

**WERABE UNIVERSITY
COLLEGE OF AGRICULTURE AND NATURAL RESOURCE
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DEPARTMENT OF AGRICULTURAL ECONOMICS**

**DETERMINANTS OF ADOPTION OF LIQUID ORGANIC FERTILIZER ON
WHEAT PRODUCTION:
THE CASE OF SANKURA WOREDA, SILTE ZONE, CENTRAL ETHIOPIA
REGION**

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ABBREVIATIONS AND ACRONYMS

Das	Development Agents
DFI	Department for International
D	Development
EG	Eco-Green
OF	Organic Fertilizer
OS	Organic soil amendments
As	
PB	Perceived behavioral control
C	
PG	Plant growth regulators
Rs	
SLF	Sustainable Livelihoods Framework
TA	Technology Acceptance Model
M	
TPB	Theory of Planned Behavior

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ABSTRACTS

In Ethiopia, the agricultural sector faces critical challenges due to soil fertility degradation, yet the adoption of liquid organic fertilizer remains low among smallholder rural farmers, severely affecting crop yields and local food security. This study identified the determinants of the adoption and use intensity of liquid organic fertilizers among wheat producers in Sankura Woreda, Silte Zone, Central Ethiopia Region. Primary data was collected from a randomly selected sample of 368 households, comprising 213 non-adopters and 155 adopters of liquid organic fertilizer. The analysis was conducted using descriptive statistics and econometric model. To address the study's specific objectives, the variations in wheat productivity attributable to technology adoption were explicitly evaluated alongside the socioeconomic factors governing farm decisions. The first-stage probit results indicated that household size negatively influenced the initial decision to adopt liquid organic fertilizer, whereas livestock ownership, frequency of extension contacts, access to information media, and membership in farmer-based organizations exerted positive and statistically significant impacts. The second-stage truncated regression revealed that farm size and membership in farmer groups significantly increased the intensity of use, while total farm income and the frequency of application had a negative correlation with use intensity. These findings demonstrate that the factors driving initial adoption decisions diverge from those dictating how intensely the liquid fertilizer is applied. Consequently, targeted policy interventions should focus on expanding specialized extension networks, reinforcing local farmer groups, and encouraging private entrepreneurs to invest in regional liquid organic fertilizer processing infrastructure to guarantee an affordable and consistent supply for smallholders.

Keywords: Adoption, Intensity, Cragg's Double Hurdle, Liquid Organic Fertilizer, Eco-Green, Sankura Woreda,

CHAPTER ONE

1.1. Background of the study

Agriculture significantly contributes to the economy by promoting private sector investments and driving related industries. It also provides income to many of the rural poor, helping them achieve food security, particularly in sub-Saharan Africa, where extreme poverty is prevalent (Belete, 2022).

The agricultural sector in Ethiopia, primarily composed of smallholder farming, confronts major issues like soil fertility degradation and low productivity, jeopardizing national food security. The investigation of sustainable farming inputs, such as liquid organic fertilizer (Eco-green), is essential for addressing these challenges (Kashif *et al.*, 2023)..

Eco-green is a locally manufactured Ethiopian organic fertilizer that provides essential macro- and micronutrients for plant growth. It is effective on different soil types, decreases pest and disease occurrences, and lowers crop protection costs. Additionally, its local production conserves foreign currency and enhances soil fertility through nitrogen, phosphorus, potassium, calcium, magnesium, and organic matter (—Organic Liquid Fertilizer Producing PLC, April 2022).

Organic agriculture, based on living organism principles, uses natural inputs, soil restoration, and crop rotation to manage elements like soil, plant, farm animals, insects, and local conditions (Ambrose *et al.*, 2018). Organic fertilizers, made from bio-degradable substances, are naturally occurring and nutrient enhancers for soil. They are essential for microorganisms and promote fertile soil with humus. Organic Liquid Fertilizer releases nutrients slowly and consistently, allowing plants to use them without over-concentration. Microbes convert organic matter into plant-needed nutrients, encouraging soil life (Abegeja *et al.*, 2022a).

In order to maintain high crop yields without degrading soil fertility, it is crucial to determine the best mix of inorganic fertilizers and organic fertilizers, such as eco-green, for cropping. This is because the combination of inorganic fertilizers and organic eco-green enhances the absorption, distribution, and function of other nutrients. Organic fertilizer supplements and complements artificial fertilizers as a low-cost, robust, renewable, and affordable source of plant nutrients.

Combining organic and inorganic fertilizers can result in enough soil fertility for long-term agricultural yields (Addis, 2019).

Organic fertilizers contribute to soil structure and productivity, but nitrogen and phosphorus fertilizers are the main limiting factors. Ethiopia's lowland soil is vulnerable to nutrient deficiencies due to mono-cropping and leaching losses. Intense crop cultivation leads to soil fertility decline, causing essential components to be lost. This stress negatively impacts crop productivity and is common in agricultural areas across the region. The current intensive cropping system leads to significant depletion of key elements (Kashif *et al.*, 2023).

Microbial bio-inoculants are organic fertilizers used in agriculture, primarily bacteria, that stimulate microbial activity, improve soil nutrient mobilization, and reduce resistance to pathogens and pests. However, their practical use is limited due to insufficient inoculants.

Research in Ethiopia indicates that organic fertilizers enhance microbial biomass and soil production but are hampered by high household energy use and demand for animal feed. Their effectiveness is limited by low nutritional value, labor requirements, and insufficient awareness. Liquid organic fertilizers are crucial for sustainable agricultural output amid soil fertility loss and the high cost of inorganic alternatives. This study focuses on the determinants of Eco-green organic liquid fertilizer among wheat farmers, analyzing the adoption of productivity, technical efficiency, and commercialization.

Consequently, this study explores the use of Eco-green organic liquid fertilizer as a sustainable agricultural solution in Ethiopia, focusing on factors influencing wheat farmers in Sankura Wereda, Silte Zone, and its effects on wheat productivity, technical efficiency, and commercialization.

1.2. Statement of the problem

Ethiopia's economy has seen significant growth, particularly in the agricultural sector, contributing to its status as one of the fastest-growing non-oil exporting economies globally. However, despite this growth, the agricultural sector grapples with low productivity, largely attributed to factors like high population growth rates leading to increased demands for energy and food. The heavy reliance on animal and crop byproducts for fuel and fodder has hindered the adoption of organic fertilizers, leading to soil fertility degradation, which poses challenges for sustainable agriculture. Since the 1970s, the Ethiopian government has intervened in the agricultural sector to overcome this problem through the promotion of various agricultural technologies such as organic fertilizers. However, soil

degradation has continued to lead to a decline in agricultural productivity. Improving soil fertility levels has become an important issue in development agendas due to its link with food security and economic well-being of the population.

The integrated nutrient management system is an alternative and is characterized by reduced input of inorganic fertilizers and combined use of inorganic fertilizers with organic materials such as animal manures, crop residues, green manure, and composts. Combined use of organic and inorganic fertilizers plays a significant role in sustaining soil fertility and the use of organic fertilizers together with inorganic fertilizers, has a higher positive effect on microbial biomass and enhances soil health.

Ethiopian farmers, particularly in Sankura district, are recognizing the need for liquid soil fertilizers to improve local agricultural productivity. The unique agro-climatic conditions in Ethiopia, such as fluctuating soil compositions and erratic rainfall patterns, present significant challenges to traditional farming practices. Liquid soil fertilizers align with sustainable agriculture practices, reducing water and chemical usage. This commitment to improving crop yields and developing agricultural technologies is crucial for long-term food security. Inorganic fertilizer scarcity is another issue faced by farmers in Sankura. Liquid soil fertilizers can address these issues by delivering essential nutrients directly to plant roots, leading to larger harvests and healthier plants.

Several researches in Ethiopia have also demonstrated the significance of organic fertilizer in increasing soil productivity. Organic fertilizers can improve soil structure and microbial biomass, making them a viable alternative to mineral fertilizers. However, their sources, such as cow dung and crop wastes, have been depleted over time, owing to their demand for domestic energy consumption and removal for animal feeding.

According to Biru G., atience Mshenga, (2016), Ethiopia's focus on agriculture and rural development aims to alleviate rural poverty and enhance overall economic growth, steering the nation towards independence from foreign aid. This necessitates the promotion of sustainable agricultural practices to improve productivity and soil fertility. While chemical fertilizers have been widely adopted, organic fertilizers have received less attention, resulting in soil degradation due to the loss of organic matter. Similarly, in this study, Efforts to promote the use of organic fertilizers are gaining momentum, with some progress seen in adoption rates in certain districts like Sankura woreda, in Silte zone, Central Ethiopia Region.

Many studies focus on one aspect or the majority of empirical studies on LOFs have been conducted

on horticultural crops (e.g., citrus, arugula, cabbage) or rice (Zeweld, W. et.al... 2018); there is a need for more research focused on staple cereal crops like wheat.

However extensive research exists on the agronomic effects of organic fertilizers, there is a relative scarcity of studies that integrate the socioeconomic determinants of adoption with empirical measurements of impact on productivity, particularly for LOFs.

Organic fertilizer has a positive impact on agricultural productivity and is a solution to deal with poor soil conditions in the study area. It is one of the agricultural technologies that has been believed to reduce direct production costs, improve environmental benefits, and increase crop yields. However, smallholder farmers have a low habit of using organic fertilizer in Ethiopia.

Furthermore, the use of organic matter is limited due to a lack of awareness and technical knowledge, a high labor demand for preparation, the need for large quantities due to low nutritional content and sluggish release, and the difficulty of getting it to crop fields. Small and marginal farmers in Ethiopia are finding it increasingly difficult to afford the application of inorganic fertilizers as a result of the ongoing rise in their costs. As a result, applying only organic fertilizer or a combination of inorganic fertilizer to soils that are deficient in nutrients might boost crop yields.

Thus, farmers faced with a lot of problems to use organic fertilizer. The problem includes the slow effect of organic fertilizer, labor intensive, limited sources of manure, higher cost of organic fertilizer, storage of manures, the emergence of weeds, and unfavorable smell of most of the organic fertilizers. Lack of skills and technical knowhow are also constraints in the use of organic fertilizers. Other major constraints to increased adoption of the organic fertilizer include technological challenges, policies for quality control of organic products, and lack of or inadequate access to extension services that provide technical advice. Moreover, development agents (DAs), who are responsible for assisting farmers at the kebele level, lack information regarding liquid fertilizers, which prevents farmers from properly implementing these methods into their farming systems. This is a result of both a lack of knowledge and comprehension of the advantages of eco-green fertilizers as well as a lack of instruction and training in their application. The high upfront costs of converting to eco-green fertilizers may also be prohibitive for many smallholder farmers, which would further limit their use.

Consequently, the researcher aimed to identify research gaps from different perspectives based on empirical facts. The first gap is modifying the problem stated in previous studies that have been concentrated basically on *the effects of adopting* the organic liquid fertilizer on farm productivity. As

a result, this study conducted to fill those *knowledge and literature gap* by examining the impact of adopting the organic liquid fertilizer on wheat productivity, in case of Sankura wereda, in the Silte Zone, Central Ethiopia Region.

Research Questions

RQ1: What are the socioeconomic factors that influence the adoption of liquid organic fertilizer in wheat production, in Sankura Woreda?

RQ2: What are the institutional factors and technological factors that influence the adoption of liquid organic fertilizer in wheat production, in Sankura Woreda?

RQ3: What factors determine the variations in wheat productivity during adoption of Eco-green liquid organic fertilizer?

1.3. Objectives of the Study

1.3.1 General Objective

- The primary objective of this study is to identify the determinants of liquid organic fertilizer adoption on wheat production in Sankura Woreda, Silte Zone, central Ethiopia Region.

1.3.2 Specific Objectives

- To identify the socioeconomic determinants, influencing the adoption of liquid organic fertilizer along with *governing farm decisions*
- To examine the institutional factors influencing the adoption of liquid organic fertilizer among smallholder wheat farmers
- To Evaluate factors causing differences in technical inefficiency among users and non-users of Eco-green

1.5 Scope and Limitations of the Study

This study focuses on analyzing the determinants of liquid organic fertilizer adoption and its subsequent impact on wheat production and productivity. The scope of the investigation is delineated along geographic, conceptual, and methodological boundaries as follows:

The study is strictly delimited to Sankura Woreda (district), located within the Silte Zone of the Central Ethiopia Region. Target Population and Data: The empirical focus is placed at the micro-level, targeting smallholder wheat farmers. Primary research relies on household-level, cross-sectional data collected from a sample of 368 smallholder farmers within the specified Woreda. Methodologically,

the study restricts its thematic focus to the socio-economic, institutional, and biophysical determinants influencing the adoption of liquid organic fertilizer. Furthermore, it evaluates the implications of this agricultural technology adoption on farm-level outcomes, specifically focusing on technical efficiency, commercialization, and wheat productivity.

1.6 Significance of the Study

The findings of this study are expected to provide valuable insights and practical benefits to a wide range of stakeholders, including smallholder farmers, agricultural extension officers, policymakers, and researchers. The specific significance of the research is outlined below:

For Smallholder Farmers: By identifying the determinants of liquid organic fertilizer adoption and addressing production and marketing bottlenecks, this study offers actionable insights to help farmers optimize wheat yields, improve technical efficiency, and boost household income.

For Policy Makers and Local Government: The empirical evidence generated regarding the socio-economic, institutional, and environmental impacts of organic fertilizer—such as its effects on employment, nutrition, and sustainable land management—will serve as a decision-making tool. Officials at the Woreda (district) and Zonal levels can utilize these findings to design targeted agricultural interventions, remove marketing barriers, and formulate supportive agricultural policies.

For Development Agencies and Extension Services: The study uncovers the specific challenges smallholders face in agricultural production and commercialization. This allows extension services to tailor their training and technology dissemination strategies to better meet the needs of the farming community in Sankura Woreda.

Contribution to Empirical Literature: Methodologically and conceptually, this research enriches the limited body of literature surrounding liquid organic fertilizer adoption within the specific context of wheat production in Central Ethiopia. It provides a foundational reference for future researchers and academicians investigating sustainable agricultural technologies in similar agro-ecological zones.

1.7. Organization of the Paper

The study comprises five chapters: the first chapter outlines its history, goals, and scope; the second reviews relevant literature; the third details the research methodology, including design, sample strategies, data collection, and analysis methods; the fourth discusses the findings; and the fifth presents the summary and recommendations.

CHAPTER TWO

REVIEW OF RELATED LITERATURES

2.1 Meaning and Use of organic fertilizer

Organic fertilizer is a more affordable and sustainable alternative to chemical fertilizers, making it more suitable for smallholders with less skill and capital. It increases crop yield, improves plant growth, increases spike length, seed quality, and resistance to pests and diseases. It also adds natural nutrients to the soil, acting as a drug for the soil (Gelgo, 2016).

Organic fertilizers are biodegradable, naturally occurring fertilizers that enhance soil productivity, prevent nutrient pollution, and improve soil structure. They promote community health by preventing eutrophication and nutrient pollution. The "ECO-GREEN" application is ideal for high grain and biomass yield (Abegeja *et al.*, 2022ab). Eco-Green enhances crop yield, plant growth, pest resistance, soil fertility, and reduces perishability. It replaces inorganic fertilizer, improves soil fertility, and minimizes crop protection costs, making it effective for various soil types (Zondo, 2020).

2.1. Theoretical Review

The adoption of agricultural innovations, such as liquid organic fertilizers (LOFs), is a complex process influenced by a multitude of factors. Understanding this process requires a foundation in the theoretical frameworks that explain how, why, and at what rate new technologies spread among farmers. This section outlines the key theories that underpin the study of agricultural innovation adoption, providing a lens through which the determinants of LOF adoption in Sankura Wereda can be analyzed.

2.1.1. Theory of Planned Behavior

The Theory of Planned Behavior (TPB), developed by Icek Ajzen (1991), provides a psychological framework for understanding and predicting human behavior. The TPB suggests that an individual's behavior is directly determined by their behavioral intention, which is, in turn, influenced by three factors: attitude toward the behavior, subjective norms, and perceived behavioral control.

Applied to the adoption of LOFs, a farmer's intention to use these fertilizers is shaped by their personal attitude towards them. This attitude is a function of their beliefs about the likely outcomes of adoption (e.g., "Using LOFs will increase my wheat yield and improve my soil") and their evaluation of these outcomes. Subjective norms refer to the social pressure the farmer perceives from important referents, such as other farmers, family members, extension agents, and community leaders, regarding whether they should or should not adopt LOFs. The influence of local cooperatives or farmers' associations would be a key component of subjective norms. Perceived behavioral control (PBC) reflects the farmer's perception of the ease or difficulty of performing the behavior, which is influenced by their assessment of available resources, knowledge, and opportunities. PBC is closely linked to actual barriers and facilitators, such as access to raw materials for making LOFs, availability of credit, technical knowledge, and labor requirements (Tama, R., Y., et.al... 2021). If a farmer believes they have a high level of control over these factors, their intention to adopt will be stronger.

2.1.2. Technology Acceptance Model

The Technology Acceptance Model (TAM), formulated by Fred Davis (1989), is specifically tailored to understanding user acceptance of information systems. However, its core concepts are highly applicable to agricultural technologies. The TAM proposes that a user's adoption of a technology is determined by their behavioral intention to use it, which is influenced by two primary perceptions: perceived usefulness and perceived ease of use.

Perceived usefulness in the context of LOFs is the degree to which a farmer believes that using LOFs would enhance their job performance as a farmer. This aligns with the DOI's "relative advantage" and includes factors such as increasing wheat productivity, reducing production costs, and enhancing sustainability (Abdulai, A. R., Pulido-Castanon, J. et.al... 2024). Perceived ease of use is the degree to which a farmer believes that using LOFs would be free from physical and mental effort. This relates to the complexity of the preparation and application processes. If LOFs are perceived as easy to produce, transport, and apply (e.g., through drip irrigation systems), adoption is more likely

(Abdulai, A. R., Pulido-Castanon, J. et.al... 2024).

Consequently, Fertilizer technology enhances soil fertility, boosts agricultural productivity, and reduces poverty by increasing farm income and consumption (Zegeye & Meshesha, 2022).

2.1.3. Sustainable Livelihoods Framework

The Sustainable Livelihoods Framework (SLF), developed by institutions like the Department for International Development (DFID), offers a holistic approach to understanding how households make livelihood decisions based on their access to five types of capital assets: human, social, natural, financial, and physical capital.

The adoption of LOFs can be analyzed through this framework. Human capital (skills, knowledge, and health) influences a farmer's ability to understand and correctly use LOF techniques. Social capital (networks, memberships in cooperatives, trust) affects access to information, shared learning, and collective action for LOF production or marketing. Natural capital (land, water, biodiversity) is central, as the motivation to adopt LOFs may be driven by the need to improve soil health (a key natural asset) and water retention (van Empel, G. J. 2012).

Financial capital (savings, credit) determines a farmer's capacity to invest in the initial inputs needed for LOF production. Finally, physical capital (equipment, infrastructure) includes access to tools for fermentation, storage containers, and irrigation systems suitable for liquid application (van Empel, G. J. 2012). The SLF emphasizes that the vulnerability context (e.g., climate change, market volatility) and transforming structures and processes (e.g., government policies, extension services) also shape livelihood strategies, including the choice to adopt technologies like LOFs.

2.2 EMPIRICAL LITERATURE REVIEW

This section synthesizes existing empirical research on the production, determinants of adoption, and impacts of liquid organic fertilizers, with a specific focus on evidence relevant to cereal crops like wheat and to smallholder farming contexts.

2.2.1. Production and Characteristics of Liquid Organic Fertilizers

LOFs can be produced from a wide variety of organic materials through processes like fermentation and anaerobic digestion. Common source materials include animal manure, plant residues, and specifically cultivated biomass. For instance, fertilizers can be produced from pig manure cultured with microalgae (*Chlorella fusca*), which was shown to increase antioxidant compounds in crops (Baruah, M., & Bhogave, A. (2023), or through the fermentation of plant materials like brassica

vegetables, mushrooms, and soybeans (Dr. Ajay B. Jadhao. 2023).

The production method significantly influences the nutrient content and effectiveness of the final product. Research comparing conventional solvent extraction and microwave-assisted extraction found that alkaline extraction was more economically and environmentally feasible for large-scale production, being ten times more efficient than water-based extraction (Baruah, M., & Bhogave, A. (2023).

The efficacy of LOFs is not solely determined by their macronutrient content (N-P-K). Studies highlight that they contain plant growth regulators (PGRs) such as auxins (e.g., Indole-3-acetic acid), gibberellins, and polyamines (e.g., putrescent, spermidine), which play crucial roles in promoting root development, nutrient uptake, and stress tolerance in plants (Rather, M. A. M. U. D., & Yadav, et.al.2023). For example, a study found that soybean-based LOF contained the highest concentrations of nitrogen (0.99%), phosphorus (0.11%), and IAA (24 µg/mL) compared to those made from mushrooms or brassicas (El-Ramady, H. et.al...2023). This combination of nutrients and bio-active substances distinguishes LOFs from mineral fertilizers and contributes to their multifaceted benefits for soil and plant health (El-Ramady, H. et.al...2023).

2.2.2. Determinants of Adopting Liquid Organic Fertilizers

Empirical studies across different regions have identified a consistent set of factors that influence a farmer's decision to adopt organic fertilizers. These factors can be categorized into socioeconomic, institutional, and cognitive domains.

Socioeconomic factors often play a primary role. Education level is frequently positively correlated with adoption, as higher education enhances a farmer's ability to access and comprehend technical information about new practices (Mittal, S., & Mehar, M. 2016).). Farm size can have a varied influence; while larger farms may have more capital to invest, smaller farms might perceive LOFs as a viable way to reduce input costs on a manageable scale. Access to credit and financial resources is critical, as the initial investment for setting up LOF production or purchasing commercial products can be a barrier (Baruah, S., Mohanty, S., & Rola, A. C. 2022). The availability of labor is another key consideration, as the production of homemade LOFs can be labor-intensive, which may discourage farmers with limited household labor (Baruah, S., Mohanty, S., & Rola, A. C. 2022).

Institutional factors are equally important. The quality and accessibility of extension services significantly impact adoption. Farmers who have regular contact with extension agents who provide

training on LOF production and use are more likely to adopt (Norton, G. W., & Alwang, J. 2020). Membership in farmer cooperatives or groups facilitates knowledge sharing, bulk purchasing of inputs, and collective marketing, thereby reducing perceived risks (Abdul-Rahaman, A., & Abdulai, A. 2020). Furthermore, government policies and subsidies that promote organic agriculture can provide a strong incentive for farmers to transition away from solely chemical-based practices (Bhatt, A., & John, J. 2023).

Cognitive and attitudinal factors relate to the farmer's perceptions. The perceived relative advantage of LOFs, such as expectations of improved soil health and long-term yield stability, is a powerful motivator (Swart, R., Levers, C., Davis, J. T., & Verburg, P. H. 2023).

Conversely, perceived complexity in preparation and application can be a major barrier. Finally, risk aversion is a significant factor; farmers may be hesitant to adopt LOFs if they are uncertain about their performance compared to familiar chemical fertilizers, especially on a staple crop like wheat that is crucial for food security.

2.2.3. Impact of Liquid Organic Fertilizers on Soil Health and Crop Productivity

A substantial body of empirical evidence demonstrates the positive effects of organic fertilizers on soil properties and crop performance, which underpins their potential impact on wheat production. The application of LOFs improves soil physical and chemical properties. They contribute to increased soil organic matter (SOM), which enhances soil structure, aggregate stability, water-holding capacity, and cation exchange capacity (CEC) (Bashir, O., Ali, T 2021).

This is particularly beneficial in areas prone to drought or with degraded soils. For example, research on citrus trees showed that liquid organic fertilization resulted in an increase in SOM compared to mineral fertilization (Wan, L. J., Tian, Y. et.al...2021). Organic fertilizers also support soil biological activity, increasing the population and diversity of beneficial microbes that aid in nutrient cycling and suppression of soil-borne diseases (Obasi, S. N., Peters, O. A. et.al...2024).

In terms of crop productivity, studies consistently show that organic fertilizers can yield comparable to or even greater than chemical fertilizers over the long term, while also improving crop quality. A review article highlighted that organic fertilizers improve nutrient uptake efficiency, chlorophyll synthesis, and carbohydrate content in plants (Obasi, S. N., Peters, O. A. et.al...2024). For example, liquid organic fertilization in citrus trees led to higher total biomass and increased uptake of macro and micronutrients compared to trees receiving mineral fertilizers (Khalil, N. H.

2023, April).

Similarly, a study on rice plants demonstrated that LOFs produced from soybeans enhanced growth and photosynthesis to a level similar to chemical fertilizers (Riddech, N., Ngo. et.al...2025).

2.2.4. Liquid Organic Fertilizers and Abiotic Stress Tolerance in Crops

A particularly relevant benefit of LOFs in the context of climate change is their ability to enhance crop resilience to abiotic stresses, such as drought, salinity, and heat. Research has shown that LOFs can significantly mitigate salt stress in plants. In a study on arugula, LOF application eliminated the negative effects of salt stress on most growth parameters, performing as effectively as NPK fertilizer (Riddech, N., Ngo. et.al...2025).

In rice, the application of LOFs containing polyamines helped alleviate salt stress by improving chlorophyll content, net photosynthesis rates, and dry weight of roots and shoots. The mechanisms for this tolerance include improved ion homeostasis, enhanced antioxidant activities, and the direct role of PAs and other compounds in stabilizing membranes and promoting growth under stress (Riddech, N., Ngo. et.al...2025).

Furthermore, organic fertilizers improve drought tolerance by enhancing the soil's water-holding capacity, allowing plants to access moisture for longer periods during dry spells. They also promote deeper root systems, which further improves water uptake (Riddech, N., Ngo. et.al...2025).

This is a critical advantage for wheat farmers in regions with irregular rainfall patterns.

2.2.5. Determinants of agricultural technology adoption

Economic analysis of agricultural technology adoption traditionally focuses on factors like personal characteristics, endowments, imperfect information, risk, uncertainty, institutional constraints, input availability, and infrastructure (Mwangi & Kariuki, 2015). Organic fertilizers, rich in essential nutrients, significantly enhance crop yields in agriculture due to their positive impact on plant productivity (Bobrenko *et al.*, 2022).

Technology factors: The adoption of technology depends on its characteristics and the ability to be tested on a small scale. Farmers should be involved in evaluating new technology's suitability for their circumstances. Climate change impacts, desert locust infestations, and internal conflicts have contributed to the rise in wheat imports (Senbeta & Worku, 2023).

Economic Factors: Farm size significantly influences technology adoption, with authors

highlighting its importance as a determinant and influenced by other factors (Lavison 2013). Scale-dependent technologies are those that are highly dependent on the size of the farm when they are adopted (Bonabana- Wabbi 2002). Studies show a positive correlation between farm size and adoption of agricultural technology, particularly in Ethiopian bread wheat production, where challenges like deteriorating soil health, erratic rainfall, and heavy reliance on chemical fertilizers persist (Publishers,2024).

Institutional factors: Social group membership boosts social capital, fostering trust, idea exchange, and information exchange among farmers. This network effect significantly influences individual decisions, especially in the context of agricultural innovations (Mwangi & Kariuki, 2015)

Household-specific factors: Farmer's human capital, including education, age, gender, and household size, significantly influences their decision to adopt new technologies, according to most adoption studies (Lorenz & Lal, 2016). Higher education enhances farmers' ability to adopt new technology, as it influences attitudes and thoughts, making them more open and rational. Labor is estimated by the number of adults and children involved in farming activities (Endale, 2011).

Organic agriculture aims to enhance sustainability by managing agricultural resources effectively to meet human needs while preserving the environment and natural resources for future generations, considering ecological, economic, and social aspects (Ambrose *et al.*, 2018). Women farmers are also challenged by the absence of capital, information and access to markets which prevents them from producing enough to full-fill the basic necessities (Region, 2015).

Summary on determinants of Agricultural Technology Adoption According to the Authors, like: Publishers,(2024), Bonabana- Wabbi (2002). Lavison (2013); Economic analysis of agricultural technology adoption considers factors like personal characteristics, endowments, risk, uncertainty, institutional constraints, input availability, and infrastructure. Organic fertilizers enhance crop yields.

Technology adoption depends on characteristics and small-scale testing, with farmers evaluating suitability. Climate change impacts, pest infestations, and internal conflicts contribute to wheat imports (Senbeta & Worku, 2023). Farm size significantly influences technology adoption, especially in Ethiopian bread wheat production. Scale-dependent technologies are highly dependent on farm size, affecting challenges like soil health and chemical fertilizer reliance. Social group membership boosts social capital, fostering trust and idea exchange among farmers. Farmer's human

capital, including education, age, gender, and household size, significantly influences their decision to adopt new technologies (Lorenz & Lal, 2016). Organic agriculture aims to enhance sustainability by managing resources effectively, but women farmers face challenges due to lack of capital, information, and market access (Region, 2015).

As Global Level

According to Hongyun Z, Wanglin, et.al,... (2021), The problem context involves the adoption of organic soil amendments (OSAs) like organic fertilizer and farmyard manure among wheat farmers in China, focusing on their impact on crop yields and net returns. This matter is significant as it addresses the potential benefits of OSAs in improving agricultural productivity and economic returns for farmers, which can influence food security and sustainable farming practices. A gap identified is the lack of understanding regarding the determinants of OSA adoption and the effects of such practices on farm performance, particularly in the context of selection bias. This paper aims to examine the factors influencing the adoption of OSAs and to assess their impact on wheat yields and net returns using a robust empirical model to account for selection bias.

As African Level

According to the study by, Anne Gichangi, A et.al,...(2022), examines the factors that influence the adoption of new improved wheat varieties (NIWV) by wheat farmers in Nakuru and Narok counties in Kenya. Cross-sectional data from 344 randomly selected wheat farmers from the Njoro and Rongai sub-Counties in Nakuru County; and Narok South and Narok North sub-counties in Narok County, Kenya were investigated. Pro bit model was run to estimate the factors influencing the adoption rate of improved new wheat varieties. Results derived from model estimates indicate that farmers' adoption of improved wheat varieties in the study area is positive due to education, availability of information, off-farm income, distance to inputs and produce markets, and exposure to extension advice services and access to credits. The study recommends that the public and private sectors promote access to advisory services to improve the dissemination of certified wheat seeds to farmers through training, workshops, and seminars.

In Ethiopian Level

The study by Mitiku, et.al, (2022) analyzed factors influencing the use of organic fertilizers among smallholder farmers in the south Gondar zone of North West Ethiopia. The research found that household head age, educational status, low skills in compost preparation, and high labor costs

impacted the use of organic fertilizers. Experience increased the use of organic fertilizer, while household income, farm size, soil fertility, and livestock numbers also influenced the use of organic fertilizers. The distance from the farm to the home also affected the use of organic fertilizers, while access to extension services positively influenced the use of organic fertilizers. Overall, the study highlights the importance of understanding and addressing soil infertility issues among smallholder farmers.

According to Biru G., P.Mshenga et.al,... (2016), The problem context involves low adoption rates of organic fertilizer among smallholder farmers in Shashemene district, Ethiopia, which contributes to soil fertility deterioration and low agricultural productivity. This issue matters as improving the adoption of organic fertilizer can enhance farm income, food security, and overall economic growth in Ethiopia, a country heavily reliant on agriculture. The gap identified is the lack of understanding of the socio-economic and institutional factors influencing the adoption and use intensity of organic fertilizer among these farmers. This paper aims to evaluate the determinants affecting the adoption decision and use intensity of organic fertilizer, providing insights for better extension services and farmer group formations to support smallholder farmers.

2.2.5. Research on Organic Fertilizers in the Ethiopian Context

While specific research on liquid organic fertilizer adoption in Sankura Wereda is limited, studies on related agricultural practices in Ethiopia provide valuable context. Research has highlighted that soil degradation and declining soil fertility are major challenges to sustainable agricultural production in the country, driving interest in integrated soil fertility management practices that include organic amendments. Factors such as small landholding size, limited access to information and credit, and inadequate extension support have been identified as common barriers to the adoption of sustainable agricultural practices by smallholder farmers. The increasing market demand for organic products, both locally and internationally, also presents a potential economic incentive for Ethiopian farmers to explore organic fertilization methods (Abebe, T. G., Tamtam . et.al...2022). This review underscores the need for location-specific studies, like the present dissertation, to understand the unique combination of factors that influence LOF adoption and impact in a specific *woreda* like Sankura.

Table 2.2: *Empirical Evidence on the Effects of Liquid Organic Fertilizers*

Crop Studied	Type of LOF	Key Findings	Source
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Citrus Trees	Animal-based & Plant-based	Increased nutrient uptake, total tree biomass, and carbohydrate content in leaves compared to mineral fertilization. Improved soil organic matter.	
Chinese Cabbage	Pig manure-based bio-fertilizer	Significantly increased antioxidant compounds (polyphenols, flavonoids) and sugars. Promoted beneficial soil bacteria (<i>Sphingomonas</i> , <i>Nocardioides</i>).	
Arugula	Anaerobic digestion-based	Eliminated salt stress inhibition on growth parameters. Showed positive effects comparable to NPK fertilizer	
Rice	Soybean-based fertilizer	Enhanced growth and photosynthesis under salt stress, performance similar to chemical fertilizer. Contained beneficial plant growth regulators (IAA, polyamines).	

Source: From various Literatures

2.2.6. Synthesis of Knowledge Gaps

The existing literature provides a strong foundation for this research; however, identifiable gaps justify the current study. Firstly, while extensive research exists on the agronomic effects of organic fertilizers, there is a relative scarcity of studies that integrate the socioeconomic determinants of adoption with empirical measurements of impact on productivity, particularly for LOFs.

Many studies focus on one aspect or the other. Secondly, the majority of empirical studies on LOFs have been conducted on horticultural crops (e.g., citrus, arugula, cabbage) or rice (Zeweld, W. et.al... 2018); there is a need for more research focused on staple cereal crops like wheat.

Finally, and most critically, the determinants and impacts are highly context-specific, influenced by local agro-ecology, socioeconomic structures, and institutional settings. Therefore, a case study in Sankura Wereda, Silte Zone, would provide critical localized evidence to inform policy and extension efforts aimed at promoting sustainable agricultural practices in the Ethiopian highlands.

DESCRIPTION OF THE EXPLANATORY VARIABLES/*Determinant factors*

Table 2.3: Description of the explanatory variables

Name of variables	Description	Measurement	Expected sign
Gender	Gender of the household head	1 if male and Otherwise	<i>Positively</i>
Level of Education	Level of formal education of the household head	Year of schooling	<i>Positively</i>
Family size	Number of household members	Number	<i>Positively</i>
Experience	Household head's experience in Farming	Years	<i>Positively</i>
Off-farm income	Whether household participated in non-farm activities or not	1 if yes and 0 Otherwise	<i>Positively</i>
Contact-Extension	Contact between the household head and extension agent during production season	Number	<i>Positively</i>
Land-size	Amount of cultivated land that a household owned	Hectare	<i>Positively</i>
Distance -market	The remoteness of the household to the closest market	Kilometer	-
Impression on yield	Whether household head perception is positive towards improved wheat variety or not	1 if positive and 0 otherwise	<i>Positively</i>
Impression on Cost	Whether household head perception is cheap towards improved wheat variety cost or not	1 if cheap and 0 otherwise	<i>Positively</i>
Varietal information	Whether household accessed to improved wheat variety information or not	1 if accessed and 0 otherwise	<i>Positively</i>
Access-Credit	Whether household accessed to credit or not	1 if accessed and 0 otherwise	<i>Positively</i>

2.3. Conceptual Framework of the study

Eco-green organic liquid fertilizer is 100% organic and free from any chemicals and it contains all the macro and micronutrients that nutrients to use for soil fertility.

The adoption of Eco-green farming practices is influenced by various factors, including household demographics, farm characteristics, economic factors, and institutional factors. Factors such as age, gender, education, farm size, income level, livestock ownership, access to credit, training and

extension access, and information access through media can all contribute to adoption. Institutional factors include membership in farmers' groups, access to extension services, and distance to the nearest market. Economic factors include access to credit, training and extension services, and better information exposure through media. Awareness levels, technology-related factors, soil fertility perception, and farm distance to the market also play a role in adoption.

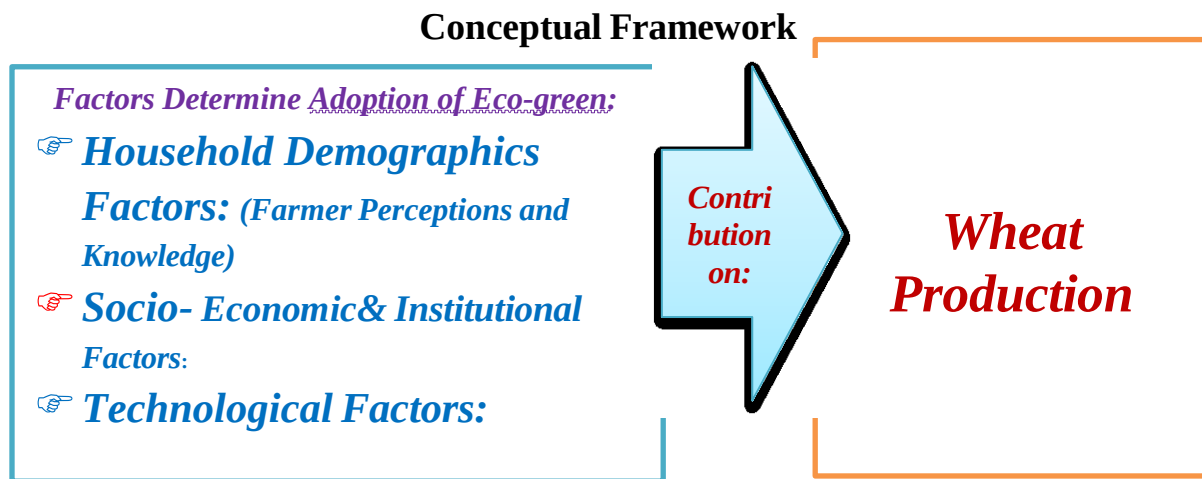


Figure 2.1: Conceptual Framework

CHAPTER THREE

RESEARCH METHODOLOGY

3.1. Research Design

In this study, both the descriptive and explanatory research Designs were employed. A descriptive research design was used to show the current status of adoption of liquid organic fertilizer and Wheat Production, while an explanatory research design was used to show the effect of adoption of liquid organic fertilizer on Productivity of wheat.

3.2. Research Approach

In this study, a quantitative research approach was employed to realize the objective of the study and measure the intended research objectives through the questionnaire.

3.3. Target Population

This study **targeted on** approximately, 2450 number of households *those're* currently involved in farming activities, in Sankura Town.

As a result, a total of **368** or $(15\% \times 2450 = 367.5)$ sampled households were selected randomly, from the study's choice area/randomly sampled districts. These **districts** were also ***selected purposively*** due to high crop population and farming land.

3.4. Sampling Techniques

The systematic random sampling techniques were used. The sampling technique is selected because of the study is done at particular in Silte zone, Sankura district; which in the past further investigation cannot be done. As a result, a total of **368** households were selected randomly, from the study's choice area/randomly sampled districts. These districts were also selected purposively due to high crop population and farming land.

3.5. Sample Size Determination

This study, conducted in Sankura Wereda, Central Ethiopia, utilized a cross-sectional survey and field experimentation involving 368 randomly selected wheat-farming households. Sample size determination effectively reduced the necessary size through finite population correction.

Data analysis incorporated descriptive statistics and logistic regression, employing systematic random sampling techniques from purposively chosen kebeles based on their relevance to wheat production and Eco-green usage.

Therefore, it is also important to clearly indicate the total population and the **sample size** taken for the study.

The sample must be representative of the population. If the population is homogeneous in nature, small size (10-30% of total population) can represent the entire population.

Thus, for the homogeneity of Population in this Sankura town, the researcher take the sample size of 15% of its total population; (Based on the given percentage taking interval of 10-30% , for the —small sizell total homogeneous population). Since the total Population is 2450; out of the total of 2450 population, the sample would be determined as: $15\% \times 2450 = 367.5$ or 368 households.

However, for heterogeneous nature of the population, it is advisable to increase the sample size and it must not be less than 30% of the total population.

Therefore, 368, total respondents would be taken as a **sample size**.

The data set contains 368 observations, of which 42% were adopters and 58% were non adopter of organic fertilizer.

3.5 Data Collection Techniques and Tools

To achieve the research objectives, this study adopts a mixed-methods research design, integrating both quantitative and qualitative approaches to collect primary and secondary data.

3.5.1 Primary Data Collection

The primary data were gathered through a comprehensive household survey administered to 368 randomly selected smallholder farmers in Sankura Woreda. The primary data collection process consists of the following components:

Survey Questionnaire: A structured, researcher-developed questionnaire will be utilized to collect quantitative data. This instrument is designed to capture demographic characteristics, socio-economic attributes, institutional factors, and farmers' behavioral attitudes regarding the adoption of liquid organic fertilizer. Qualified enumerators will be recruited and intensively trained on the specific subject matter of the research, ethical considerations, and interviewing

techniques. Data collection was executed by these enumerators under the strict, close supervision of the researcher.

Pre-Testing (Pilot Survey): To ensure validity, reliability, and clarity, the questionnaire will be pre-tested through a pilot study conducted on 10% to 20% of the sample size in a neighboring locality with similar agro-ecological conditions. Based on the feedback from the pilot test, ambiguous questions were modified and refined before final deployment.

Qualitative Primary Tools: To complement the quantitative survey, qualitative insights would be gathered through personal field observations and informal discussions with rural households and local Development Agents (DAs).

3.5.2 Secondary Data Collection

Secondary data would be systematically gathered to triangulate and support the empirical findings. Qualitative and quantitative secondary information would be sourced from relevant institutional records, reports, and publications from, Woreda and Zonal Offices of Agriculture and Rural Development. Organization documents, technical manuals, and distributions reports from **Eco-Green PLC** regarding liquid organic fertilizer.

3.5.3 Data Analysis Techniques and Data Integration

The study employs a cross-sectional temporal design. The integration of quantitative and qualitative datasets serves to validate the findings, enhance credibility, and minimize method bias.

Quantitative Data: Data obtained from the household survey would be cleaned, coded, and analyzed using both descriptive statistics (e.g., frequencies, percentages, means) and inferential econometric models (to determine the factors influencing adoption and productivity).

Qualitative Data: Information obtained from observations, informal discussions, and secondary literature will be analyzed contextually to explain, enrich, and cross-examine the statistical patterns derived from the quantitative analysis.

CHAPTER FOUR

REVIEW OF RELATED LITERATURES

Regarding the first Specific Objective:

4.1. Socio-economic Characteristics of the Respondents

As per the information indicated below; *Table 4.1* presents the averages and *t*-values of continuous variables while *Table 4.2* presents the proportions and *chi*² results of selected categorical socio-economic variables. The data set contains 368 observations, of which 42% were adopters and 58% were non-adopters of organic fertilizer. The results indicated that the average of livestock ownership, higher education level of any of family member, farm size, farm income, group membership and extension visits was significantly different between the organic fertilizer adopters and non- adopters. The average for each of these variables was higher among the adopters compared to the non-adopters.

Moreover, although some variables did not exhibit significant difference in terms of their means between the adopters and non-adopters of organic fertilizer, it is clear that there is variation in the averages of these variables among the adopters and non-adopters of organic fertilizer (*Table 4.1*).

Table 4.1: Result on Socio-economic Characteristics (Continuous variables)

Characteristics	Adopters		Non adopters		Test	
	statistics					
	Mean	SD	Mean	SD	Overall mean	t- value
Age (years)	43.99	11.00	44.20	11.88	44.11	-0.17
Household head education (years)	6.35	3.84	5.74	3.39	5.99	1.61
Highest education in the family (years)	10.65	2.90	10.10	3.01	10.33	1.75*
Household size (family number)	7.26	3.01	7.02	3.36	7.13	0.71
Labor (number)	3.27	2.76	2.95	2.70	3.09	1.11
Livestock holding (TLU)	7.81	5.15	3.48	4.36	5.31	8.71***
Farm size (hectares)	1.06	0.53	0.86	0.40	0.94	4.06***
Farm income (Birr)	14497.55	7491.62	11868.04	6979.41	12975.58	3.46***
Experience (years)	23.97	10.57	23.89	11.16	23.93	0.07
Group membership (number)	0.59	0.52	0.31	0.49	0.42	5.31***
Access to credit (amount in ETB)	529.03	1520.89	828.17	2020.33	702.17	-1.55
Extension (number of extension visit)	3.67	2.79	2.86	2.61	3.2	2.85***
Distance to the nearest market (km)	3.57	2.42	3.61	2.3	3.59	-0.71

Note, *** and * indicate significance at 1% and 10% respectively while SD denotes standard deviation.

Source: Authors' survey data, 2025

The results of categorical variables showed that majority (88.4% of the adopters and 88.7% of the non- adopters) of the households were male headed both among the organic fertilizer adopters and non-adopters. In relation to marital status, 96.1% of the households were married among the adopters while the remaining 3.9% were widowed. On the other hand, 94.4%, 3.3%, 1.9% and 0.5% were married, widowed, single and divorced respectively among the non-adopters. Regarding farm fertility, 72.9%, 23.9% and 3.2% of the organic fertilizer adopter households perceived that their farms were medium, not fertile and fertile respectively. About 74.6%, 22.1% and 3.3% percent of the non-adopters believed that their farms were medium, not fertile and fertile respectively. In relation to type of employment, 99.3% of the organic fertilizer adopters expressed

that they work on their farms full time while the remaining 0.7% work part time. On the other hand, 99.1% of the non-adopters work full time on their farms while 0.9% work part time. About 83.2% of the households had access to information media among the adopters whereas 13.8% did not. Among the non-adopters, 69.9% of the households had access to information media while 30.1% did not. Further, access to information media (radio and television) was significantly correlated with adoption decision of organic fertilizer while soil fertility, gender, marital status and type of labor was not (Table 4.2).

4.1.1. Discussion of Socio-Economic Characteristics (*Continuous variables*) Based on the survey data on Table 4.1 above; the following analysis interprets the continuous variables comparing adopters and non-adopters.

Significant Drivers of Adoption (1% Significance Level)

Several key resource and institutional factors show a highly significant difference ($p < 0.01$) between the two groups, suggesting they are primary drivers of adoption.

Livestock Ownership (TLU): Adopters hold significantly more livestock (7.81 TLU) compared to non-adopters (3.48 TLU). With a t-value of **8.71**, livestock wealth appears to be a major determinant, likely providing the capital or manure necessary for adoption. *Farm Size and Income:* Adopters manage larger farms (1.06 hectares vs. 0.86 hectares) and earn higher annual incomes (14,497.55 Birr vs. 11,868.04 Birr). Both factors are highly significant (**4.06** and **3.46** t-values respectively), indicating that higher landholding and financial liquidity facilitate the adoption of new technologies. *Institutional Support:* Adopters have significantly higher group membership (0.59 vs. 0.31) and receive more frequent extension visits (3.67 vs. 2.86). This underscores the vital role of social capital and government advisory services in promoting new practices.

Human Capital and Education: The data suggests that family-wide education plays a more relevant role than just the education of the household head.

Highest Family Education: This variable is significant at the 10% level (**1.75** t-value), with adopters' families having a higher maximum education level (10.65 years) than non-adopters (10.10 years). *Household Head Education:* While the mean is higher for adopters (6.35 years) than non-adopters (5.74 years), the difference is not statistically significant at standard levels (t-value of 1.61).

Non-Significant Factors

Interestingly, several traditional demographic factors do not appear to influence the adoption decision in this specific context.

Table 4.1.1. Interpretation to **Non-Significant Factors** (*demographic Characteristics*)

Characteristic	Adopter Mean	Non-Adopter Mean	t-value	Interpretation (<i>Based on the Result</i>)
Age (years)	43.99	44.20	-0.17	No age-based gap
Experience (years)	23.97	23.89	0.07	Similar farming longevity
Household Size	7.26	7.02	0.71	Labor pool is comparable
Market Distance	3.57 km	3.61 km	-0.71	Proximity to markets is equal

Discussion and Implications (*demographic Characteristics*)

The results highlight a **resource-based adoption gap**. Farmers with greater physical capital (land and livestock) and higher financial returns are significantly more likely to adopt the practice. This suggests that the technology or practice might require a certain threshold of wealth or serve as a risk that only wealthier farmers can afford to take.

Furthermore, the significant t-values for **extension visits** and **group membership** suggest that "knowledge-push" strategies are working. However, the lack of significance in **access to credit** (where non-adopters actually had a higher mean amount of ETB, though not significantly so) implies that simply having credit may not be enough if other factors like land size or extension support are missing. *Generally*, to increase adoption among the "non-adopter" group, interventions should focus on increasing extension contact and supporting group memberships, as these institutional factors currently represent the widest divide between the two groups alongside physical asset ownership.

Table 4.2: Results on Socio-Economic Characteristics (Categorical Variables)

Characteristics	Adopters		Non-adopters		Test
	statistics				
	Freq.	%	Freq.	%	Ch ² - value
Gender					
Male	137	88.4	189	88.7	0.01
Female	18	11.6	24	11.3	
Marital status					
Single	0	0.0	4	1.9	3.75
Married	149	96.1	201	94.4	
Divorced	0	0.0	1	0.5	
Widowed	6	3.9	7	3.3	
Farm fertility					
Not fertile	37	23.9	47	22.1	
Medium	113	72.9	159	74.6	0.17
Fertile	5	3.2	7	3.3	
Labor type					
Part time	1	0.7	2	0.9	0.10
Full time	154	99.3	211	99.1	
Access to information media					
Yes	129	83.2	149	69.9	8.56***
No	26	16.8	64	30.1	

Note, *** denotes significance at 1%.

Source: Authors' survey data, 2025

Based on the results in **Table 4.2**, most socio-economic variables—such as gender, marital status, land fertility, and labor type—do not significantly influence the adoption status of the participants. These groups are effectively similar in their basic demographic and farm profiles.

In line with this, regarding to **Gender and Marital Status**: the data suggests that demographic profiles are remarkably similar across both groups. *Gender*: The vast majority of both adopters (88.4%) and non-adopters (88.7%) are male. With a Chi-square (χ^2) value of **0.01 (1%)**, there is no statistically significant difference in adoption rates based on gender. *Marital Status*: Most respondents are married (96.1% of adopters and 94.4% of non-adopters). While a few non-adopters are single (1.9%) or divorced (0.5%), the test statistic of **3.75** indicates that marital status does not significantly influence the decision to adopt.

According to **Farm Fertility and Labor Type**:- the physical and operational characteristics of the farms do not appear to be primary drivers for adoption in this sample.

Soil Fertility: Most farmers perceive their soil fertility as "Medium" (approx. 73–75% for both

groups). The low χ^2 value of **0.17** confirms that perceived soil quality is not a distinguishing factor between adopters and non-adopters. *Labor Type*: Almost all respondents work full-time on their farms (over 99% in both categories). Consequently, the type of labor employed shows no significant correlation with adoption ($\chi^2 = 0.10$).

According to **Access to Information Media**: it is the most critical finding in the data.

Significant Difference: There is a highly significant difference between the two groups regarding access to radio and television. *Adopter Advantage*: 83.2% of adopters have access to information media, compared to only 69.9% of non-adopters.

Statistical Significance: The test statistic for this variable is **8.56**, which is marked with three asterisks (***). This indicates that the difference is **statistically significant at the 1% level**.

Discussion: The results indicate that while "hard" factors like gender, soil quality, and labor availability are uniform across the study area, **information asymmetry** is a major barrier to adoption. The highly significant $p < 0.01$ result for media access suggests that farmers who are exposed to radio and television are much more likely to adopt new practices. This implies that information dissemination through mass media is an effective tool for increasing adoption rates, whereas traditional demographic factors may not be the primary constraints in this specific context.

Regarding the Second & Third *Specific Objectives*:

4.2. Inferential Statistics

4.2.1. Factors Affecting Adoption Decision of Organic fertilizer

To determine the major factors affecting adoption and use intensity of organic fertilizer, Cragg's double hurdle model was employed. Before executing the final analysis, preliminary analysis involving likelihood ratio (LR) test was carried out to check for superiority of the double hurdle model over the independent Tobit model. The results showed that the restricted Tobit model should be rejected in favor of unrestricted (double hurdle model) to analyze the use intensity of organic fertilizer. Multi-collinearity was also checked among the explanatory variables using variance inflation factors (for continuous variables) and contingency coefficients (for categorical variables). The results showed that multi-collinearity was not a serious problem among both continuous and categorical explanatory variables. Therefore, the employed model was the most robust and complete.

4.2.1.1 Factors affecting adoption decision of organic fertilizer

The first stage of the double difficulty model deals with the adoption decision of organic fertilizer. Farmers were assigned 1 if they are adopters of organic fertilizer and 0 otherwise. The results of the Cragg's double hurdle model presented in Table 3 revealed that household size, number of livestock units, extension services, access to information media and membership in local farmers based organizations had significant effect on household's adoption decision.

In relation to household size, the results showed that an increase in the size of the household by one member decreased the likelihood of adopting organic fertilizer by about 2.3% at 5% significance level. Although a given household reports large family size, some members may not be available for farm work due to several reasons such as migration and schooling. For example, Kpadonou *et al.* (2015) noted that although migration may provide additional income to the household through remittances, it may also result in a smaller workforce for farming activities. In addition, Mutimba *et al.* (2011) found that the household size is negatively related to adoption of compost in Malawi. They explained that majority of the adopters of compost manure were middle aged (30 - 49 years) with their children still at school and would not have been available for making compost. Thus, having large family size *per se* does not necessarily mean all family

members are available for the farm work. On the other hand, Tedla (2011) found that household size has positive effect on decision to adopt agricultural technology. He contended that a larger household size is associated with expectation of more labor in the family. Further, Terefe *et al.* (2013) showed that household size has no significant influence on the adoption of organic fertilizer in Ethiopia.

Results on the number of livestock owned indicate that an increase in the number of livestock by one animal increased the likelihood of adopting organic fertilizer by about 3.9%. The results were statistically significant at 1% significance level. The availability of more animal manure as the number of livestock unit increases possibly justifies the positive correlation between livestock ownership and organic fertilizer adoption. Animal manure is the potential source of organic fertilizer. It is the main ingredient during composting. Thus, households who own large number of livestock's are likely to get more manure and therefore adopt organic fertilizer. The finding was consistent with Tefera *et al.* (2013). They explained that the households with more livestock holding are likely to adopt organic fertilizer due to their better capacity to have animal manure. Akpan *et al.* (2012) also noted that domestic animals constitute a good source of organic manure serving as a good substitute for chemical fertilizer.

In relation to extension services, the results show that one additional meeting with extension workers increased the likelihood of organic fertilizer adoption by about 2.3%. It was found to have positive and significant effect on adoption of organic fertilizer at 1% significance level. One of the most important role of extension service is to raise farmer's awareness about agricultural productivity through providing them important information related to adoption of agricultural technologies. According to Kassie *et al.* (2009), in most cases, extension workers establish demonstration plots where farmers get hands-on learning and can experiment with new farm technologies which enhance adoption of new technologies. The results of the study therefore confirm that better information dissemination through extension workers could enhance adoption of organic fertilizer by improving knowledge about the advantage of new technology.

Thus, for a given household, the more the frequency of meeting extension workers were; the higher likelihood of organic fertilizer adoptions. The finding was in line with Kassie *et al.* (2009). They argued that farmers who have regular contact with agricultural experts are more motivated to participate in agricultural technology adoption due to intensive information they may get from the experts.

Access to information media increased likelihood of adopting organic fertilizer by about 10.9% revealing its positive influence on the adoption of organic fertilizer at 10% significance level. Farmers who have had access to information through television, radio or any other social media were considered to have access to information media. Better access to information could likely empower farmers to seek for agricultural technologies which may improve their farm productivity. This is mainly because access to information could enable one to have more knowledge and awareness about different technologies. For example, in adoption of organic fertilizer, farmers can have information such as how to prepare, apply on the farms and so on with better access to information. Thus, such a farmer can possibly intensify adoption of this technology compared to other groups of farmers who have no access to information through these media. Several recent studies on agricultural technology adoption in Ethiopia did not include this variable in their analysis (Berhe, 2014; Terefe *et al.*, 2013).

Membership to one additional local farmers based association increased the likelihood of organic fertilizer adoption by about 10.1 percent. The results show that membership to farmers based organizations had influenced decision to adopt organic fertilizer positively and significantly at 5% significance level. The positive effect might be due to increase in possibility of meeting with other farmers as one becomes a member of different farmer groups and be informed about the new technology. Farmers based organizations in rural areas make possibility of information transfer easier among the farmers through increasing frequency of discussion among the members (Berhe, 2014). Thus, households whose membership belongs to farmer groups such as associations and cooperatives can easily access fertilizer technology (Martey *et al.*, 2013).

Table 4.3: Results of the model (Probit output) on determinants of decision of adoption of organic fertilizer

Variables	Coef.	Std. Err.	z – value	dy/dx
Age	-0.003	0.011	-0.28	-0.001
Gender	-0.002	0.263	-0.01	-0.001
Household size	-0.076**	0.035	-2.17	-0.023
Household head education	0.006	0.026	0.23	0.002
Farm income	0.000	0.000	-0.56	0.000
Experience	-0.002	0.011	-0.19	-0.001
Farm size	0.210	0.200	1.05	0.064
Soil fertility	-0.111	0.159	-0.69	-0.034
Livestock number	0.126***	0.019	6.48	0.039

Credit amount	0.000	0.000	-0.68	0.000
Extension number	0.074***	0.028	2.70	0.023
Access to information media	0.356*	0.196	1.82	0.109
Membership	0.331**	0.153	2.16	0.101
Distance to nearest market	0.018	0.033	0.55	0.006
Marital status	0.270	0.218	1.24	0.082
Labor	-0.005	0.048	-0.11	-0.002
Family's highest education	0.016	0.029	0.56	0.005
Constant	-1.518	0.881	-1.72	
N	367			
Log likelihood	-939.093			
Wald chi ² (17)	82.09			
Prob. > χ^2	0.000			

Note, ***, ** and * indicate significance at 1%, 5% and 10% respectively while dy/dx denotes marginal effects.

Source: Authors' survey data, 2025

4.2.1.2 Factors affecting use intensity of organic fertilizer

Most farmers/households in Sankura district use some sources of organic fertilizer such as manure without measuring its amount and it was difficult to know the exact amount of organic fertilizer use by the farmers on their farms. However, households who use compost use m³ (cubic meter) measurement when preparing and *quintal* (a unit of weight equal to 100 kg) when transporting it to their farms. Thus, the application level of compost is better known by farmers compared to other types of organic fertilizer such as manure. Due to this, the second stage used compost as a proxy to evaluate factors affecting use intensity of organic fertilizer. The results showed that farm income, farm size, membership in farmer based organizations and frequency of organic fertilizer application had significant influence on use intensity of organic fertilizer.

The results indicated that an increase in household income by 1 Birr decreased use intensity of organic fertilizer by about 0.002 quintal per hectare at 1% significance level. This shows that the household income had negative effect on use intensity of organic fertilizer. A household with high income may prefer to use chemical fertilizer compared to organic fertilizer which can be substitute for each other. If farmers can afford to buy chemical fertilizers, then the propensity of using labor intensive fertilizers such as manure decreases (Ketema and Bauer, 2011). Organic fertilizer preparation (for instance composting) is also time intensive requiring more time. Due to this, households with better income may prefer to buy and use chemical fertilizer within short period of time. In addition, little cash holding households are likely to prefer more organic fertilizer as it is relatively cheaper compared to chemical fertilizer.

According to Martey *et al.* (2013), investment of financial resources in interest earning assets which are associated with high income are also likely to explain low fertilizer use with increase in income though the components of fertilizer was not captured.

Regarding farm size, the results indicate that an increase in the farm size by a unit hectare increased use intensity of organic fertilizer by about 26.11 quintal per hectare. The positive impact of farm size on use intensity of organic fertilizer can be justified in relation to better economies of scale associated to larger farm size. The farmers with larger farm size would also use organic fertilizer as it is less costly compared to inorganic fertilizer. These could have encouraged some farmers to use organic fertilizer in the study area. Further, the farm size is a significant determinant of organic fertilizer adoption at 1% significance level. The results were consistent with the findings of Kassie *et al.* (2009). They noted that ownership of the farm land increases assurance of future access to the returns of the investments thus increasing probability of using organic fertilizer such as compost.

Membership to one additional local farmers based association increased the use intensity of organic fertilizer by about 10.62 quintal per hectare at 10% significance level. This shows that membership in farmers based organizations had positive effect on use intensity of organic fertilizer. Several reasons have been pointed out in the first hurdle of this model regarding positive correlation between a membership to farmers group and adoption decision of organic fertilizer. Furthermore, farmers based associations serve as a platform for accessing and dissemination of information and technology (Martey *et al.*, 2013) therefore enhancing communications for development (Berhe, 2014). These could possibly allow farmers to share ideas and experiences therefore likely intensifying per hectare use of organic fertilizer.

In relation to frequency of organic fertilizer application, the results show that application of organic fertilizer in a given season decreased its reapplication in the following season by about 28.86 quintal per hectare. The negative relationship between the frequency of organic fertilizer application and intensity of organic fertilizer use could be mainly due to the farmer's expectation of residual value of this fertilizer. In the study area, most farmers believe that the farm can stay fertile for a period of about four years once organic fertilizer is applied on it.

Due to this, once they apply on their farms, the following season, they relatively apply fewer amounts. The results further indicated that the frequency of organic fertilizer use had significant effect on use intensity of organic fertilizer at 5% significance level. Frequency of application was

found to have highest (nearly 29 quintal per hectare decrease every season) influence on use intensity of organic fertilizer. It also seems that the farmers in the study area are uncertain about the length of the time that compost maintains soil fertility.

Thus, efforts to bring the exact time period of applying this fertilizer coupled with its right amount per hectare could be the best strategy to enhance use intensity of organic fertilizer. Several recent studies related to adoption of organic fertilizer did not include frequency of application in the analysis (Lavison, 2013; Tefera *et al.*, 2013; Ajewole, 2010).

Table 4. 4: Results of model, for the factors affecting intensity of organic fertilizer adoption

Variables	Coef.	Std. Err.	t – value
Age	-0.313	0.446	-0.70
Gender	3.180	9.573	0.33
Household size	-1.418	1.365	-1.04
Education of household head	0.114	0.893	0.13
Farm income	-0.002***	0.00	-3.57
Experience	-0.060	0.449	-0.13
Farm size	26.112***	6.269	4.17
Soil fertility	0.354	5.483	0.06
Livestock number	0.958	0.693	1.38
Credit amount	0.002	0.002	1.03
Extension Visits	1.527	1.023	1.49
Access to information media	3.213	7.847	0.41
Membership	10.621*	5.460	1.95
Distance to the nearest market	0.560	1.190	0.47
Marital status	1.618	8.225	0.20
Labor	-1.783	1.786	-1.00
Family's highest education	0.197	1.190	0.17
Application frequency	-28.858**	13.129	-2.20
Constant	122.638	43.019	2.85
/sigma	30.65	1.998	15.34
N	367		
Log likelihood	-939.093		
Wald chi ² (17)	82.09		
Prob. > χ^2	0.000		

Note, ***, ** and * indicate significance at 1%, 5% and 10% respectively.

Source: Authors' survey data, 2025

Discussion of Model Results

Result on Model Fit

As per the result on the above table 4.4; the model diagnostics indicate a **strong overall fit** for the data: **Wald $\chi^2(17) = 82.09$** with a **Prob > χ^2 of 0.000**. This confirms that the independent variables included in the model significantly explain the variation in the intensity of organic fertilizer adoption. The *Constant* (122.638) is significant at the 1% level, representing the baseline intensity when other factors are held at zero.

According to the result on the above table 4.4; **on the model**, which identifies factors specifically affecting the **intensity** of organic fertilizer adoption (how much is used) among farmers who have already decided to adopt.

Significant Drivers of Adoption Intensity: Three variables emerged as statistically significant determinants of the volume or intensity of organic fertilizer application:

Farm Size (26.112*): This variable has a positive coefficient and is highly significant at the **1% level** ($t = 4.17$). This suggests that as farm size increases, the intensity of organic fertilizer use increases substantially. Farmers with more land likely have more space to apply organic matter and potentially greater resources to manage the logistics of larger-scale application. *Farm Income* (-0.002*): Interestingly, farm income shows a highly significant but **negative** relationship with adoption intensity ($t = -3.57$) at the **1% level**. This could imply that as income increases, farmers might shift away from labor-intensive organic fertilizers toward commercial inorganic alternatives or that organic fertilizer is treated as an "inferior good" in this specific economic context. *Membership in Organizations* (10.621):* Social capital, measured by membership, is significant at the 10% level ($t = 1.95$). Being part of a group likely provides better access to collective labor, knowledge sharing, or resources that allow farmers to apply organic fertilizer more intensively.

Constraints on Adoption Intensity: *Application Frequency* (-28.858): This variable is significant at the **5% level** ($t = -2.20$) with a negative coefficient. This inverse relationship suggests that if the required frequency of application is too high, the overall intensity (amount) applied decreases. This may be due to the high labor demands associated with frequent manual application of bulky organic materials.

Non-Significant Factors: The model indicates that many demographic and institutional factors—which often influence the initial *decision* to adopt—do not necessarily dictate the *intensity* of use once the decision is made:

Human Capital: Age, gender, household size, and education (both of the head and the family's highest level) show no significant impact on how much fertilizer is applied. *Institutional Access:* While extension visits ($t = 1.49$) and credit amount ($t = 1.03$) have positive coefficients, they did not reach statistical significance in this stage of the model. *Infrastructure & Environment:* Distance to market ($t = 0.47$) and perceived soil fertility ($t = 0.06$) also appear to be non-factors for application intensity in this sample.

4.3. Discussion of the Result

This study aimed to identify the factors influencing the use of organic fertilizers among sankura woreda's smallholder farmers, in the silte zone, Central Ethiopia Region. The study found that head age was a significant factor, with older farmers having more experience and knowledge about organic fertilizer. Married marital status was also positively associated with organic fertilizer use, as it increases farmers' concern for household welfare.

Educational status was strongly linked to organic fertilizer use, with educated smallholder farmers being more knowledgeable about organic fertilizer preparation and its benefits. However, low skills related to compost preparation could limit the use of organic fertilizer. The number of laborers in a family increased, and the cost of laborers significantly influenced the use of organic fertilizer.

Experiencing increased the amount of organic fertilizer used on a farm, suggesting more experienced farmers have gathered more information and knowledge about the usage of organic fertilizer over time. Household income was negatively associated with the use of organic fertilizers, as higher incomes may prefer to purchase and use chemical fertilizers on time. Soil fertility was negatively associated with the use of organic fertilizers, with non-fertile soil being less likely to use organic fertilizers. The number of livestock was positively associated with the use of organic fertilizer, as domestic animals provide a good source of organic manure.

Distance from the farm to the home negatively affected the use of organic fertilizers, possibly due to high transportation costs and manpower requirements. Information about organic fertilizers was key to the use of organic fertilizers by smallholder farmers. Access to extension services positively influenced the use of organic fertilizer, potentially due to better education on the effects of organic food on human health.

The highly significant $p < 0.01$ result for media access suggests that farmers who are exposed to

radio and television are much more likely to adopt new practices. This implies that information dissemination through mass media is an effective tool for increasing adoption rates, whereas traditional demographic factors may not be the primary constraints in this specific context.

The significant t-values for **extension visits** and **group membership** suggest that "knowledge-push" strategies are working. However, the lack of significance in **access to credit** (where non-adopters actually had a higher mean amount of ETB, though not significantly so) implies that simply having credit may not be enough if other factors like land size or extension support are missing. *In conclusion*, to increase adoption among the "non-adopter" group, interventions should focus on increasing extension contact and supporting group memberships, as these institutional factors currently represent the widest divide between the two groups alongside physical asset ownership.

As the results indicated above analysis; the frequency of organic fertilizer use had significant effect on use intensity of organic fertilizer at 5% significance level. Frequency of application was found to have highest (nearly 29 quintal per hectare decrease every season) influence on use intensity of organic fertilizer. It also seems that the farmers in the study area are uncertain about the length of the time that compost maintains soil fertility. **Thus**, efforts to bring the exact time period of applying this fertilizer coupled with its right amount per hectare could be the best strategy to enhance use intensity of organic fertilizer.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1. Summary and Conclusion

This study assessed the factors influencing the adoption and use intensity of organic fertilizers among 368 farmers in the Silte zone, Sankura district, Central Ethiopia. The results indicate that various independent variables significantly affect organic fertilizer usage. Thus, findings are crucial for developing programs and policies aimed at promoting organic fertilizer use in Sankura woreda.

About 42% of the households were adopters of organic fertilizer which was below the average while the remaining 58% were non-adopters. The results indicated that the household size, livestock number, extension visits, access to information media and membership to farmer based organizations had significantly influenced decision of adoption of organic fertilizer. The household size negatively influenced organic fertilizer adoption while the remaining four factors influenced adoption decision of organic fertilizer positively. Household income and the application frequency of organic fertilizer had negative influence on use intensity of organic fertilizer while the farm size and membership to farmer based organizations had positively influenced use intensity of organic fertilizer.

The empirical evidence clearly showed that determinants of adoption decision of organic fertilizer are different from determinants of use intensity of organic fertilizer except membership to farmer groups which influenced both adoption decision and use intensity.

Thus, to promote more intensive use of organic fertilizers, policy interventions should focus on land-holding capacity and social organization (memberships). Furthermore, the negative correlation with farm income suggests a need to investigate whether high-income farmers are abandoning organic practices in favor of chemical alternatives, which may have long-term implications for soil health.

5.2. Recommendation

Based on the above conclusion, the factors that affect adoption of decision are not necessarily the same as factors that affect use intensity.

- Thus, it's recommended as: addressing of these core determinants with appropriate policy options could enable farmers to have the opportunity to adopt and intensify the use of organic fertilizer. Information diffusion seems to play a crucial role in adoption of the organic fertilizer

as well as its use intensity.

Therefore, for smallholder farmers to benefit from adoption of organic fertilizer, intervention packages aimed at providing better extension services, better access to information media and farmer's group formation are crucial.

- Apart from these, encouraging entrepreneurs to invest in organic fertilizer processing plants would also improve availability of organic fertilizer for smallholder farmers, especially those who do not own livestock.
- Farmers should be provided better technical advice on organic fertilizer preparation especially composting through regular extension visits.
- Furthermore, extension workers should focus on raising awareness about the importance of organic fertilizers to encourage or expand their use among smallholder farmers.

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ANNIXES:

Questionnaires:

WERABE UNIVERSITY
COLLEGE OF AGRICULTURE AND NATURAL RESOURCES
DEPARTMENT OF AGRO-ECONOMICS

Title of the Thesis research: *DETERMINANTS OF ADOPTION OF LIQUID ORGANIC FERTILIZER AND ITS IMPACT ON WHEAT PRODUCTIVITY: CASE IN SANKURA WEREDA, IN SILTE ZONE, CENTRAL ETHIOPIA REGION.*

Introduction

The agricultural sector in Ethiopia, dominated by smallholder farming, faces significant challenges related to soil fertility degradation and low productivity, which threaten national food security. The exploration of alternative, sustainable farming inputs such as liquid organic fertilizer (referred to as Eco-green) is a critical area of academic inquiry. The central objective of this thesis is to systematically investigate the factors that influence the ***adoption of*** this specific ***technology among smallholder wheat farmers*** and, subsequently, to quantify the impact of this adoption on their agricultural output. The success of such a quantitative study hinges on the quality and robustness of its data collection instrument. A poorly designed questionnaire can lead to unreliable data, weak analytical results, and unsubstantiated conclusions, undermining the integrity of the entire research endeavor.

Mapping of Independent and Dependent Variables

This section serves as the core reference for the questionnaire's design, explicitly linking the theoretical constructs to the specific questions used for measurement. The study of agricultural technology adoption is grounded in several well-established theoretical models, chief among them the Diffusion of Innovations Theory. This framework posits that the rate of adoption is influenced by the characteristics of the innovation itself (its perceived effectiveness, relative advantage, and complexity), the personal and socioeconomic characteristics of the individual adopter (e.g., age, education, income), and the institutional environment in which they operate (e.g., access to information, credit, and markets).

The questionnaire is designed to systematically measure each of these dimensions, linking the theoretical concepts to tangible, measurable data points. By operationalizing these variables, the research can rigorously test hypotheses regarding the causal relationships between them and the adoption behavior of farmers. {For any further clarity regarding this study/questions, you can contact me with my Address: 0913086811 or 0921001205 **Ms. Mersha Tilahun**}.

Questionnaires are as follows:

The purpose of this study is to better understand how farmers make decisions about using new fertilizers and how these decisions affect their harvests. Your participation is completely voluntary, and all your answers was kept confidential. There are no direct benefits or risks to you for participating.

- *So, please fill your own appropriate response which aligned with the given corresponding Questions! (below).*

Section A: Demographic part Questions

Q1. What is your **age** in years?

○ -----

Q2. Are you male or female?

○ -----

Q3. What is the highest level of education you have completed?

○ -----

Q4. How many people, including yourself, live in your household?

○ -----

Q5. How many members of your household are engaged in farming activities?

○ -----

Section B: Farm Characteristics and Resources

Q6. What is the total size of the land you cultivate for all crops during one farming year?

○ -----

Q7. Do you have access to irrigation for your farm?

○ -----

Q8. What is the main type of soil on your farm?

○ -----

Q9. In the last 12 months, what was your household's total income from all farming activities?

○ -----

Q10. In the last 12 months, what was your household's total income from non-farming activities (e.g., small business, daily labor)?

○ -----

Q11. How many head of livestock does your household own?

○ -----

Q12. Do you use manure from your livestock on your fields? If you do, how do you see Eco-green fitting in? Is it a replacement for manure, or something you would use with it?

○ -----

Section C: Socio-Institutional and Economic Factors

Q13. In the past 12 months, have you been able to get a loan or credit for your farming activities?

○ -----

Q14. Thinking about the cost of chemical fertilizers for your wheat farming, how would you describe it for you?

○ -----

Q15. Are you a member of a farmers' cooperative or any other farming group?

○ -----

Q16. If yes, for how many years have you been a member of a cooperative?

○ -----

Q17. How far is your farm from the nearest market where you buy farming inputs or sell your crops?

○ -----

Section D: Information and Extension Access

Q18. In the past year, have you received any formal training or attended workshops on farming techniques or new technologies?

○ -----

Q19. How many times did a government extension worker visit your farm in the last wheat growing season?

○ -----

Q20. Which of the following do you use to get information about farming? (Read options and mark all that apply).

○ -----

Q21. Do you have access to a radio or television at home to get information?

○ -----

Section E: Farmer Perceptions and Knowledge of LOF (Liquid Organic Fertilizer) **Q22.** Have you heard about a liquid fertilizer called Eco-green?

○ -----

○ **If Yes, from where?** -----

Technology-Related Factors (Likert scale type of Questions)

Q23. Soil Fertility Perception

- **Question:** Overall, how would you rate the fertility of your farm's soil today?
(Circle one number)
- 1. Very Poor
- 2. Poor
- 3. Average
- 4. Good
- 5. Very Good

Q24. Perceived Effectiveness

- **Question:** Compared to other fertilizers you know, how effective do you think Eco-green is at helping your crops grow? (Circle one number)
- 1. Very Ineffective
- 2. Ineffective
- 3. Neutral
- 4. Effective
- 5. Very Effective

Section F: Adoption and Application of Liquid Organic Fertilizer

Q25. Have you ever used Eco-green liquid organic fertilizer for your wheat crop?

- ----- (If No, proceed to Section G)

Q26. In the last wheat growing season, how many times did you apply Eco-green to your wheat crop?

○ -----

Q27. For your most recent application, how many liters of Eco-green did you use per hectare of land?

The Dependent Variables

Section G: Wheat Productivity and Production

To accurately calculate wheat productivity (yield per hectare), it is imperative to collect data on both the total harvest and the total land area dedicated to the crop.

- **Q28.** In the most recent wheat growing season, how much wheat did you harvest in total from your fields?
○ -----
- **Q29.** On how much land did you grow this wheat?
○ -----
- **Q30.** What was the total cost of all inputs (e.g., seeds, chemical fertilizer, other fertilizers) for this wheat season?
○ -----
- **Q31.** How many days of labor did your household spend on wheat farming in the last season? -----