence from Ethiopia and Kenya. *Agricultural Economics, 46*(4), 639–653. https://doi.org/10.1111/agec.12180.

Khonje, M., Manda, J., Alene, A. D., & Kassie, M. (2015). Analysis of adoption and impacts of improved maize varieties in eastern Zambia. *World Development, 66*, 695–706. https://doi.org/10.1016/j.worlddev.2014.09.008.

Kyotalimye, M., Kiggundu, N., Kajoba, G., & Birungi, P. (2018). Determinants of fertilizer use among smallholder coffee farmers in Uganda: Evidence from a gender-disaggregated farm household survey. Journal of Sustainable Development, 11(6), 120-131.

Lemma, D. T., & Megersa, H. G. (2021). Impact of climate change on East African coffee production and its mitigation strategies. World Journal of Agricultural Sciences, 17(2), 81-89.

Liu, T., Bruins, R. J. F., & Heberling, M. T. (2019). Factors influencing farmers' adoption of best management practices: A review and synthesis. *Sustainability, 10*(2), 432. https://doi.org/10.3390/su10020432.

Liverpool-Tasie, L. S. O., Omonona, B. T., Sanou, A., & Ogunleye, W. O. (2019). Is increasing inorganic fertilizer use in Sub-Saharan Africa a profitable proposition? Evidence from Nigeria. *World Development, 122*, 54-71. https://doi.org/10.1016/j.worlddev.2019.05.004.

Mango, N., Makate, C., Mapemba, L., & Sileshi, G. W. (2017). The role of crop diversification in improving household food security in central Malawi. *Agricultural & Food Security*, *6*, 47. https://doi.org/10.1186/s40066-017-0122-4.

Martey, E., Kuwornu, J. K. M., & Adogla-Bessa, T. (2020). Adoption of organic fertilizer for maize cultivation in Ghana: Evidence from a double hurdle model. *Environmental Science and Pollution Research, 27*(17), 21140–21152.

https://doi.org/10.1007/s11356-020-08569-9.

McFadden, D. (1974). Conditional logit analysis of qualitative choice behaviour. In P. Zarembka (Ed.), *Frontiers in econometrics* (pp. 105–142). Academic Press.

MinAg (Ministry of Agriculture, Uganda). (2018). National Coffee Development Strategy. Retrieved from https://ugandacoffee.go.ug.

Minten, B., Koru, B., & Stifel, D. (2013). The last mile(s) in modern input distribution: Pricing, profitability, and adoption. *Agricultural Economics, 44*(6), 629–646. https://doi.org/10.1111/agec.12053.

Mishra, A. K., Khanal, A. R., & Mohanty, S. (2018). Gender differentials in farming efficiency and profits: The case of rice production in the Philippines. *Land Use Policy*, *79*, 70–79. https://doi.org/10.1016/j.landusepol.2018.07.036.

Mukwaya, P. (2016). The dynamics and resilience of periodic markets in the Mt Elgon Region Uganda: a geographical perspective. Rural-Urban Dynamics in the East African Mountains, 235-271.

Mulatu, Z. (2019). Yield and Quality Response of Malt Barley (Hordeum vulgare l.) Varieties to Seed Rate and Time of Nitrogen Fertilizer Application at Bekoji, Southeastern Ethiopia (Doctoral dissertation, Haramaya University).

Muratori, L. (2016). Price gap along the Ugandan coffee value chain (No. 1/16)

Musoni, T., Ongom, B., & Byabashaija, D. (2020). The effect of socio-economic factors on the use of organic and inorganic fertilizers by smallholder coffee farmers in Uganda. Journal of Agriculture and Rural Development in the Tropics and Subtropics, 121(1), 97-105.

Mwangi, M., & Kariuki, S. (2015). Factors determining adoption of new agricultural technology by smallholder farmers in developing countries. *Journal of Economics and Sustainable Development,* *6*(5), 208–216. https://www.iiste.org/Journals/index.php/JEDS/article/view/20517.

Mwaura, F., Okoboi, G., & Mugisha, J. (2020). Adoption of improved agricultural technologies in Uganda: Evidence from the national panel survey. *African Journal of Agricultural and Resource Economics, 15*(1), 55–69.

Ntakyo, P. R., & van den Berg, M. (2019). Determinants of farmers' adaptation to climate change in Uganda: Evidence from micro level data. *Climate and Development*, *11*(8), 693–704. https://doi.org/10.1080/17565529.2018.1442801.

Nyamuhumuza, M. (2021). Farmers' perceptions of coffee price volatility in Rukiri Subcounty Ibanda district, Uganda (Doctoral dissertation, Makerere University).

Ogada, M. J., Mwabu, G., & Muchai, D. (2019). Farm technology adoption in Kenya: A simultaneous estimation of inorganic fertilizer and improved maize variety adoption decisions. *Agricultural and Food Economics, 7*(1), 10. https://doi.org/10.1186/s40100-019-0124-5.

Ogundeji, B. A., Olalekan-Adeniran, M. A., Orimogunje, O. A., Awoyemi, S. O., Yekini, B. A., Adewoye, G. A., & Bankole, I. (2019). Climate hazards and the changing world of coffee pests and diseases in Sub-Saharan Africa. Journal of Experimental Agriculture International, 41, 1-12.

Ogunniyi, A. I., Olagunju, K. O., & Ogundele, O. O. (2021). Adoption intensity of sustainable intensification practices and its welfare impacts among smallholder farmers in Nigeria. *Land Use Policy*, *101*, 105112. https://doi.org/10.1016/j.landusepol.2020.105112.

Osabohien, R., Matthew, O., Gershon, O., Ogunbiyi, T., & Nwosu, E. (2019). Agriculture development, employment generation and poverty reduction in West Africa. The Open Agriculture Journal, 13(1).

Ragasa, C., Berhane, G., Tadesse, F., & Taffesse, A. S. (2016). Gender differences in access to extension services and agricultural productivity. *The Journal of Agricultural Education and Extension, 22*(5), 485-505. https://doi.org/10.1080/1389224X.2016.1205847.

Santos, V. P., Ribeiro, P. C. C., & Rodrigues, L. B. (2023). Sustainability assessment of coffee production in Brazil. *Environmental Science and Pollution Research*, *30*(4), 11099-11118.

Sheahan, M., & Barrett, C. B. (2017). Ten striking facts about agricultural input use in Sub-Saharan Africa. *Food Policy, 67*, 12–25. https://doi.org/10.1016/j.foodpol.2016.09.010.

Simtowe, F., & Zeller, M. (2006). The impact of access to credit on the adoption of hybrid maize in Malawi: An empirical test of an agricultural household model under credit market failure. *MPRA Paper No. 45*. https://mpra.ub.uni-muenchen.de/45/

Sinyolo, S., Mudhara, M., & Wale, E. (2017). The impact of social grants on poverty and food security in South Africa: A simulation approach. *South African Journal of Economic and Management Sciences*, *20*(1), 1–9. https://doi.org/10.4102/sajems.v20i1.1646.

Smith, J. (2010). The Introduction and Spread of Coffea arabica in Uganda. Journal of Coffee Research, 32(4), 567-579.

Smith, J., & Brown, A. (2019). Socioeconomic Factors Influencing Fertilizer Adoption by Smallholder.

Tambo, J. A., & Wünscher, T. (2017). Adoption and impact of improved maize varieties on food security in Uganda. *Food Security, 9*(6), 1381–1395. https://doi.org/10.1007/s12571-017-0725-5.

UCDA (Uganda Coffee Development Authority). (2019). Annual Report 2019. Retrieved from https://ugandacoffee.go.ug/sites/default/files/2022-03/UCDA%20Annual%20Report_2019-2020_0.pdf.

UCDA (Uganda Coffee Development Authority). (2022). Annual Report 2022. Retrieved from https://new.ugandacoffee.go.ug/resource-center/reports/annual-reports.

UG Gov (Government of Uganda). (2019). Agricultural Credit Facility. Retrieved from https://www.finance.go.ug/sites/default/files/archive-files/Publications/BMAU%20Policy%20Brief%2016-19%20-Performance%20of%20Agriculture%20Credit%20Facility%20in%20Uganda%20-%20What%20are%20the%20trends.pdf

Voora, V., Bermúdez, S., & Larrea, C. (2019). Global market report: Coffee.

Wanyama, I., Okello, D. K., & Namara, R. (2017). Determinants of smallholder farmers' decision to use inorganic fertilizers in Uganda. African Journal of Agricultural Research, 12(23), 1984-1996.

Warr, P., & Suphannachart, W. (2021). Agricultural productivity growth and poverty reduction: Evidence from Thailand. Journal of Agricultural Economics, 72(2), 525-546.

Worku, M., Tadesse, M., & Bekele, K. (2019). Effect of spacing and fertilizer application on growth and yield of Arabica coffee (Coffea arabica L.). *International Journal of Agricultural Research, 14*(3), 87–95.

UGANDA CHRISTIAN UNIVERSITY
A Centre of Excellence in the Heart of Africa

DIRECTORATE OF POSTGRADUATE STUDIES DISSERTATION CORRECTION COMPLIANCE FORM (POST VIVA FORM)

Date: 06th September, 20225

Name of Candidate: **BIIRA BABRA ALIGANYIRA** Reg. No: **J22M43/008**

Title of Dissertation: **DETERMINANTS OF FERTILIZER USE BY SMALLHOLDER ARABICA COFFEE FARMERS IN BUGINYANYA SUB-COUNTY, BULAMBULI DISTRICT.**

S/N	COMMENTS BY EXAMINERS	ACTION TAKEN	INDICATOR
1	**Acknowledgment of Key Stakeholders**: The dissertation presentation did not adequately acknowledge key stakeholders (farmers, extension agents, cooperatives, and relevant organizations).	The section was well addressed.	Page iv
2	**Clarity and Alignment of Objectives with Title**: Objectives did not sufficiently align with the dissertation title.	The results were presented in a chronological order, beginning with descriptive statistics to provide a general overview of the data, and then moving to inferential statistics to test relationships and draw conclusions.	Pages 33 to 38
3	**Consideration of Fertilizer Types**: Focused mainly on organic fertilizers, neglecting inorganic fertilizers.	Results on categorising fertilizer use in the study area are well presented in both descriptive and inferential statistics.	Page 33 to 36
4	**Inclusion of Fertilizer Uptake**: Fertilizer uptake rates were omitted.	The findings are presented in a tabular form on page 45 and discussions	Pages 45 to 52
5	**Basis for Conclusions and Recommendations**: Conclusions and recommendations not sufficiently grounded in findings.	The conclusions and recommendations were drawn from the statistical findings	Pages 53 & 54

		which were statistically significant.	
6	**Focus on Fertilizer Types and Application Rates**: Application rates not discussed.	Well, addressed in the chapter four	Pages 36 to 43
7	**Structure and Order of Objectives**: Sequencing of objectives requires adjustment (agronomic practices before socio-economic factors).	The objectives for this study are maintained in chorological order as approved at the Proposal and REC clearance committees and it has ensured coherence.	Page 4

Candidate's Name: Signature

BIIRA BABRA ALIGANYIRA

Supervisor's Name: Signature

DR.JOHN LIVINGSTONE MUTYABA