ANALYSIS OF HIGHLAND WHEAT SEED SUPPLY SYSTEM: THE CASE OF GEDEO ZONE, SOUTHERN ETHIOPIA PEOPLES' REGIONAL STATE, ETHIOPIA

MSc THESIS

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Declaration

I hereby declare that this MSc thesis is my original work and has not been presented for a degree in any other university, and all sources of material used for this thesis have been duly acknowledged.

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ABBREVIATIONS AND ACRONYMS

ATT= Average Treatment impact on Treatment

BoARD= Beaureu of Agricultural and Rural Development

CADU=Chilalo Agricultural Development Unit

EIAR= Ethiopia Agricultural Research Institute

ESC= Ethiopian Seed Corporation

ESE=Ethiopia Seed Enterprises

FGD= Focused Group Discussion

FWSS= Formal Wheat Seed Supply Source

GDP=Gross Domestic Product

HH= HouseHolds

IBCR= Institute of Biodiversity Conservation and Research

IWSS= Informal Wheat Seed Source

MOARD= Ministry of Agriculture and Rural Development

NARS =National Agricultural Research Systems

NCIC= National Crop Improvement Committee

NSIA= National Seed Industry Agency

NSC= National Seed Council

NVRC= National Variety Release Committee

SNNPR=Southern Nations Nationalities and Peoples' Region

SSA=Sub Sahara Africa

SSE=South seed enterprise

PSM= Propensity Score Match

SARI= Southern Agricultural Research Institute

WADU=Wolaita Agricultural Development Unit

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Abstract

Wheat is one of the top priority crops of the Ethiopian government to ensure food security and income generation. Regarding production volume and area coverage, Ethiopia is the second-largest wheat producer country in Africa; However, average wheat productivity per area is low compared to international wheat productivity records. This may result from different factors, among which Seed insecurity is the most remarkable problem. This study was initiated to: identify available wheat seed sources and actors, determine factors affecting farmers' utilization of improved wheat seed, assess farmers' perceptions of formal seed supply sources, and measure the wheat productivity impact of using improved wheat seed. For the study, 203 sample households were selected from four kebele by employing a simple random sampling technique. A structured questionnaire was used to collect data from sample households, while a checklist was used to collect data from key informants and focus group discussions. Descriptive and inferential statistics were used to analyze and interpret the study findings. The findings of the study reveal that formal wheat seed supply sources are the Woreda agricultural office and Hawasa agricultural research centre, while informal seed sources included farmers' saved seed, farmers to farmers, and direct purchases on local markets. The bivariate probit model result indicates that education, social position, credit use, and extension contact significantly and positively affected smallholder wheat-producing households' utilization of improved seed from formal sources, while the quantity, quality, and access time of wheat seed significantly and negatively affected wheat-producing households' utilization of improved wheat seed from formal sources. Farmers negatively perceive the existing formal wheat seed supply system mainly due to late delivery, insufficient quantity, and poor information. The propensity score matching model result indicates that using improved wheat seed contributes to on average additional 11 quintals of wheat yield gain per hectare compared to local wheat seed users which on average yield less than 11 quintals/ha. The study hence recommends urging agricultural extension personnel at regional, zonal and woreda levels and seed enterprises to pay attention to overcoming the system's limitations, particularly concerning the quantity, quality, delivery time, and information provision that improve inclusive accessibility to improved wheat seed by smallholder farmers in the study area.

Keywords: *Actors, Bivariate probit, Farmers, Seed Sources, Smallholder, Perception, propensity score matching, Wheat*

CHAPTER ONE

INTRODUCTION

1.1. Background of the Study

Ethiopia's economy is fundamentally dependent on Agriculture, it offers about 80-85% of employment, more than 61% of total export, and 38.5% GDP of the country(Wosene & Gobie 2021). But, still, the sector is not adequately commercialized to bring about rapid change in production in line to respond to increasing population pressure (Alemu, 2011). The problem is not raised from Ethiopia being poorly endowed with agricultural resources but new technologies have not been appropriately used (Teressa, 2019). Hence to boost the production and productivity of agricultural, the use of modern agricultural technologies is essential, among them fertilizer and a high-yielding crop variety are the most important technologies (Abebe & Lijalem, 2011).

Using improved crop varieties seed is one of the important ways of reducing hunger and food ins ecurity by boosting agricultural productivity. For that, increasing access to improved seeds are cr itical factor for smallholder farmers to improve agricultural production, productivity and food insecurity. Hence to get the important contribution of improved seeds, a well-organized seed system set-up is a fundamental factor to sustainable access to the seed. (Teressa, 2019; Abebe & Lijalem, 2011; Leake & Adam, 2015).

The seed system represents the entire complex organizational, institutional, and individual proce dures related to the development, multiplication, processing, storage, distribution, and sale of see ds (Abebe & Lijalem, 2011; Zegeye et al., 2020; Tekeste and Admasu, 2022). These Seed systems can be either formal or informal. Formal systems produce and market seed by following established regulatory procedures but informal seed systems have no established regulatory procedures (Amare Tesfaw, 2015).

Ethiopia's seed system has a long history, which started around the 1930s (Bishaw et al. 2008). However, it was unable to reach a wide range of farmers by improved seed, (Tesfaye et al., 2018). Hence to reach out to all farming families, major seed actors were reconstituted and established into new legal entities through various proclamations and regulations (Kifle *et al.*,2022). These

seed actors in the Ethiopian seed sector have been governed by policies formulated in the 1990s and different public proclamations and regulations that were put in place (Abebe & Lijalem, 2011).

Although the Ethiopian government has made seed system policy amendments at different times to reach all farming families by expanding the institutional horizon and inviting private companies, still the sector is unable to reach the majority of farmers appropriately which has resulted resulting negative consequences on agricultural production and productivity. These issues are mainly raised by the policy gap which is indicated by different authors, in fact, (Kifle *et al.*, 2022) noted that the Ethiopian seed policy has not been revised for a long time to guide its development and has negative consequences for plant genetic resources conservation, plant breeding research & development, and seed production and distribution system. Teressa, (2019) noted that Ethiopia's seed policy, relevant laws and regulations have not been revisited and amended to keep up with new developments in the industry.

Besides, the problem of improved seed inaccessibility raised from the limitation of functional per formance and capacity of seed organizations to access improved seed to farmers has been challen ging the production and productivity of smallholder farmers, which was pointed out by researche rs as follows. Ethiopia's seed system has undergone tremendous changes but the sector is unable to guarantee farmers' access to seeds of improved varieties, in the right quantity, of the right quality, and on time due to the absence of linkage and integration among the stakeholders, limited engagement of the private sector (Amare,2015; Teressa, 2019). Ethiopia's seed distribution system was confronted with several problems such as a lack of enough amounts of quality seed, transportation problems, and the required amount of seed being not reached at the right time. hence these vicious problems forced farmers to use their own saved seed and purchase seed from the local market (Bishaw, 2004; Sperling, 2008; Wosene & Ejigu, 2021).

On the other hand, improved seed using a probability of farmers affected by demographic, socioeconomic, institutional and perceptional conditions of farmers. Abraha & Yohannes, (2013) reported that distances between farmers' fields and seed outlets, poorly maintained roads, high transportation costs, and inadequate storage arrangements affected seed production, quality, and affordability. Sperling et al., (2013); Jilito & Wedajo, (2020) noted that the unavailability of quality seeds at the right place and time is one of the important factors accounting for the limited

use of improved crop seeds by farmers. H. Tesfaye et al., (2018) reported that weak integration between research and extension is the major factor limiting the flow of information, knowledge, use of new technologies, and resources among actors in the technology delivery and utilization system. (Amare Tesfaw, 2015) reported that most farmers use conserved seeds from their previous production due to farmers having strong trust in the existing landraces that last relatively productive for many years. Yitayew et al., (2023) indicated that high prices, lack of availability on time, poor quality, and lack of credit access hinder farmers from using improved bread wheat seed from formal seed sources

Concerned about wheat production, Ethiopia is the second-largest producer of wheat in Africa next to South Africa in terms of total wheat area coverage and the amount produced (Yirga et al., 2015). There are 4.7 million wheat-producing farmers in Ethiopia, among them 99% of wheat producers found in Oromia, Amhara, SNNPR, and Tigray regions(Abate et al., 2018; Abeyo et al.2020; Yitayew et al., 2023). Currently, Ethiopia is given top priority for wheat production both as a source of food and as a source of income(Mengistu, 2021). However, wheat production and marketing of smallholder farmers are being found problems due to credit inaccessibility, low seed quality, late seed delivery and shortage of seed quantity (Anteneh & Asrat, 2020).

SNNPR is one of four potential wheat-producing regions in Ethiopia. However, farmers' wheat seed demand in the region has not been met, which has been affecting the wheat productivity of the region. Research findings of Kasa and Merkine, (2020) reveal that only 30 % of the land was covered by improved seed from out-of-land under major crops in SNNPR. Also under the southern nation nationality and people regional state, there are selected potential wheat producer zones, among them the Gedeo zone is one of the potential wheat-producing areas but as Part of SNNPR, the shortage of improved wheat seed supply hinders its production potential and productivity. However, there is no research-based evidence that indicates the intensity, sources of the problems, and means of intervention. Result of this, smallholder farmers in the area have been losing economic benefits that can be obtained from their wheat farms. Thus, the main aim of this study was to analyze of wheat seed supply system and its impact on wheat productivity of smallholder farmers, and thereby indicate evidence-based intervention means to the problems related to the wheat seed supply system under the Gedeo zone.

1.2. Statement of the Problem

Seed is among the fundamental agricultural input technologies to improve productivity sustainable agricultural growth and food security(Leake & Adam, 2015; Meselu, 2019). Other studies by other scholars for instance McGuire & Sperling, (2011) asserted that seed security and food security are interrelated concepts.

Seed security as defined by Sperling & Katungi,(2009) is the situation under which all farming families at all times get seed availability, seed accessibility, and utilization of seed at the right quality and planting season. Similarly, FAO, (1998) and Scowcroft and Polak Scowcroft, (1997) stated that families are said to be seed secure when the farming households (men and women) have access to seed of adequate quantity, acceptable quality- of adapted crop varieties -, during all times for planting.

Seed insecurity, however, remains a very impressive problem and has attracted the attention of several research studies in Ethiopia. Research finding of Westengen et al., (2023) reveals that seed insecurity is significantly affecting the agricultural production of smallholder farmers in central Ethiopia. The research result of Wosene & Gobie (2021) conducted in Womberma District, North West Ethiopia shows that the contribution of public seed companies for supplying improved bread wheat seed was only 33% whereas 67% from farms saved and the local market. In line with this, research findings by Yitayew et al (2023) reported that in northwestern Ethiopia 41.5% of farmers utilized farm-saved seeds from the previous cropping season, (11.4%) accessed from neighbouring farmers, (7.5%), relatives, and (39. 6%) formal seed suppliers. The same study stated that high prices, lack of availability on time, poor quality, and lack of credit access, are among the attributing to farmers feeling insecure about improved seeds from formal seed sources. On the other hand, research conducted by Teressa (2019) on a national seed system confirmed that regardless of Ethiopia's seed system has undergone tremendous changes, the sector is unable to guarantee farmers' access to seeds of improved varieties. Emphasizing the important role of quality seed provision, Amare Tesfaw, (2015) in his research study, concluded that despite accessing improved seed for all farmers has a critical role in improving farmers' income and alleviating poverty, many farmers still fail to access improved seeds at the right time with quality.

There are also, research findings in the SNNPRS reported that seed insecurity results in low agric ultural productivity for smallholder farmers. For instance, a research study by Tarekegn et al., (2022) in SNNPR shows that out of the total land under major crops, only 30 % of the land was covered by improved seeds in the 2019 production year and about 35% per hectare overall productivity difference was estimated among improved seed users and non-users. In line with this, the study report by Kusse & Kassu, (2019) conducted in the southern Omo zone of SNNPR asserted that the seed supply system is unable to fulfil the farmer's need for access to improved seed varieties of needed quantity, at expected quality and on time. The assessment survey on improved agricultural inputs usage by SARI, (2020) indicates that the majority of the farmers in the Gedeo zone use informal seed sources, this has been hindering the highland cereal production potential of the area by resulting in low productivity.

Although there are research findings in southern Ethiopia**,** there is no empirical study conducted on the Gedeo-zone context with particular attention to the wheat seed supply system to address farmers' problems. It resulted, in smallholder farmers in the study area have been losing the economic benefits of the wheat farm. But the real causes of the problem have not been discovered yet. Therefore, this study was initiated to analyze the wheat seed supply system and its impact on the wheat productivity of smallholder farmers, in the case of the Gedeo zone. Through systemati c and empirical investigation, the study has generated a new body of knowledge that pertains to the planning and execution of development interventions to promote farmers' demand-oriented and efficient seed systems in the study area and beyond.

1.3. Objectives of the Study

General Objective

The overall objective of this study was to analyze the seed supply system and its impact on the wheat productivity of smallholder farmers, the case of the Gedeo zone,

Specific Objectives of the Study

1. To identify the wheat seed sources and key actors in the seed supply sources

2. To assess smallholder farmers' evaluative perception towards formal wheat seed supply sources

3. To determine factors affecting smallholder farmers' use of formal wheat seed supply sources

4. To measure the impacts of improved wheat seed on the wheat productivity of smallholder farmers

1.4. Research Questions

1a. What are the existing wheat seed supply sources in the study area?

1b. Who are the key actors and their role in the wheat seed supply source?

2. How do smallholder wheat farmers perceive the formal wheat seed supply source?

3. What are the factors affecting smallholder farmers' use of formal wheat seed supply sources?

4. How many quintals of wheat productivity difference results between improved and local wheat seed user farmers?

1.5. Significance of the Study

The result of this study helps to indicate the actors involved in the wheat seed supply system, their role, and influential factors that constrain the smooth functioning of the supply system in the study area. Besides the study results help to show factors that hinder wheat producer farmers' use of improved seed from formal wheat seed supply sources and it also helps to point to measured impacts of using formal wheat seed sources on wheat productivity. Finally based on findings could indicate some corrective measures to benefit end-users.

Thus it could be used as input for policymakers and development planners who are concerned about the wheat seed supply system. The study also will help someone interested in conducting the study on the thematic area as information sources.

1.6. Scope of the study

This study was conducted in the Gedeo zone by focusing on determining wheat seed supply sources, actors, and their roles, identifying factors affecting participation decisions in improved wheat seed sources; assessing farmers' evaluative perception on formal wheat seed supply system and indicating measured impacts of using formal wheat seed sources on productivity. Methodologically the study integrated both descriptive and inferential statistics analytical frameworks. The time scope of this study was one year starting from August 2022 up to October 2023.

1.7. Limitation of the Study

On the other hand, due to time and financial resources limitations; the study only focused on the wheat seed supply system among other cereal crops produced in the study area. The study also does not include a lowland(irrigated) wheat seed supply system. Data for this study was collected from Gubeta and Galcha kebeles from the Gedeb district and Dibadinbe and Gubeta Kabeta kebeles from the choriso district were selected as sample districts among available six districts in the zone.

1.7. Organization of the Thesis

Regarding thesis structural organization, the writing consists of five major chapters/topics. Under the umbrella of each chapter, there are many sub-listed subtopics. The main chapters and each sub-topic raised under chapters were discussed as follows. Chapter One deals with the introduction of the study, under this chapter statement of the problem, the objective of the study, research questions, significance, limitations, and scope of the study were discussed. Chapter Two presents the literature review. In this chapter, conceptual review, theoretical review, empirical review, and conceptual framework were discussed as sub-topics. Chapter three presents the research methodology. Under these main topics, some subtopics were raised, those are the description of the study area, research and sample design, methods of data collection and methods of data analysis, and definition and hypotheses of variables. Chapter four presents the result and discussion. This part of the study presented results and made discussion regarding subtopics of socio-demographic backgrounds of sample household heads, wheat seed supply sources and supply chain, determining factors of wheat seed supply sources by smallholder farmers, perceptions on formal wheat seed supply sources and impacts of improved seed on wheat produc tivity. Chapter Five presents a summary, conclusion, and recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.1. Conceptual and Theoretical Review

2.1.1. The concept of seed, and seed system

Scholars describe seeds in a variety of ways, but they all share the idea that a seed is a living organism that serves as the foundation for the next generation, indeed, Seeds are parts of agricultural, silvicultural, and horticultural plants used for sowing or planting purposes(Maredia et al., 1999). Seeds are the living organisms that carry the genetic properties of crop plants, it is also the single most important input in all plant-based agricultural systems, which determine the upper limit on yield potential, by resistance to environmental conditions and therefore determine the productivity of other inputs(Boesewinkel & Bouman, 1984; Jaffee & Srivastava, 1992; Mugonozza, 2001).

Seeds have different classes, such as breeder seed, basic seed, and certified seed. Breeder seed is a type of seed in a seed certification program that is produced under the direction of the plant breeder or organization that developed the variety. Basic seed is a class of seeds called "foundation seed" that is used to produce certified seed. Improved seed is a class of new or improved type of varieties that are the result of research on crop improvement. Certified seed is a class of seed that has been certified to meet the standards for genetic purity established and enforced by a seed certifying authority and provided to farmers for general production. Local seed is a type of variety inherited by seed users with no known pedigree or linkages with formal breeding research and development efforts. A seed enterprise is any organization involved in seed growing, processing, storing, and marketing either directly or through contracts with others as a for-profit business activity(Maredia et al., 1999; Alemu,2010; Mergia, 2010; Atilaw et al., 2016:Mamo et al., 2023).

The term "seed system" refers to the entire complex of institutions, organizations, and people connected to a country’s seed program, it includes both informal systems of farmer-selected, multiplied, processed, exchanged, and retained seeds as well as the non-traditional or formal system of institutions, individuals, and organizations engaged in specialized tasks connected to producing and marketing seed for sale to seed users and farmers' families for planting(Maredia et

al., 1999). The seed system is the system that makes seeds available to farmers (Westengen et al., 2023). Seed systems are made up of several dynamic interactions between seed supply and demand, which lead to the use of seeds and, consequently, plant genetic resources at the farm level (Fikre Mulugeta, 2010). The associated operations with the seed system are the de velopment, multiplication, processing, storage, distribution, and marketing of seeds in the country. (Abebe & Lijalem, 2011; Tomek & Robinson, 2003).

2.1.2. Forms of the Seed Supply System

The seed supply system is a complex institutional chain arrangement in which seed supply passes through varietal development up to seed users. Different authors classify this seed system in either two categories (formal and informal) or three (formal, informal, and intermediary). Indeed, seed systems are classified as formal and informal (Maredia *et al*., 1999; Etwire et al., 2013; Croft et al., 2018; and Torres et al., 2021). Also, other authors classified seed systems as formal, informal, and integrated (Louwaars & De Boef, 2012; Sperling et al., 2013; Munyi & De Jonge, 2015; and Kromann et al., 2016).

2.1.2.1. Formal seed supply system

The formal seed system as a sector includes all seed program elements, including plant breeding, seed production, processing, marketing, extension, quality control, and certification, which interact with one another and are typically governed by legislation. It was established and structured with the primary objective of disseminating high-quality seeds of improved varieties produced by official breeding programs. In this system rules and regulations guide a variety of release procedures, intellectual property rights, certification programs, seed standards, and contract laws that influence the structure, coordination, and performance of the seed system(Fikre, 2010; Abebe & Lijalem, 2011; Tomek & Robinson, 2003).

This seed system is a government-supported system with several public institutions involved, such as National Agricultural Research Systems (NARS), the Ministry of Agriculture (MoA), Ethiopian Seed Enterprise (ESE), and private seed companies specializing in specific crops. NARS is responsible for the development and supply of initial seeds, ESE and RSEs are responsible for the mass production of improved seeds, MoA is involved in variety release, multiplication, certification, and distribution, and private seed growers and farmer institutions are also involved.

Legal institutions such as a variety of release procedures, intellectual property rights, certification programs, seed standards, contract laws, and law enforcement are also important components of the system. (Maredia, et al, 1999).

The formal seed system is built on scientific procedures for plant breeding. Significant investments have been made along the way, and experts from the public and private sectors are in charge of managing and running the multiplication process(N. Louwaars, 2007; Louwaars & De Boef, 2012). Public agricultural research agencies and public institutions of higher learning have dominated this system's variety of development and early-generation seed production(Bogale et al., 2018).

2.1.2.2. Informal seed supply system

Cromwell et al.,(1992) explained that the informal seed system is often referred to as the local system. It is so named because it involves farmer-to-farmer seed exchanges and is not governed by the law. The majority (60–70%) of the seed used by smallholder farmers in Ethiopia is stored on-farm and traded amongst farmers, with the balance (20–30%) being borrowed or purchased locally. According to Belay (2004), 90% of the seed used by smallholder farmers comes from the informal seed system. Due to the following main factors, the majority of Ethiopian farmers have a propensity to depend on the informal sector, this is due to the less expensive and easily accessible in farmers' communities at the exact moment a seed is needed.

2.1.3. The concept of seed security

Scholars define seed security in different ways, but they commonly share words that focus on having enough seed quantity, adequate seed quality, and getting seed in all planting seasons. Indeed, defined seed security as seed security is a situation when farming families have access to seeds of adequate quantity and acceptable quality, and in time for planting at all times, it may not only be grain that is sown but may also include the form of cuttings, tubers, and other agricultural planting materials (Sperling & Katungi, 2009; Sperling 2008; McGuire & Sperling, 2011)

2.1.4 The Concepts of Perception and its Measurements

Different scholars have defined the concepts of perception in different ways, some of these conceptual definitions of perception are as follows. According to the definition by Qiong, (2017), perception is the process of attaining awareness or understanding of the sensory organization. As expressed by Arifin et al., (2017) perception is about objects, events, or relationships obtained by

inferring information experience interpreting messages. According to expression of Saks, (2011), perception is the process of interpreting the messages of our senses to provide order and meaning to the environment.

Based on the direction of information flow, theories and explanations of perception are divided into two basic groups, namely bottom-up and top-down theories. Bottom-up theories advocate the use of only bottom-up processes to acquire and process sensory data. Its processes are those that begin at the most distant levels of cognitive apparatus and gradually progress to more complicated processes. Whereas the top-down theories suggest that in the process of discriminating, when processing sensory stimuli, it begins by "feeling" sensory data on receptors, their processing assumes a downward impact of higher cognitive contents. It prefers direct perception without the participation of knowledge and previous experience and follows indirect perception (Démuth, 2013). This study preferred Gibson's theory of direct perception under bottom-up perception theories, which focused on direct participation based on previous experiences and knowledge, it focused on attributes of the determinative role of the environment and its influence on the whole process of perception. The study to get evaluative farmers' perception of the whole formal seed supply system, focused on evaluating each formal seed supply system attributes through the direct participation of farmers based on their previous knowledge or experiences.

The way to measure perception is self report measures like magnitude estimation, magnitude pro duction, method of adjustment, forced choice, and Likert scale reporting(Kamaruzaman,2021). Likert scales are rating scales which contain a series of "anchors" that allow numerical measurements of an item or questions (Vagias, 2006). The Likert scale is a rating scale used to measure, attitudes or behaviours, this measurement scale is great for capturing the level of agreement (Pritha and Kassiani 2020). This study used a five-point Likert scale of agreement, by considering to give a wide chance to farmers' agreement level expression and manageability of scale.

Also, Scholars classified perception into three forms namely positive, negative and neutral perception. They explained it as follows: According to the expression of Ahmadi, (2020), positive perception means a form of response, action, or attitude that shows, accepts, recognizes, approves, and implements the norms that apply where the individual is located. Asandimitra et al., (2021) expressed negative perception as negative perception is a perception that describes all knowledge

(know it or not) and responses that are not aligned with the object being perceived. Gasper et al., (2019) express neutral perception as neutrality arises when positive and negative impacts are both minimal. This situation reflects a state of indifference, where one feels neither strongly positive nor negative.

Generally, the aforementioned concepts and theories guided the overall track of the study by indicating the functional meaning of the concepts (seed, seed classes, seed system, perception) and actors involved in which the study is focused, hence it helped to plan the data collection tools and points the issue need to be focused on. Also, the theory of perception leads to how to measure concepts of perception on which measurement scale and theories of forms seed system indicated the operational classification seed supply system to select sample groups (formal and informal seed supply sources users) and the way to measure the concepts (analysis model selection) in the context of the study.

2.2 Empirical Reviews

2.2.1. Actors and their roles in Ethiopian wheat seed supply system

Research conducted on Seed Value Chain Analysis as a means for a Sustainable Seed System in the Oromia region by Fikre Mulugeta,(2010) indicated that the Oromia Bureau of Agriculture and Rural Development, Ethiopian Seed Enterprise (ESE) Asella branch and FAO-CDMDP are directly involved in farmer-based seed production in the study area which was Arisi zone.

Research Findings of Yitayew et al., (2023) in Amahara region, Ethiopia shows that farmers acquired certified wheat seed from only one formal seed supplier (Amhara Seed Enterprise/ASE), which covered nearly 40% of the respondents, while the rest of the respondents 41.5%, 11.3%, and 7.5% got it from their own saved seed (own stock), neighbours, and relatives, respectively.

The research entitled Wheat Production in the Highlands of Eastern Ethiopia by Nigus *et a*l., (2022) indicated that the Bureau of Agriculture (BoA) is the primary source of wheat seed for the majority of respondents (45%) whereas the remaining portion of seed demand covered from farm-retained seeds (23.0%), followed by a farmer-to-farmer seed exchange (17.0%), local markets (6.3%), Haramaya University (4.6%), and donations from various non-governmental organizations (4.2%).

The research finding of Tassew Arficho, (2017) shows that Hadiya Zone Agriculture and Natural Resource Office, Lemo woreda Agriculture and Natural Resource Office, Licha Cooperative Union, South Seed Enterprise, Wheat seed multiplier farmers, and Farmers at the kebele level are identified as the main actors currently involved in different intervention areas of the Woreda concerning improved wheat seed marketing.

The research conducted by Tarekegn & Mogiso,(2020) on the Assessment of improved crop seed utilization status in selected districts of Southwestern Ethiopia indicates that farmers get seed from both the informal and formal seed systems, among them, the main formal sources are the governmental agricultural office, Southern Seed Enterprise (SSE), Southern agricultural research centres, and farmer cooperatives, while the access coverage expressed as Government agricultural offices (37.5 %), farmers own stock (28.5 %), market (19.5 %), and farmer-to-farmer seed exchange (14.5 %).

When generalizing about key actors participating in the Ethiopian seed system are higher learning institutions(universities), Ethiopia agricultural research institutes, regional agricultural institutes, federal and regional seed enterprises, cooperatives and agricultural offices at region, zone and woreda levels common ones from formal seed supply systems. Whereas actors from informal seed systems are; seed traders and farmers.

2.2.2. Smallholder farmers' evaluative perception towards formal wheat seed supply

The study conducted under the title of Dynamics of Formal Seed Utilization and Use Intensity: Evidence from Wheat Growers in East Gojjam Province, Northwestern Ethiopia by Amare Tesfaw, (2015) reveals that although formal seeds have an important advantage, most farmers save seeds from previous seasons because they have a strong trust in existing landraces that are relatively productive for many years and are unwilling to take risks associated with the use of newly introduced varieties.

Research Findings of Yitayew et al., (2023) entitled Source of bread wheat seed in north-west Ethiopia, reveal that farmers have their reasons for deciding whether or not to accept seed supplies through the formal channel, 72% of the respondents said that they are always willing to accept seed from formal sources, whereas about 28% do not always show positive interest, those farmers

who said" not always willing" to accept the seed from formal sources mentioned their reason of poor quality, a high price, and late delivery.

Research conducted on Farmers' perceptions of improved bread wheat varieties and formal seed supply in Ethiopia by Bishaw & Alemu, (2017) showed that discrepancy between the value of attainment indices of varieties and the amount of seed supplied by the formal sector, resulting in a mismatch between demand and supply, resulting in significant carryover seed, hence to respond to developing problems and did not meet farmers' preferences, the formal sector should consider broadening its bread wheat varietal portfolio and increasing seed supply capacity.

Research conducted on the Wheat Seed System in Ethiopia: Farmers' Varietal Perception, Seed Sources, and Seed Management by Bishaw et al.,(2010) shows that most farmers less frequently buy certified seed from the formal sector due to limited seed availability which resulted from less developed seed programs.

The findings of research entitled Customer Evaluation of Supply Systems: The Case of Ethiopian Seed Supply Systems by Bogale et al., (2018) reveal that although formal seed supply systems exist to serve the needs of local farmers as their end customers, farmers are dissatisfied with the system on some of their evaluative criteria, which are the right variety, at the right quality level, available at the right time and accessible location, sufficient quantities, and affordable prices. furtherly Seed systems offer advantages and disadvantages, as indicated by the combination of admires and dislikes that farmers connect with various seed delivery systems. As a result, there is potential for a range of seed supply systems that fulfil the diverse needs of farmer clients. For example, the generally dominant informal structure guarantees that the seed given is readily available in the farmers' villages when it is required.

Mulesa et al., (2021) indicated that Seed insecurity difficulties are common to both subsistence and economically oriented systems, However, the nature and intensity of challenges vary, particularly when it comes to the formal seed system. For instance, whereas farmers have low availability and access to seed through the official system, this occurs in particular in subsistence-oriented districts where improvement of crop research and formal seed supply channels are almost non-existent.

When summarizing previous findings about farmers' perception of the formal seed system: even if the formal seed system is expected to have relative advantages over the informal seed system, most smallholder farmers are not satisfied with it. This is due to its service-related problems like poor quality, a high price, and late delivery shortage of quantity. Additionally, negative farmers' attitudes towards formal seed supply systems hinder their use. Indeed, they have more trust in stayed landrace s in their community rather than newly introduced and they are unwilling to take risks associated with the use of newly introduced varieties. The overall effect of these reasons contributed to farmers negatively perceiving formal seed systems.

2.2.3. Factors affecting smallholder use of formal wheat seed sources

The research findings of Amare Tesfaw, (2015)on dynamics of Formal Seed Utilization and Use Intensity: Evidence from Wheat Growers in East Gojjam Province, Northwestern Ethiopia shows that Farmers' tendency to utilize formal seeds and the volume of formal seeds utilized was significantly influenced by many factors including size of land allocated for improved wheat, the number oxen, family size, the frequency of extension service delivery, high seed prices and late delivery of the seed.

Research conducted in Womberma District, North West Ethiopia by Wosene & Gobie, (2021) shows that wheat producers and farmers faced challenges in getting seed from formal seed distribution system due to the high price of improved seed, late delivery of improved seed, and shortage of seed quantity. The result of this contribution of public companies for supplying improved bread wheat seed was only 33% whereas 67% of producers' sources of bread wheat seed from farms saved and local markets which were uncertified leading to production deterioration.

Research conducted in northwestern Ethiopia by Yitayew et al., (2023) revealed that the majority of farmers access their bread wheat seed from informal sources: 41.5% of farmers utilized farm-saved seeds from the previous cropping season, (11.4%) accessed from neighbouring farmers, (7.5%), relatives and only (39. 6%)formal seed suppliers. This is due to high prices, lack of availability on time, poor quality, and lack of credit access. These factors, make farmers feel insecure about improved seeds from formal seed sources

Research conducted in southern Omo zone Ethiopia by Kusse & Kassu, (2019) shows that access to, supply and utilization of improved seeds are critical factors for the ability of smallholder

farmers to increase agricultural production and productivity, ensuring food security and improve livelihoods, but, the sector is unable to fulfil the farmer's needs of access to improved seed varieties of needed quantity, at expected quality and on time, mainly because of the highly centralized seed distribution system and the virtual absence of seed marketing conducted by the seed producing enterprises and companies.

Research conducted on wheat production in the highland of eastern Ethiopia by Nigus et al., (2022) reveals that, although Ethiopia is one of the potential wheat producers in Sub-Saharan Africa (SSA) owing to the suitable agro-ecological conditions, its actual yield under farmer condition is very low due to different production constraints. Indeed, lack of improved seed accessibility, small land size and wheat disease were major ones.

Research conducted on Wheat Production and Breeding in Ethiopia by Tadesse et al., (2022) indicates that wheat production in Ethiopia is dominated by subsistence farmers and its productivity is still under its actual evaluated potential by stakeholders concerned on the line due to the limited availability, accessibility and affordability of inputs such as fertilizers, improved seeds, irrigation water, pesticides and farm machinery.

Research finding of Westengen et al., (2023) reveals that seed insecurity is significantly affecting the agricultural production of smallholder farmers in central Ethiopia which is expressed as a form of mismatched seed demand and access. Indeed, discrepancies between what the seed farmers prefer and those they use, limited availability of improved varieties especially certified seeds, challenges with seed quality from some sources and lack of information.

Research conducted in Ethiopia by Teressa (2019) shows that the Ethiopia seed system has undergone tremendous changes but, still, the sector is unable to guarantee farmers' access to seeds of improved varieties, in the right quantity, of the right quality, and on time, in fact, based on last five years' evidence among total annual arable land coverage by major food crops, 96.5% is covered by local seed and 3.5% is by improved seeds.

The research results of Khed, et al. (2021) on Seed Delivery Pathways and Farmers' Access to Improved Wheat Varieties in Ethiopia and India, show that farmer has more area under wheat, and they tend to use OFS than seeds from other farmers in the village, the large farm size is a negative

determinant of sourcing seeds from farmer cooperatives, road access is found positively associated with a probability of cooperatives acting as a seed source, total wheat area and livestock ownership reduces the probability of accessing seeds from the local market and older farmers tend to purchase seeds more often from seed companies than youngsters.

The review results of Hussen & Geleta, (2021) indicate that the major challenges of the seed system in Ethiopia are inadequate seed marketing information, infrastructure, diseases, and pests introduction, lack of a clear seed strategy, inefficient extension service, limited collaboration within the seed sector, private companies tend to concentrate on profitable crops for their pocket, lack of awareness and knowledge gap about seed production, inadequate basic seed supply, budget limitation and lack of impactive large scale seed enterprises.

The study result of Leake & Adam, (2015) on factors determining the allocation of land for improved wheat variety by smallholder farmers of northern Ethiopia indicated that access to the credit facility, family size in adult-equivalent, TLU, extension contact, and education level of household head affect the adoption of improved wheat variety positively and significantly. Whereas variables like distance from the nearest market and main road and the perception of households about the cost of the technology affect the adoption of improved wheat variety negatively and significantly.

As indicated in the aforementioned findings, credit accessibility, TLU, extension contact, and education level are facilitating factors of farmers' use/ adoption of improved seed. Inadequate seed marketing information, inefficient extension service, distance from the nearest market and main road, the perception of households, limited seed availability and accessibility, high seed prices, and late delivery time are the most common negatively affecting factors. On the other hand, family size and land size as situationally either positively or negatively affecting factors.

2.2.4. Impacts of improved Seed sources on smallholder farmers' wheat productivity

Tesfaye et al., (2016) indicated that the output of the propensity score matching analytical method showed improved wheat variety adoption and boosted wheat yields among adopters by approximately 1 to 1.1 t ha-1 compared to non-adopters. Research conducted by H. Tesfaye et al., (2018) on the Impact of Improved Wheat Variety on Productivity in the Oromia Regional State,

Ethiopia reveals that improved wheat variety adoption appears to increase production by 34-38% on average for farm households in the study area.

Research conducted on the assessment of improved crop seed utilization status in southwestern Ethiopia by Tarekegn & Mogiso (2020) indicated that compared to local seed user farmers, impr oved seed users had an estimated 35% higher overall productivity per hectare. However major obstacles preventing the use of improved seed in the study area were its high seed cost, the worry over the costs of DAP and urea, which are provided alongside the improved seed, a lack of financial resources, a lack of improved seed in the required amount of time, poor seed quality, and a lack of seeds available on credit. Research conducted by Tassew Arficho, (2017) on Analysis of Improved Wheat Seed Marketing: The Case of Lemo District, Hadiyya Zone, Southern Ethiopia reported that improved wheat technology adopters gain 10-11 quintals of additional wheat productivity per hectare compared to the non-adopters.

Research conducted by Hagos & Hadush, (2017) referring smallholder farmers benefit from the adoption of improved wheat seed revealed that Southern Tigray Ethiopia indicated that the smallholder farmers that had adopted improved wheat seed technology on their marginal farmland gained an average of 14 quintals of additional wheat yield per hectare, compared to non-adopters. Research conducted by Melkamu et al., (2022) on training at farmers' training centres and its impact on crop productivity and households' income in Ethiopia: indicated that the impact of adopting rust-resistant improved wheat varieties increases on average 16.62 quintals of additional wheat productivity per hectare, compared to non-adopters.

The impact of improved seed on productivity may depend on different factors available in its actual condition. However different scholars try to measure it by using analytical tools that control the conditional difference and creating common comparable grounds. In that manner, when summarizing the aforementioned findings regarding the impacts of improved seed on wheat productivity based on PSM, there is on average 10-16.5 quintals of wheat productivity difference resulting among improved seed users and their counterparts.

3. Methodological review

The study employed a bivariate probit and propensity score matching model to explore the factors affecting the use of formal seed supply sources and the impacts of improved wheat seed on wheat productivity, respectively. However, to ensure that the selected methods of analysis were relevant to measuring intended concepts the study looked into related literature that employed these econometrical models as analytical tools. The following are some of the related research that employed the chosen econometric models.

3.1. Bivariate Probit Analysis of Factors Affecting Use of Improved Seed Sources

Even if some previous researchers in fact (Yirga et al., 2015; Kromann et al., 2016; Laduber et al 2016; Kangile et al., 2018)had used multinomial logit or probit analytical methods by targeting to identify constraining factors in each seed supply source regardless of sector, each source is generally categorized under two sectors (formal and informal) and more or less problem under the same sectors are nearly the same. Hence making separate analyses under the same source is not that important. For that, this research used a bivariate probit analytical method because the research focuses on sectorial (formal and informal seed supply source) analysis of seed supply sources. Also, some researchers consistently used sectoral analysis methods of seed supply sources, some of them as follows.

The research conducted by Wosene & Gobie(2021)on Determinants of Seed Distribution System: The Case of Womberma District, North West Ethiopia, had undergone sectorial analysis of the seed distribution system by using bivariate logit. The research conducted by Amare Tesaw (2022) on the dynamics of formal seed utilization and Use Intensity: evidence from wheat growers in East Gojjam Province, Northwestern Ethiopia, underwent sectorial analysis of the seed supply system.

Research conducted by Alkan, (2021)on the Analysis of factors affecting alcohol and tobacco concurrent use by bivariate probit model in Turkey, was used bivariate probit to analyse factors affecting alcohol and tobacco use. Research conducted by Sanou et al., (2017)on determinants of adoption and continuous use of improved maize Seeds in Burkina Faso, was used bivariate probit to identify determinants of adoption and continuous use of improved maize seed. Besides, research conducted by Nkamleu & Adesina, (2008)on determinants of chemical input use in peri-urban

lowland systems: bivariate probit analysis in Cameroon, was used bivariate probit to investigate factors affecting chemical input use in peri-urban lowland systems.

3.2. Propensity Score Matching Analysis of Impact

Although there are different impact analysis models, their use is based on the authors' reasons intended to measure their planned study objectives. Among them, PSM is one of the popular impact analysis models that different scholars used in their research analysis.

Research conducted by Hagos & Hadush, (2017) on does improved wheat seed adoption benefits farmers. empirical evidence from Southern Tigray Ethiopia, employed a PSM analytical tool to measure the impact of adopting improved wheat seed technology on wheat productivity among smallholder farmers. Research conducted by Melkamu et al., (2022) on training at farmers' training centres and its impact on crop productivity and households' income in Ethiopia: A propensity score matching (PSM) analysis indicated that the impact of adopting rust-resistant improved wheat varieties increases on average 16.62 quintals of additional wheat productivity per hectare, compared to non-adopters.

The research under the title Impact analysis of Mede Telila small scale irrigation scheme on house poverty alleviation: the case of Gorogutu district in eastern Haratghe Oromia national regional state Ethiopia by Haji et al., (2013) used propensity score matching(PSM) as an analytical model to assess the impact of the small-scale irrigation system on poverty alleviation among two groups of households were compared. Indeed, Participant households (the treatment group) and nonparticipant households (the control group).

The research entitled Impact of the Alternate Wetting and Drying water-saving Irrigation Technique by Rejesus et al., (2011) used the propensity score matching method as an analytical tool to evaluate the impacts of a controlled irrigation technique on rice production among farmers. Research under the title Training at Farmers Training Centres and its Impact on Crop Productivity and Households' Income in Ethiopia by Wonde et al., (2022) used propensity score matching (PSM) analysis to assess the impact of training on crop productivity and households' income among farmers.

Research under the title Impact of Agricultural Extension Program on Smallholders' Farm Productivity: Evidence from Three Peasant Associations in the Highlands of Ethiopia by Elias et al., (2013) employed the Propensity score matching model to evaluate the impact of agricultural extension program participation on farm productivity. The research entitled Agricultural Credit and Productivity of Crops in India: Field Evidence from Small and Marginal Farmers Across Social Groups by Yadav & Rao, (2022) used the propensity score matching model to measure the impact of institutional agricultural credit on crop productivity.

3. 3. Conceptual Frameworks of the Study

This study used utility maximization theory, to explain farmers' choice among available wheat seed supply sources through existing constraints (demographic, institutional, economic constraints and input supply factors) to achieve their maximum utility(payoff)/wheat productivity). Utility maximization theory refers to individuals and organizations seeking to attain the highest level of satisfaction from their economic decisions (Guzman, 2008). The theory postulates that an individual performs a cost-benefit analysis to determine whether an option is right for them.

Therefore, this study analyzes the factors affecting the choice of seed supply sources by wheat producers and their impact on the final utility (wheat productivity) of producers. For the identification of affecting factors to seed source choice by smallholder farmers and its impact on wheat productivity, empirical evidence was identified from literature reviews. Finally, the evidence obtained from literature reviews was operationalized through individual interviews. Accordingly, the relation among variables is presented in Figure_ 1. Indeed farmers' attitude towards available seed source preference is affected either positively or negatively by their surrounding factors like demographic, socio-economic institutional and input supply factors. Their resulting perception under the suppression of surrounding factors contributes to the preferred seed source among available seed source choices. Ultimately their preferred seed source decides the amount of their wheat yield getting from the farm.

To express the relation among the variables this conceptual framework is developed based on reviewing different literature.

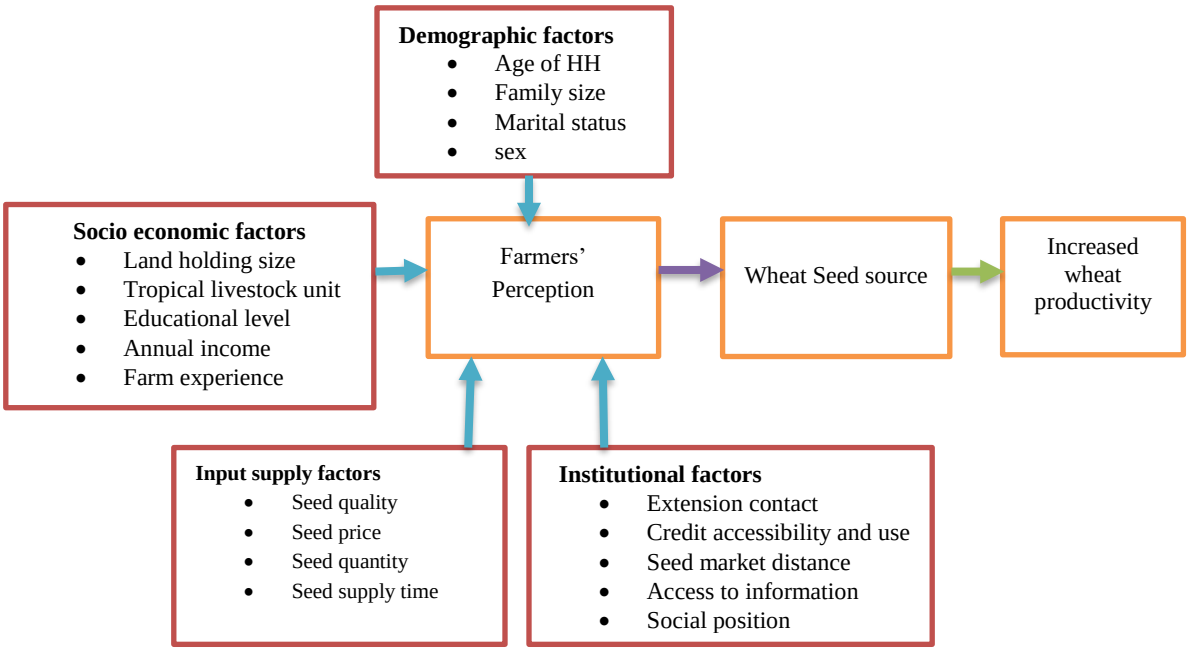

***Figure_ 1 Conceptual framework*, Source: self-formulated,2023**

CHAPTER THREE

RESEARCH METHODOLOGY

3.1. Description of Study Area

3.1.1. Location of the study area

The study was conducted under the southern Ethiopia regional state, in the Gedeo zone. The zone is found 369 kilometres from Addis Ababa on the southern Addis Ababa-Moyale international route and 90 kilometres from Hawasa. Regarding relative location, the zone is situated between 5^{o} 53' and 6^{o} 27' N and between 38^{o} 8' and 38^{o} 30' E, North of the Equator. The altitude ranges from 1500 to 3000 a.sl. The total land area of the zone is 1347.04 square kilometers based on the current border delineation Geographically (Gebretsadik & Negash, 2016; Mebrate et al., 2022).

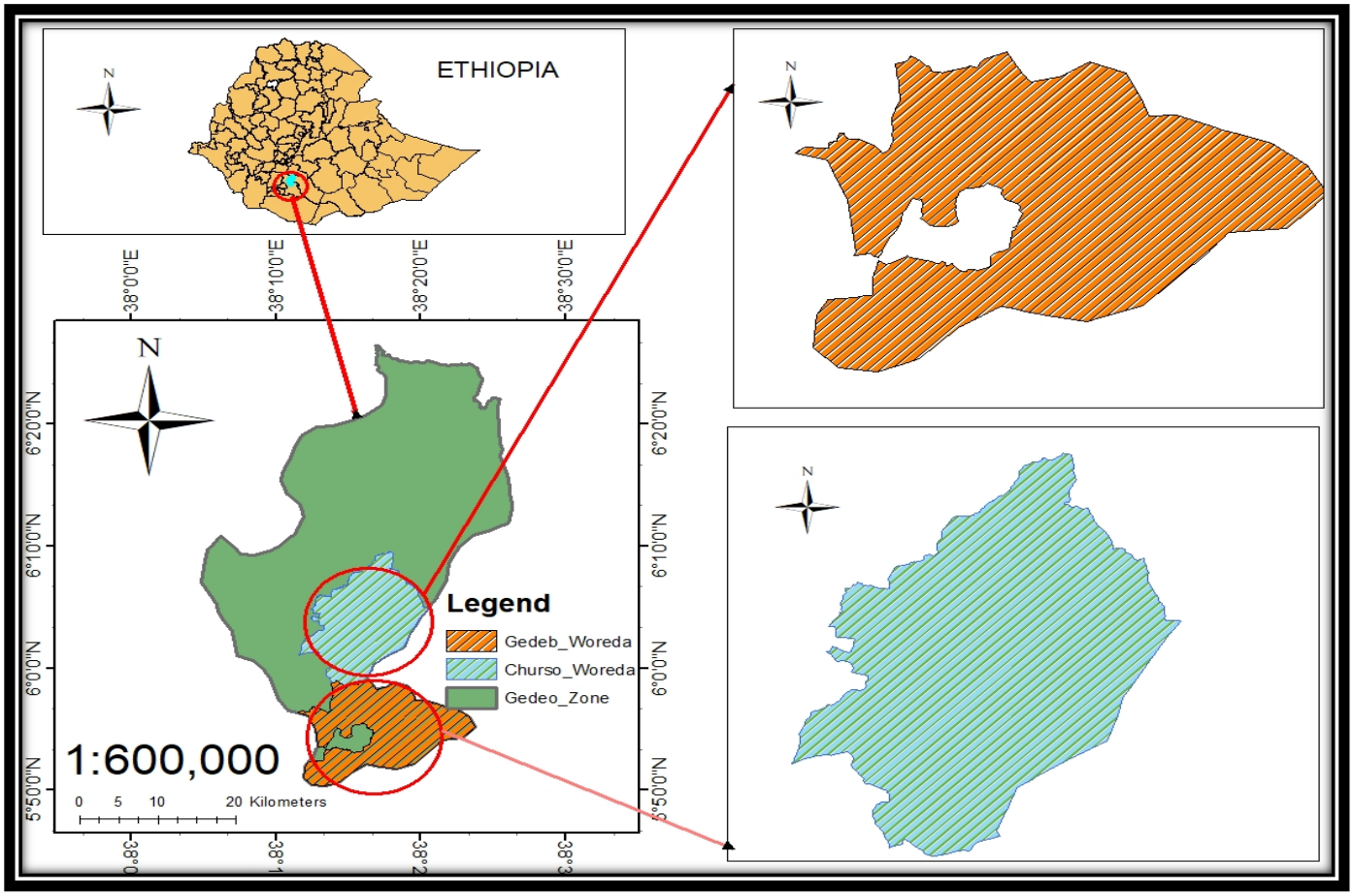

Figure_ 2 Map of the study area, Source: derived from Ethioadimin map, 2022

3.1.2. Description of the biophysical conditions of the study area

The Gedeo zone experiences a sub-humid tropical climate with an average annual rainfall of 1500 mm and a range between 1200 to 1800 mm. The area is located in the inter-tropical convergence zone, receiving rain from two sources: The Atlantic and monsoon currents. As a result, the zone experiences a bimodal pattern, i.e., a short rainy season starting in March and ending in May, and a long rainy season starting in July and ending in October. The zone consists of three different agro-ecological zones: Dega (2400–3086 m asl), Woyna Dega (1800–2400 m asl), and Kola (1245–1800 m asl). Its area coverage proportion is "Dega" (30%), "Woyina-Dega "(67%) and "Kola "(3%). The mean monthly temperature of the zone is 21.50 °C(Gebretsadik & Negash, 2016; Mebrate, Kippie, et al., 2022).

The land use of Gedeo consists of 80 % cultivated, 19 % pasture, and 1 % forest. The agroforestry area makes up roughly 89,239.7 ha, or 69.3%, of the entire area. The Gedeo indigenous agroforestry system "home gardens" is unique among the oldest traditional farming methods in Ethiopia. Also, native shrubs, trees, and annuals(crops) that are extremely diverse and closely spaced make up the continuous vegetation cover (Gebretsadik & Negash, 2016; Mebrate, Kippie, et al., 2022)

Gedeo agroforestry system is the foundation of their economic activities. It has distinctive qualities commonly unique from the system in other areas. It is not a system of supplementary production where solely fruit and vegetables are raised to support field-grown staple crops. Instead, it is a primary system of subsistence where all types of crops, such as supplementary, cash, and staple crops, are grown together. The system supports about 900 people per square kilometer (Degefa, 2016).

3.1.3. Socio-economic conditions of the study area

The total population of the Gedeo zone is 847,434 people, among the 424742 are men and 422,6 92 are women. Regarding their residence place, 107,781 (12.72%) are urban inhabitants, while 7 39653(87.28%) are rural dwellers among them 39 individuals are pastoralists. Regarding

household numbers, 179,677 households were counted in this Zone, which results in an average of 4.72 persons per household, and 172,782 housing units (CSA, 2007).

The Gedeo people have a rich culture and indigenous knowledge that foster environmental conservation, hard work, and well-mannered social principles (seera) that led to well-established local knowledge of environmental protection and conservation. They believe in Magenno (the sky God), the one and only Supreme Being. "Magenno" is believed to have manifested himself in his works of creations such as mountains (kobba), hills, forests, rivers, large trees, and other natural landscapes. They further stated that nature is regarded as a legitimate intermediary between the Creator, God, and people. Consequently, the Gedeo have a strong respect for nature in general. (Maru et al., 2020)

The Gedeo people have strong cultural and economic (business) partnerships with their neighbors such as the Guji, the Sidamo, wolaita and Gamo. Among them, the Gedeo and the Guji have an even greater economic relationship, in exchange for livestock and livestock products, ensete food and coffee products. The streams and rivers that flow from the Gedeo highlands into the rift valley, connecting the standard of living of the two peoples, further increase this connection(Kanshie, 2002).

3.1.4. Farming system and wheat production of the study area

Farmers in the Gedeo zone commonly practice mixed farming systems under their agroforestry which includes raising animals and cultivating different crops. The main crops planted in conjunction (sequentially or concurrently with inset) include maize, banana, mango, avocado, wheat, barley, pulses, sweet potato, coffee, taro, sorghum, onion, garlic, leaf cabbage, and Irish potato. Their main method of land use is mixed farming through rain-fed agriculture, which involves smallholder farming to get diverse agricultural output(Kanshie, 2002).

Wheat is potentially produced in 4 woredas among 6 woredas found under the zone. According to the Gedeb Woreda Agricultural Development Office annual report, (2022) shows that among the total of 371 hectares of land covered by wheat in the “Ethiopia meher” production season in 2021/2022, only 95 hectares of land (25.6%) were covered by improved wheat seed and remaining 276 hectares of land (74.4%) covered by local wheat seed. As the report shows regarding wheat productivity per hectare, the average wheat productivity of improved wheat seed user farmers was

34 quintals per hectare, whereas the average wheat productivity of local wheat seed sources user farmers was 13 quintals per hectare. Additionally, the 2022 annual report of the Choriso Woreda Agricultural Development Office shows that among the total of 178 hectares of land covered by wheat in the "Ethiopia meher" production season in 2021/2022 only 32 hectares of land (17.97%) was covered by improved wheat seed and remaining 146 hectares of land (82.02%) of land covered by local wheat seed. Concerning wheat productivity per hectare, the average wheat productivity of improved wheat seed user farmers was 32 quintals per hectare, whereas the average wheat productivity of local wheat seed sources user farmers was 21 quintals per hectare.

3.2. Research Design

This study employed the cross-sectional research design with both qualitative and quantitative approaches. In this arrangement, all required data were collected from the respondents at specific times (four consecutive weeks) as part of an operational timetable.

3.3. Sampling procedure and sample size determination

The study employed multistage sampling techniques to select study zones, sample Woreda, kebeles, and final sample households, by applying both non-probability sampling techniques. Accordingly, in the first stage, the Gedeo zone and two sample Woredas were selected purposively. The selection of the Gedeo zone was done after taking into consideration two fundamental issues from the researcher's point of view: first, the research-mandated area of grant-giving institutions and second, among the potential wheat-producing zones under the research-mandated area. Also, two sample Woredas namely Gedeb and Chorizo were selected purposively among 6 Woredas under the zone because they had relatively high wheat production potential among the other four Woredas in the Gedeo zone. This selection was done at the zone level after discussing with zonal agricultural development experts and leaders regarding the purpose of the study and the wheat production potential of the available woredas.

In the second stage, two sample kebele were randomly selected from each Woreda; accordingly, from 10 kebeles under Gedeb woreda the Gubeta and Galcha kebeles were selected while in Choris wereda from 11 kebeles Dibadinbe and Gubeta were selected randomly for the study. The selection of sample kebele was done based on a discussion held on each woreda regarding to wheat production potential of the available keble.

In the third stage, sample size determination and stratification were done. The study used Yamane's (1967) formula to determine the study sample size as specified below: accordingly, among a total of 412 wheat-producing households in four sample kebele, 203 sample households were selected.

$$n = \frac{N}{1 + N(e^2)} = \frac{412}{1 + 412(0.05^2)} = 203$$

Where N =is the total population size (in this case wheat producer farmers in four sample kebele),

e =is the level of precision (0.05 at 95% confidence level)

n= is the total sample size selected from four sample kebele

At this stage, after the determination of the total sample size, each kebele wheat-producing household was grouped into two strata, because wheat-producing households are heterogeneous Type equation here.regarding the seed source usage. This is due to making a random sample household selection from a subsectioned population can lead to a biased sample selection. Hence to make them homogeneous they stratified by referring to the kebele wheat producers registration book(sample frame). Accordingly, the first strata was HH which used formal wheat seed sources. The second strata were informal wheat seed source users.

In the fourth stage,203 sample households were selected randomly from 4 kebeles by considering probability proportionate to size from each stratum. Accordingly from the first strata(formal seed users), 86 sample households were selected among a total of 175 households and from the second strata(informal seed source users) 117 sample households were selected among a total of 237 households, their size distribution by Kebele explained (Table_1).

Table 1 Distribution of study household by kebele

Woreda	Kebele	Total HH*	Sample HH**	Sample HH from Strata -1 (formal seed sources users)	Sample HH from strata -2 (informal seed sources users)
Gedeb	Gubeta	83	41	17	24
	Galcha	109	54	23	31
Churiso	Dibadinbe	108	53	22	31
	Kabeta Gubeta	112	55	24	31
Total		412	203	86	117

Source: * kebele administration HH register book; ** own computation in proportion to population

The selection of KII and FGD participants employed purposive sampling techniques.

Development agents, kebele chairman, village/other kebele leaders, model farmers, and Woreda agricultural office experts were included, considering the representativeness of society members, and they had better know-how about the wheat supply system and other targeted issues (supply actors, constraints to using improved wheat seed). Accordingly, a total of 4 FGDs were conducted in four kebele by including male and male households, considering their selection to include age group, educational level, and model and follower farmers to participate in each FGD as representatives.

3.4. Data Collection Method

3.4.1. Data type and source

Both quantitative and qualitative forms of data were collected from primary and secondary sources. Primary sources of data (household interviews of selected sample kebele (Gubeta, Galcha, Dibadinbe, and Kebeta Gubeta), key informant interviews of sample four kebele development agents, kebele chairman, village/other kebele leaders, model farmers, Woredas agricultural office experts, seed trader interviews of Dilla, Gedeb, and Choriso towns, agricultural researchers' interviews, seed enterprise expert interviews, and focused group discussions). Secondary sources of data were collected from annual reports of Woreda and zonal agricultural bureaus, as well as a review of published materials from print and online sources.

3.4.2. Data Collection Techniques

Household survey

Household surveys were held to get household data in the form of quantitative indeed household socioeconomic, demographic profiles, and household income, wheat yield data, as well as qualitative indeed actors of the wheat supply system, information on factors affecting the use of improved wheat seed by wheat producers and the attitudes of smallholder wheat producing farmers toward an improved wheat seed supply system. Those household data were collected through a structured questionnaire.

These data collection tasks were done by the care of selected researchers (four enumerators) from the Hawasa Agricultural Research Center. Among four enumerators two were MSc. degree and two were BSc. degree. Besides all of the enumerators have above three years' experience in field data collection. Amharic and the local language"Gedeogna" was used in the interview session. The data was collected through face-to-face interviews with individual wheat producers who were selected as the sample for the study. During the data collection session researcher(student) served as both supervising and data collecting responsibilities.

Key informant interview

Data collected from key informant interviews served as supportive data for three objectives(to identify seed supply sources and actors, to determine affecting factors, and to assess evaluative perception) to check the accuracy of information obtained from other sources through triangulating problems with different stakeholders. These key informant interviews were held with kebele development agents, model farmers, the kebele chairman, woreda and zone agricultural development office experts, wheat seed traders at Gedeb, Churizo, and Dilla towns, southern seed enterprise office experts, Ethiopia agricultural works corporation office experts at the Hawasa branch, and researchers from the southern agricultural research institute. These data were collected through checklists.

Focus Group Discussion(FGD)

Data collected from FGD served as supportive data for three objectives three objectives(to identify seed supply sources and actors, to determine affecting factors, and to assess evaluative perception), this was done to know the reliability of data obtained from individual interviews and

to get additional causes of problems from team members. These FGDs were held with selected community representatives for both improved and local wheat seed users, including different age groups, sexes, educational backgrounds, social positions, and status of framing habits. One separate FGD was conducted in each selected sample kebele, namely Gubeta, Galcha, Dibadinbe, and Kebeta Gubeta. FGD in each Keble included 6-12 group members. FGD data were collected by using checklists and audio recordings during the discussion.

Document review

Documents review was held to collect secondary data from unpublished data sources (annual reports of Gedeb and Choriso Woredas, and the Gedeo Zone Agricultural Development Office) and published sources (journals, books, and thesis) focusing on wheat seed demand, supply systems, and constraints faced by farmers in using improved wheat seed. These important data collection techniques were served as integral parts of the study which conducted concurrently with the planning, field data collection and writing session of the study.

3.5. Methods of Data Analysis

After completion of data collection and entry, data cleaning, management, and analysis were done by using a combination of SPSS software version 26 and STATA version 15. The study used statistical analysis methods (descriptive and inferential) and econometric models as analysis tools. Also, qualitative (data and information from FGD and key informants) data was analyzed through summarizing and narrating techniques.

Among statistical analysis methods, descriptive statistics (mean, frequency, standard deviation a nd percentage) were used to characterize the socioeconomic and demographic characteristics of s ample households and the sources of wheat seed used by sample households. On the other hand, among inferential statistics, the chi^2—test was employed to investigate the relationship between wheat seed source usage and the demographic and socioeconomic characteristics of wheat farmers regarding categorical variables, whereas the t-test was used to examine the mean difference between wheat growers who used formal seed sources and those who used informal seed sources concerning continuous variables.

Five-point Likert scale was used to evaluate farmers' perception of formal wheat seed supply systems relative to informal wheat seed supply systems. To make it measurable, a group of

indicator questions (6 positively stated questions) followed by their scales (strongly disagree, disagree, neutral, agree strongly agree with representative value 1,2,3,4,5 respectively) were used to know the extent of agreement or disagreement of households. However, the outcome variable (perception) used for analysis is the latent variable. Hence it needs to check to what extent of questions in scale are related to each other and to know their degree of reliability to express the proposed issue, so the Cronbach alpha(α) coefficient was used which was estimated via Stata software. Commonly, its value falls between 0 and 1, while giving its decision the value equals zero (0) reveals all items on the scale are independent whereas 1 item in the scale tends to measure the same underlying concept(Virginia, 2015). George & Mallery, (2003) defined the coefficient to have excellent internal consistency if the Cronbach's alpha is above 0.9, if it is 0.89 to 0.8 it has a good internal consistency, between 0.79 and 0.7 it has acceptable internal consistency, if it is between 069 and 0.6 it has questionable internal consistency, between 0.59 and 0.5 it had poor internal consistency and below 0.5 it has an unacceptable internal consistency.

Also, evaluative farmers' perception of formal wheat supply system analysis was done by estimating the summative mean (perception index) for a given perception score by applying descriptive statistics. A mean score of perception (perception index) was calculated by:

$$PS_i = \frac{\sum_{j=1}^{N} Q_j}{N}$$

Where,PS_i= perception score(index) of i^{th} household (i=1……203), Q_j = response on j^{th} perception question (j=1…6) and N=sample HH. The mean score obtained from the above formula is a continuous number between 1 and 5. To apply for the purpose, five equal class intervals including the lowest to highest value of 1 up to 5 are needed. Hence five equal ranges were used to label the perception indexes (mean score) into five categorical rankings. Boone & Boone (2012)indicated that Likert scale data can be analyzed by using interval measurement. It can be created by calculating a composite score (sum or mean) from four or more Likert-type items, therefore the composite score of Likert scales can be analyzed at the interval measurement scale, by using descriptive statistics like mean standard deviations, as well as other methods like Pearson's r, t-test, ANOVA, and regression procedures. Warmbrod, (2014) indicated that an essential principle of the Likert scale measurement methodology is that the scores produced by a Likert scale are

composite (summated) values formed from an individual's responses to the various questions on the scale to make quantitative analysis.

The probability of the hypnotized factors that affect farmers' usage of wheat seed from relevant supply sources was examined through the selection of an appropriate econometric model. The dependent variable (farmers' participation in seed supply sources) was defined as whether farmers used formal or informal seed sources. Each source was coded as a binary (dummy) variable, where the seed source used was coded as one (1) and zero (0) otherwise. Additionally, each dependent variable has two choices and is asked dependently, among which the decision maker has to choose. The commonly affecting factors in two sources were expected to be identified. Hence, an appropriate econometric model that identifies determinants of joint decisions would be either a bivariate probit or logit regression model rather than a binary probit or logit regression model. The former models run dependent variables at once, so they have the advantage of increasing model efficiency and identifying jointly affecting factors in the sectors (formal and informal seed sources) better than the latter model. For those reasons, a bivariate probit regression model was selected as an analytical framework to identify factors affecting farmers' choices of wheat-seed supply sources. The appropriateness of selection bivariate probit rather than separate binary probit was statistically checked by the significance of correlation coefficient(rho), if (rho) is significant shows there is a relation between wheat seed sources and shows that selection bivariate probit is efficient, otherwise, there is no relation between two seed sources and model selection is inefficient that means separate binary probit is appropriate.

In the bivariate Probit model estimation, the choice of two wheat-supplying sources by individual farmers corresponding to the binary choice (yes/no) equation was modelled jointly while accounting for correlation among disturbances. The model was estimated by bivariate specification to improve over those from univariate specification when the error correlations are significantly different from zero. Otherwise, the two modelling frameworks lead to comparable results. Hence, if a household uses one wheat seed source, there are two equations, each describing a latent dependen_t variable that corresponds to the observed binary outcomes for each wheat seed source, that would need to be estimated simultaneously.

Wheat producer farmers are assumed to make seed source use decisions based upon an objective of utility maximization. Let U_{1i} be the utility of using formal wheat seed source by I^{th} and U_{2i} be the utility of using informal wheat seed source by I^{th} farmer, the underlying utility functions which rank the preference of the ith farmer are assumed to be a function of farmer-specific attributes, ``X '' (e.g. age, sex, farm size, etc.) and a disturbance term having a zero mean:

$U^*_{1i} = \beta_1 X_i + €_{i1,}$ U^*_{1i} is the unobservable utility of i^{th} farmer using formal seed source and $U^*_{2i} = \beta_2 X_i + €_{i2,}$ U^*_{2i} is the unobservable utility of i^{th} farmer using informal wheat seed source

The utilities are random, the ith farmer can select the alternative ``use seed source'' if $U_{1i} > U_{2i}$

Then bivariate probit is expressed as;

$$y_1^* = X'1\beta 1 + \epsilon_1; \int_{y_1=0,otherwise}^{y_1=1,if\ y*>0} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

$$y_2{}^* = X'_{2\beta_2} + \varepsilon_2 \int_{y_2=0,otherwise}^{y_2=1,if y^*>0\ and y^*_{2>0}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

Where, y^*_1 and y^*_2 are latent variables to be measured to explain the probability of farmers using formal and informal wheat seed sources respectively, X_1 and X_2 are vectors of explanatory variables of the using decision of formal wheat seed sources and informal wheat seed sources respectively, β_1 and β_2 are parameter to be estimated, $€_1$ and $€_2$ are error terms.

PSM was used to measure the impact of improved wheat seed on household wheat productivity. Accordingly, to generate a propensity score, the probit model was employed by using observable covariates thereby estimating the impact of improved wheat seed on productivity. Although it is possible to estimate the impact of improved wheat seed on the wheat productivity of wheat farmers by comparing mean productivity differences among improved wheat seed users and their counterparts by applying descriptive statistics, a mere comparison of productivity quantity differences among improved and local wheat seed users has no causal meaning. However improved wheat variety use depends on endogenous factors, hence it may not indicate other factors that can bring wheat productivity difference rather than improved wheat seed use among wheat farmers because farmers have different socioeconomic, demographic and institutional conditions.

On the other hand, there are some analytical tools to run impact analysis like the difference in difference model but it requires continuous year-recorded wheat yield data among wheat farmers, but there was no reliable yield data recorded data at kebele or farmers level.

To end this problem, estimating improved wheat seed impact on productivity by evaluating households under similar conditions, making their difference in only using improved wheat seed is an important aim of the study. In this case, improved wheat seed user framers were used as the treatment group and locally sourced seed user farmers were considered as a control group. However, improved wheat seed users and local seed users may not be directly comparable. So before proceeding with counterfactuals, one first needs to establish comparable conditions to avoid differences between participants and non-participants in the program (Munyi & De Jonge, 2015; Cafallndo & Kopeinig, 2008). The basic idea of PSM was introduced by Rosenbaum & Rubin, (1983) who observed that self-selection bias could be removed through adjustment (matching) using propensity score between the treated and untreated groups.

In the case of this study, the self-selection problem (bias) may occur because the use of improved wheat seed delivered from formal seed sources by farmers is not random but based on factors influencing farmers' decisions. Thus, farmers who used improved wheat seed may systematically differ from local wheat seed users who delivered from informal seed sources based on several factors such as farm-specific, and socio-economic characteristics, which might influence the wheat yield of farmers. This self-selection bias is solved by implementing PSM, which involves the use of a binary choice model (logit model) to generate propensity scores for each farmer in the study. PSM, each farmer receiving treatment is matched with untreated farmers based on observable covariates, such that treatment is not randomly assigned and then measures the average differences in productivity (wheat yield) between the users and non-users of improved wheat seed delivered from formal seed sources. Hence to estimate the propensity score(probability) among participants, the logit regression model was used.

$$P(Y) = \frac{1}{1 + e^{-(\beta_0 X_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots \beta_n X_{n+} \varepsilon_i)}}$$

Where Y is a variable representing farmers' seed source choice, Yi is the observed status of using improved seed from formal sources by each farmer, and X_1 …..X_n is an explanatory variable that

includes farmer and farm characteristics (socio-economic, demographic and institutional), β_0 ……. β_n is a parameter to be estimated and ui is a normally distributed error term.

After estimating propensity scores, matching algorisms employed to match each improved wheat seed user with local wheat seed users with similar propensity scores were used. Accordingly, the study runs all four matching algorisms; nearest neighbour, radius, stratification and kernel matching algorisms. Based on the result of the t-value and number of sample treatments and the control group used in each algorism, three appropriate (significant t-value and large sample number included to match) matching algorisms were selected and used for final presentation except radius matching algorism due to it cut out a large number of sample treatment and control group.

The balancing property of the sample was necessary to be observed in the analysis to check that all farmers within the common support area have a similar distribution of observable characterist ics, irrespective of whether the farmer used improved wheat seed or not (Villano et al., 2015). The balancing property indicates the matching quality of the samples. This balancing was checked statistically, hence balance was satisfied and allowed to proceed next step.

The next step was checking enough common support areas and overlap among improved wheat seed users and local wheat seed users using estimated propensity scores by applying descriptive statistics (mean, min and max) and kernel density graph. Hence it was done appropriately and found enough common support regions and overlap of the kernel density distribution of propensity score among households.

The last step was estimating the causal impact of using improved wheat seed from formal seed sources on wheat yield was calculated using the average treatment impact on the treated (ATT). The average treatment impact is defined as the mean difference between the treatment group matched with the control group, which was balanced on the propensity scores and within the regions of common support. However, this study applied utility maximization theory for an analytical framework. It was expressed as wheat producer farmers are assumed to make seed source use decisions based upon an objective of utility maximization. Let U_{1i} be farmers' utility of using improved wheat seed from a formal source by I^{th} farmer $_{and}$ U_{2i} be farmers' utility of using local wheat seed from an informal source by the i^{th} farmer, the underlying utility functions

which rank the preference of the ith farmer is assumed to be a function of farmer-specific attributes, ``X '' (e.g. age, sex, farm size, etc.) and a disturbance term having a zero mean:

$U^{*}_{1i} = \beta_1 X_i + €_{i1,}$ where U^{*}_{1i} is the unobservable utility of i^{th} famer using improved wheat seed from formal seed source and $U^{*}_{2i} = \beta_2 X_i + €_{i2,}$ where U^{*}_{2i} is the unobservable utility of i^{th} farmer using local wheat seed from the informal seed source. The utilities are random, the ith farmer will select the alternative seed source if $U_{1i} > U_{2i.}$ Hence, the average utility(AU) of i^{th} famer using improved wheat seed from the formal source over local wheat seed from a local seed source is expressed as:

$AU = U^{*}_{1i} - U^{*}_{2i,}$ however, the utility of using different wheat seed sources is unobservable and difficult to measure, in the case of this study it was expressed as average wheat productivity impact on improved wheat seed user, it is commonly used as ATT (average treatment impact on treated). This ATT is mathematically explained as follows:

ATT = E (Y1|D = 1), where ATT is the average wheat productivity for an improved seed user

ATU =E (Y2|D = 0), where ATU is the average wheat productivity for local wheat seed user farmer

The average wheat productivity impact on improved wheat seed user become the average wheat seed productivity difference between improved wheat seed user and their counterpart, hence it expressed as:

$ATT = ATT - ATU = E(Y1|D = 1) - E(Y0|D = 0)$

Where ATT is the average treatment impact on treated, ATU is the average treatment impact on untreated, and Y_1 Y_0 are average quantity of wheat yield(quintal/hectare) for improved wheat seed users from formal seed sources and local wheat seed users from informal seed sources. D is a dummy variable that takes two values D=1 if farmers used improved wheat seed from formal seed sources and D=0 if farmers do not use improved seed from formal seed sources.

3.6. Description of Variables and Their Hypothesis

Dependent and outcome variables:

Wheat seed sources: The wheat supply source is a binary choice variable (formal wheat source and informal wheat seed source) measured as HH's use of each seed supply source to get wheat seed for their wheat production. For each source, the question of participation(use) was asked separately, the response 1 represents the use of the wheat seed source to say yes, and 0 otherwise.

Increased wheat productivity: increased wheat productivity is a continuous variable that is measured by the number of quintals of wheat grain yield obtained from one hectare of land, which is calculated by dividing harvested wheat yield by planted wheat area.

Farmers' Perception: It is a continuous variable; it is measured in summative mean (perception index) value calculated from farmers' responses to express a degree of agreement with Likert scale questions related to formal wheat seed supply system.

Independent variables

Sex: This variable is a dummy variable which represents household heads, 1 male, and 0 female. It is hypnotized as male-headed households more participates on formal seed sources than female-headed households. The research finding of Jaleta et al., (2023) indicates that male-headed households more probably bought wheat seed from the formal seed market than female-headed households. The findings of Tanellari *et al*., (2014) reveal that compared to male-headed households, female-headed households are less likely to adopt improved varieties. Oyetunde-Usman *et al*., (2021) indicated that the adoption of improved seeds and diversified farming practices was less common among female household heads this is a result of technological preferences, cultural acceptance, and the suitability of a particular agricultural technology duties for females.

Marital status: It is a nominal variable, which is measured as 1 single, 2, married, 3. divorced and 4 widowed. It was hypnotized as married HH was more likely to participate in improved wheat seed from formal sources. Onyeneke, (2017) showed that married farmers likely adopt improved agricultural technologies because wives and children of married farmers constitute a major labour

force in rice production. The finding of Umar *et al*., (2014) shows that the marital status of the farmer has a positive impact on the adoption of improved maize varieties because married farmers have more responsibilities to shoulder in terms of providing the basic needs of their family.

Age of household head(age): It is a continuous variable and measured in years. Aged households are assumed to be conservative in using improved agricultural inputs, and it was expected to negative impact on improved wheat seed use. Amare Tesfaw, (2015)reported that there is a negative relationship between the age of household heads and the probability of using improved seeds this is due to as household heads get older, they do not want to accept innovations as they expect production risks or high labour demand in using that technology.

Education level: It is the continuous variable that was measured using the formal schooling year of the household head and it is hypothesized to affect the selection of formal seed sources positively. The higher the education level of the household head, the better would be his/her awareness of the selection of formal wheat seed sources to get quality seed. Jaleta et al., (2023)showed that household heads who have relatively better education are more likely to use improved wheat varieties on their farm on a regular base compared to their counterpart. Siyum et al., (2022) showed that the probability of improved bread wheat adoption was influenced positively by the education level of the household head.

Family size: is a continuous variable, it was measured in the size of family members. It was hypnotized as having a positive impact on the use of improved wheat seed from formal seed sources. This relating to having large family members is an indicator of the available farm labour and striving to improve wheat productivity to feed their family members. Beshir, (2014) reported that family size has positively influenced the intensity of using improved forages because improved practices are labour intensive and hence household with relatively high labour force uses the technologies on their farm plots more than their counterparts.

Farming experiences: It is a continuous variable; it was measured in the number of years since a respondent started farming on his own. The experience of the farmers was hypnotized as positively affecting the selection of formal seed supply sources. Chandio & Jiang, (2018) showed that farm experience has a positive association with the adoption of improved wheat varieties, this is due to

more experienced wheat growers having better technical knowledge, and likely to be getting possible profits from investment in new technology.

Landholding: is a continuous variable measured in terms of the amount of land a household has in hectares. It was hypnotized as farmers having a large amount of cultivable land select formal seed supply sources. Tesfaw, (2022) indicated that farmers who have relatively bigger plots have a great tendency to have the option of paying for the improved seed from formal seed supply sources.

Frequency of extension contact: It is a discrete variable and it was measured as a discrete value taking of 1, 2 3…., frequency of development agent has contact with a farmer. The frequency of extension contact was expected to have a positive impact on the selection of formal wheat seed supply sources. Siyum et al., (2022) noted that the frequency of extension contact positively affects a household's probability of improved technology adoption relative to their counterparts.

Credit use: It is a continuous variable and measured in the amount of money in Ethiopian birr that the sample wheat producer farmers borrowed from either private or governmental organizations. This variable was hypnotized as it has a positive influence on the selection of formal seed supply sources. when the farmer who used credit improves his/her financial capacity to buy improved wheat seed from formal sources. Wosene & Gobie (2021) indicated that credit use positively and significantly influences the selection of a formal seed distribution system this is due to farmers with access to credit being more capable of accumulating than their counterparts.

Distance from the seed market: It is a continuous variable expressed as the average distance in km from the farmer's home to the wheat seed marketplace (distribution centre) where farmers commonly go to buy seed. it was hypnotized as negatively affecting the use of improved wheat seed from formal seed sources. This is due to the distance of the seed market from the farmer's home increases also related transaction costs increase, hence they prefer alternatively available seed sources at short distances. Wosene & Gobie (2021) pointed out that distance from the seed distribution area negatively influences the selection of households on formal seed sources.

Tropical livestock unit (TLU): it is a continuous variable, it was measured by the size of the TLU the sample households have. It was hypnotized as a positive impact on using improved wheat

seed. farmers who possess a large size of livestock are assumed to have the potential to pay more for the formal seed supply. Siyum et al., (2022) indicated that livestock wealth(TLU) also positively influences the adoption of improved bread-wheat technologies. This might be a result of Ethiopia farm machinery not yet widely used by smallholder farmers in this case livestock are the major source of drafting and traction power.

Total annual income: It is a continuous variable and is measured by ETB. It is the income generated and earned from all activities in the previous year by a sample household. It was hypothesized that this positively affects the use of formal wheat seed supply sources. Onyeneke, (2017) noted that the income of farmers had a positive and significant impact on the likelihood of adopting improved rice varieties the results are related to the fact that higher-income farmers are possibly less risk-averse.

Seed supply time: It is a dummy variable, expressed as seed access time is the problem of a wheat farmer, if yes takes the value 1 and 0 otherwise. The seed accessing time was hypnotized as it has negative impacts on the utilization of wheat seed from formal seed sources. If wheat farmers face late seed access time at planting season for the first year, they tend to be informal seed sources for the next year. Yitayew et al., (2023) lack of seed availability on time is negatively affecting wheat farmers to use improved seed from formal sources

Seed quantity: It is a dummy variable, it was expressed as the unavailability of sufficient wheat seed quantity is a problem for wheat farmers, if yes it takes values 1, and 0, otherwise. Shortage of sufficient wheat seed quantity was hypnotized as, negatively affecting to use of improved wheat seed from formal seed sources. If wheat farmers face a shortage of wheat seed quantity as they planned to purchase from formal seed sources in a particular year, the next time they lose confidence in getting enough amount of seed at that source. The finding of Wosene & Gobie, (2021) shows that the Supply of limited seed quantity is one of the problems affecting farmers' participation in the formal seed distribution system. The finding of Mulesa *et al.,* (2021) shows that although farmers prefer to access seed from formal supply sources, the limited availability of improved varieties is a challenge for them. Kassa et al., (2021) shortage of improved seed quantity leads to a low adoption rate of improved faba bean technologies.

Seed Quality: It is a dummy variable, and it was expressed as wheat seed quality is the problem of the wheat farmer when they use the formal seed sector, if yes it takes values 1 and 0, otherwise. It was hypnotized as positively affecting to use of wheat seed from formal seed sources. When wheat farmers participate in formal wheat seed supply sources they get quality seed, so they are motivated to participate again in that source. The finding of Jaleta et al., (2023) indicates that most wheat-producing farmers rely on formal seed supply sources to get quality seed.

Wheat Seed price: It is a dummy variable, it was expressed as how wheat producer farmers perceive the price of improved wheat seed sourced from formal seed sources If expensive takes values 1 and 0 otherwise. It was hypnotized as negatively affecting wheat-producing participation in formal sources, if the price of improved wheat seed delivered from formal seed sources is higher than alternative seed sources available in the area, wheat farmers are less likely to participate in formal seed sources. Yitayew et al., (2023) reported that high seed price is hindering farmers from sourcing improved wheat seed from formal seed supply sources.

Social position: It is a dummy variable which takes 1 if households have a certain position within the community, and 0 otherwise. It was hypothesized that it has a positive impact on the respondent's use of improved wheat seed delivered from formal seed sources. Atinafu et al., (2022) indicated that membership in social organizations positively and significantly affects the probability of adoption and intensity of adoption of improved wheat production technology, this the due to participation in social organizations increases social networks and share of information on technology which increases the adoption of these technologies Jaleta et al., (2023) reported that farmers' access to various pieces of information often utilized to make decisions regarding their farming operations may be impacted by the socioeconomic networks in which they participate. These networks frequently disseminate information about the availability of improved crop varieties, the quality and efficiency of various farm inputs, including seed, and farming techniques for reducing biotic and abiotic risks in crop production.

Table 2 Summary and hypothesis of variable

No	List of variables	Nature variables	Measurement unit	Expected sign
Dependent variable				
1	Farmers' choice of seed sources	Dummy	1 yes, 0 otherwise, for each source	
2	Increased wheat yield	Continuous	Yield in quintals per hectare	
3	Perception level	Continuous	The summative mean value of Likert scale question responses	
Independent variables				
1.	Age of household head	Continuous	In the number of years	-
2.	Gender of household head	Dummy	1 if male, 0 if female	+
3.	Marital status	Nominal	1 single, 2 married, 3 divorced, 4 widowed	+
4.	The educational level	Continuous	In the Number of school years	+
5.	Family size	Continuous	Size of family members	+
6.	Landholding	Continuous	In hectare	+
7.	Extension contact	Discrete	In the number of days	+
8.	Farming experience	Continuous	In the number of years	+
9.	Distance of seed market	Continuous	Distance in km	+
10.	Tropical livestock unit	Continuous	In number	+
11.	Total annual income	Continuous	Amount of money earned annually in ETB	+
12.	Credit use	Continuous	Amount of money borrowed in ETB	+
13.	Seed quantity	Dummy	1 if the problem,0 otherwise	-
14.	Seed quality	Dummy	1 if the problem,0 otherwise	-
15.	Seed access time	Dummy	1 if the problem,0 otherwise	-
16.	Seed price	Dummy	1 if expensive, 0 otherwise	-
17.	Social position	Dummy	1 if has a position, 0 otherwise	+

CHAPTER FOUR

RESULT AND DISCUSSION

This chapter first parts presents characteristics of sample households' socio-economic and demographic characteristics, then presents the result of planned research tasks regarding wheat seed supply source, actors in the system, farmers' perception of formal wheat seed supply system, factors affecting farmers' use of available seed sources and impacts of improved wheat seed on wheat productivity of smallholder farmers. The last part of each raised issue made discussion on the major findings of the study by relating prior research findings which are accompanied by the thematic area of the study.

4.1. Characteristics of Sample Households

In this section, the demographic and socio-economic characteristics of sample households by use of wheat seed sources indicated in (Table_3) for dummy and (Table_4) for continuous variables, by focusing on their association and mean difference to the HH's seed source use are discussed below respectively.

Table 3 respondents demographic characteristics(dummy variables),n=203

	Wheat seed source					
Variables	**Informal source user (n=117)**		**Formal source user(n=86)**		**Chi^2(1)-test**	**P**
Sex	**Freq.**	**%**	**Freq.**	**%**		
Female(n=41)	24	58.5	17	41.5	0.0171	0.896
Male(=162)	93	57.4	69	42.6		
Marital status						
Married (n=186)	104	55.914	82	44.08	3.0607	0.216
Divorced (n=11)	9	81.81	2	18.18		
Widowed (n=6)	4	66.67	2	33.33		
Social position						
Yes (n=115)	52	45.22	63	54.78	16.7544	0.000
No (n=88)	65	73.86	23	26.14		

Source: survey data (2023)

Sex: Among the total sample households, 79.80% (n = 162) were male, whereas 20.20% (n = 41) were female (Table 3). Concerning the association between wheat seed source usage and gender, the values of Pearson chi2(1) = 0.0171 and Pr = 0.896 (pr>α). This shows that there is no statistically significant association between gender and the wheat seed source used by wheat producers. This implies that the maleness or femaleness of the household head does not determine the selection of wheat seed sources but is determined by other socio-economic conditions and issues related to the wheat seed supply system.

Marital status; Among the total sample of HH, 91.62% (n = 186), 5.42% (n = 11), and 2.96% (n = 6) were married, divorced, and widowed, respectively. The $Chi^2(2)$-test statistics result ($chi^2(2)$ = 3.0607, Pr = 0.216 (Pr>α)) reveals that there is no statistically significant relation between the marital status of sample HH and the type of wheat seed source used by HH.

Social position: Regarding wheat seed source usage, out of HH who have a social position, 45.22% (n = 52) and 54.78% (n = 63) used informal and formal wheat seed sources, respectively. On the other hand, out of HH who have no social position, 73.86% (n = 65) and 26.14% (n = 23) used informal and formal wheat seed sources, respectively. As the $Chi^2(1)$= 16.7544, P=0.000, the result reveals that there is a strong association between HH wheat seed source usage and HH social position at a 1% significance level. HH who has a social position (model farmer, kebele chairman and other leadership positions, religious leaders) most likely uses formal wheat seed sources compared to HH who has no social position. This might result from information access differences among them.

Table 4 Respondents' socio-economic characteristics (continuous variable),n=203

Variables	Combined mean	Wheat seed source				Mean diff	P-value
		Informal seed source user (n=117)		Formal seed source user (n=86)			
		Mean	Std. Err.	mean	Std. Err.		
Age	40.6	41	.9646369	39.8	.9680817	1.35	0.001
Family size	8	8	.2351753	8	.2570082	.0829	.814
Education	5.24	4.025	.3891131	6.88	.4623791	2.86	0.000
Farmexpernce	2.86	18.205	.6810494	17.3	.6561527	.8679	.3735
Landholding	1.72	1.5525	.0782896	1.942	.0903537	.3893528	.0015
Wheat area	0.63	.578	.0455656	.696	.0412065	.1174791	0.0672
TLU	3.33	2.9605	.2143127	3.821	.277412	.8607238	.0135
Total income	64005.15	54950.76	6820.073	76323.34	5536.423	21372.58	.022
Extension contact	4	3	.1631438	6	.2851398	3	0.000

Source: survey data (2023)

Age: The combined mean age of the sample HH of both informal and formal wheat seed source users was 40.6 years. Regarding the mean age difference between informal and formal wheat seed source users in sample HH, the average age of the sample households that used informal and formal wheat seed source users was 41 and 39.8 years, respectively. The t-test result of their mean age difference is statistically significant at a 1% significance level (mean difference =1.35 and P = 0.001), (Table_4).

Family size: The combined average family size of the sample HH was approximately 8 in number. Regarding the mean family size difference among informal and formal wheat seed source users, the average family size in both informal and formal wheat seed source users was approximately 8 people per family. The t-test result reveals, that their average family size mean difference is not statistically significant (mean difference =.0.829 and P = 0.814).

Farm experience: In a comparison of the mean difference in farm experience for each wheat seed source user, the average number of years of farm experience of the sample household of informal and formal wheat seed source users was 18.205 and 17.3 years, respectively. The t-test result reveals that there is no statistically significant mean farm experience difference among formal and informal wheat seed users (mean difference =.8679 and P =.3735).

Education: The average education attainment years of the sample HH were 5.24 years. The average educational attainment years of informal and formal wheat seed source users in the sample HH were 4.025 and 6.88 years, respectively. T-test statics results show that their mean educational attainment year difference is 2.86 and P = 0.000. which shows that at the 1% significance level, there is a statistically significant mean educational year difference among informal and formal wheat seed source user samples HH.

Landholding: The average landholding size of the sample HH was 1.72 hectares. Concerning the mean landholding of each seed source, the average landholding size of informal and formal wheat seed sources in the user sample HH was 1.5525 and 1.942 hectares, respectively. As the t-test result shows at the 1% significance level, there is a statistically significant mean difference in land holding size between informal and formal wheat seed source users (mean difference =.3893528 and P =.0015).

Wheat area: The average land allocated to wheat production in sample HH was 0.63ha. The average land size for wheat production of the sample household of informal wheat seed source users was 578 hectares and that of formal wheat seed source users was 696 hectares. As the T-test result shows (mean difference =.1174791 and P = 0.0672) points that at the 10% significance level, there is a statistically significant mean difference in the land given to wheat growth between informal and formal wheat seed source users HH.

Tropical livestock unit (TLU): The TLU (tropical livestock unit) was used to compare livestock ownership among sample households. The average TLU of the sample HH was 3.33. In a comparison of each source's mean TLU, the mean numbers of livestock owned by informal and formal wheat seed source user sample HH were 2.9605 and 3.821, respectively. As a result of the T-test result (mean difference =.8607238 and P =.0135) showing at the 10% significance level,

there is a statistically significant mean difference in TLU between informal and formal wheat seed source user sample households.

Total annual income: The average total income of the sample HH was 64005.15 ETB. While comparing the mean total annual income between the wheat seed source user sample HH, the average total annual income of the sample households of informal and formal wheat seed source users was 54950.76 and 76323.34 ETB, respectively. According to the t-test statistics results, there is a statistically significant mean annual income difference between informal and formal wheat seed user sample HH (mean difference= 21372.58ETB) (P =.022) at the 10% significance level.

Extension contact: The average extension agent contact number to the sample HH per year was 4.2. Whereas comparing the mean extension agent contact number per year between informal and formal wheat seed source user HH, the average number of extension contacts between informal and formal wheat seed sources in the user sample HH was 3 and 6, respectively. The mean difference is 3 and P =.000, which shows that at the 1% significance level, there is a statistically significant mean extension contact number difference among informal and formal wheat seed source users.

4.2 Wheat seed sources and actors of the supply system in the study area

In the study area, there are two seed supply sources namely, the informal and the formal wheat seed supply sources (fig. 3) presented below.

4.2.1. The informal seed sources and actors

Trader/Local Trader: The seed trader most commonly collects seed from different sources and again distributes seed to farmers. They use marketing time and place time utilities. Key informant interview of seed traders in Gedeb and Choriso woreda indicates that wheat seed traders in the Gedeo zone collect both improved and local wheat variety seeds. They sourced their seed from cooperatives from the surrounding zone Oromia region around the Demitu area and local seed from local farmers. Besides, the seed traders indicated that limited access to seed sources especially not permitting access to wheat seed from formal seed sources is an impressive factor in reaching quality seed to farmers. FGD discussion approved that local traders are major wheat seed supply outlets for the farmers however wheat seed supply is constrained by quality issues.

Farmers: FGD and Key informants' information conducted in Gedeb and Churiso Woredas indicates that farmers access their wheat seed from either formal or informal sources depending on their socioeconomic, demographic and institutional factors. On the other hand, they act as seed supplies for local seed traders**,** so farmers are both seed sellers and buyers. They get improved seeds from formal sources like Agricultural offices and research centers. As well as they also source local seeds from their own saved, nearby farmers and local traders. Their role in the local seed supply chain is seed producing, cleaning, storing, and seed distributing to other neighbor farmers and local seed traders, again seed purchaser/demander from other neighbor farmers and local traders. In the case of an improved wheat seed supply system, farmers are only seed purchasers/demanders.

Further, FGD, Key informant interviews and household interviews indicated that farmers have been facing constraints in the wheat seed supply system. Among them, high improved seed price, low improved wheat seed quantity access, untimely access to improved wheat seed, lack of seed market information, the prevalence of pests and diseases lack of agrochemical assessment, and low seed quality were major suppressing constraints. The finding of Teressa, (2019) reveals that the majority of smallholder farmers in Ethiopia depend heavily on the informal system because it makes seed cheaper and more readily available in the farmer's village when it is required. Accessing improved seeds through the formal system has not always been consistent; seeds provided too late for the planting season, seeds delivered of the incorrect variety and seed shortages, are significant obstacles to wheat farmers(Wosene Minwagaw & Gobie Ejigu, 2021; Gebreselassie et al., 2017)

4.2.2. The formal seed sources and actors

Southern agricultural research institute(SARI):

Key informant review of SARI pointed out that, the research institute is responsible for the coordination of the southern research system by dividing the mandate area into its centers and appointing to develop seeds wheat varieties suitable for the area. The tasks of this responsibility begin in identifying the seed usage problems in society, generating new seed technologies, conducting adaptation and verification trials by using on and off-farm (on-farm and on-research sites), producing pre-basic and breeder seeds, and demonstrating and popularization wheat

technologies to farmers. In this seed supply chain, participants and surrounding farmers get improved wheat seed varieties directly from the research centre, indeed the Hawasa research center. Besides the Hawasa and worabe agricultural research centers under SARI plays a particular role by accessing pre-basic and basic seeds to certified seed multipliers such as SSE, ESE and farmers' cooperatives following the permission of SNNPRS Agricultural Bureau.

ESE-Hawasa branch:

The Key informant interview of ESE-Hawasa explained that the institution's function is seed production, cleaning, packaging, storing, and distributing seeds by following formal regulatory commands. Also, they pointed out that the seed enterprises facilitate their seed-producing responsibilities by accessing their seed from state farms and practising contractual farming from the farmer cooperative field. As Gedeo zone agricultural office experts indicated farmers in the study area (Gedeo zone) receive their wheat seed supplies alternatively from the ESE Hawasa branch through the care of the regional and zonal agricultural and extension bureau. But key informants from ESE noted that the institution has been facing constraints like a lack of continuous access to basic and pre-basic seeds from research centers, and a lack of integration among seed actors/ stakeholders in the process of production, marketing and distribution of seed.

Southern Seed enterprise: The key informant from Southern Seed Enterprises pointed out that the seed enterprise is responsible for producing certified seeds of different crops for farmers. Wheat seed is one of many crops the enterprise focuses on. To fulfil its seed demand, the organization has been practicing producing seed on state farms and farmers-based contractual farming. The organization also produces C1 seed under contract. It provides seeds for contracted farmers and extension assistance or supervision. Then the seed business purchases at a predetermined quantity after harvest. The major tasks of seed enterprise are; producing, collecting, cleaning, packaging, storing and distributing seeds based on the formal seed distribution command of the regional agricultural bureau. Farmers in the study area access their wheat variety seeds from Southern Seed Enterprise under the care of the zonal and Woredas agricultural extension office.

Gedeo Zone Agricultural Office; The key information interview of the Gedeo Zone Agricultural Office expert indicates that the office facilitates all operations being carried out as a higher office in the study area, regarding wheat seed supply. The office strives for farmers to have access to

improved wheat seed varieties on time. Additionally, it participates in the capacity building of far mers and subject matter experts through workshops and refresher training on the marketing of w heat seeds. However agricultural office has limitations in expanding the horizon of wheat seed su pply means like establishing farmers' cooperatives and encouraging private seed accessing companies to reach wheat seed access to farmers.

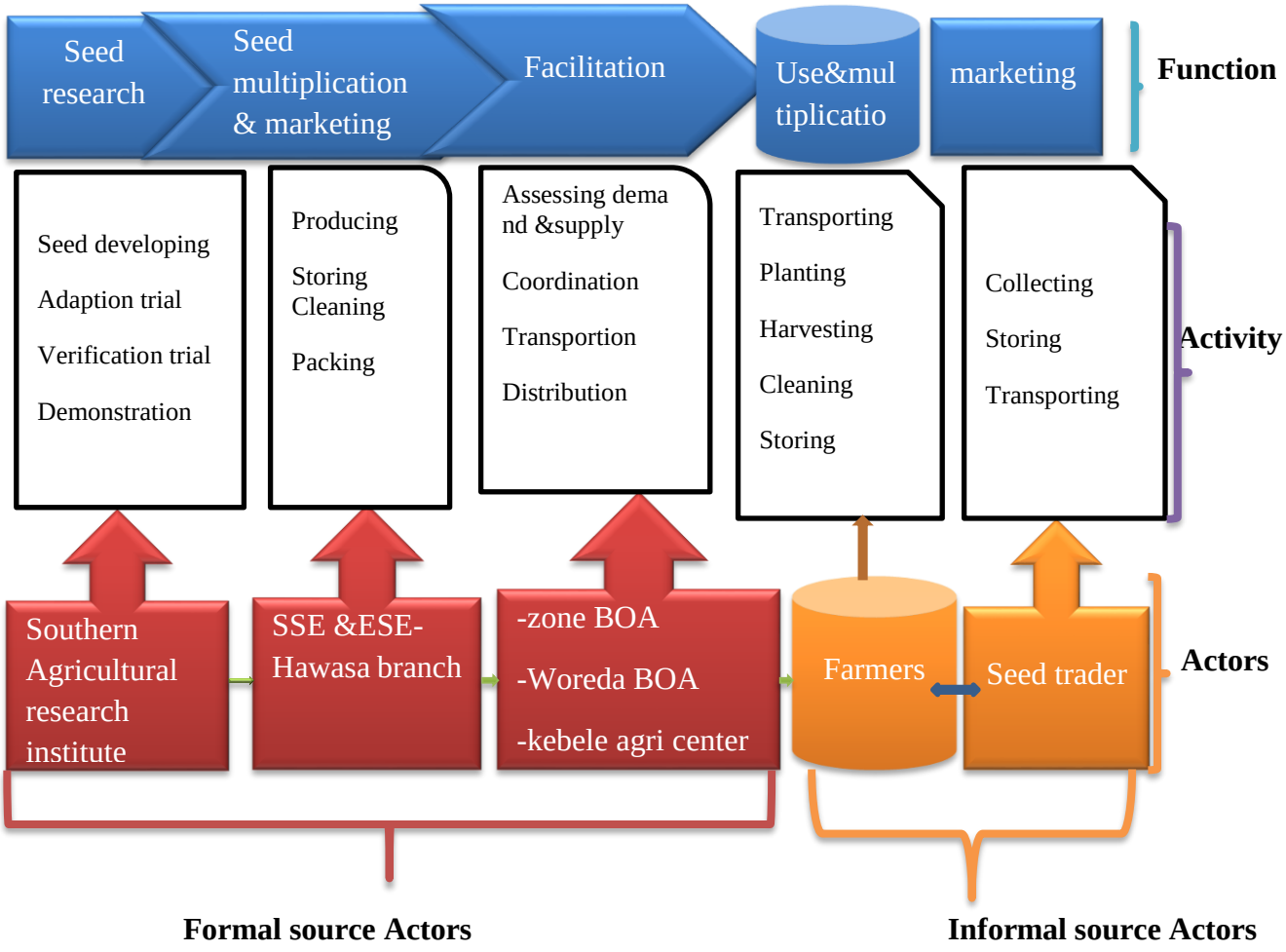

Figure_ 3 Seed supply chains and actors

Source: self-developed (2023) based on FGD &Key informant data

4.2.3. Smallholder wheat producers' participation and use of seed supply sources

The study result (Table-5) indicates that the majority of farmers sourced their seed from informal seed sources. This pointed out that informal wheat seed sources play a relatively dominant role in the seed supply system in the area. Regarding farmers' participation in each seed source, farmers' participation frequencies exceed the total number of sample HH because a single farmer participates in more than one seed source to fulfil his or her wheat seed needs. This implies there is a seed supply shortage in the area. Hence, to overcome their seed needs, farmers use different seed sources during the same planting season.

Table 5 Wheat seed supply system and actors in the system

Wheat Seed supply sources	Response	Freq.	Percentage
1. Formal source actors (n=86)			
Agricultural office	Yes	68	**33.50**
	No	135	66.50
Research Centre	Yes	27	**13.30**
	No	176	86.70
2. Informal source Actors (n=117)			
Local traders	Yes	127	62.56
	No	76	37.44
Another farmer	Yes	31	**15.27**
	No	172	84.73
Farmer Own saved	Yes	98	48.28
	No	105	51.72

Source: survey data (2023)

4.3. Farmers' evaluative perception of formal wheat seed supply system

To evaluate farmers' perception of formal seed supply sources Likert items (statements) were prepared based on literature reviews and operationalized through housed hold interviews. Before using the statements/indicators(Table_6), their reliability was measured by using Cronbach's alpha; the estimated coefficient was 0.77, which was found in the acceptable range. The study result (Table_6) indicates farmers' perceptions based on six positive statements about the formal wheat seed supply system. Among six farmers' perception index (mean score) concerning sufficient seed quantity, seed supplying time, seed price, and seed information fall in the negative range, which implies they do not agree with the statement and they negatively perceive the formal wheat seed supply system. Whereas seed quality falls in the positive range, which implies they

agree with the statement and they positively perceive the formal wheat seed supply system relative to the informal seed supply system. Also regarding, seed supplying distance, their perception index (mean score) falls in the neutral range, which means they did not show any agreement or disagreement on the formal wheat seed supply system regarding its stated elements.

Table 6 Farmers' evaluative perception of formal seed supply system

	Perception scale					**Mean**
	SD(1)	**D(2)**	**N(3)**	**A(4)**	**SA(5)**	**score**
Likert items(Statements)	**F(%)**	**F(%)**	**F(%)**	**F(%)**	**F (%)**	
The formal seed system supplies a sufficient quantity of wheat seed.	85(41.9)	55(27.1)	11(5.4)	38(18.7)	14(6.8)	**2.22**
The formal seed system supplies wheat seed on time at planting season.	137(57.5)	35(17.2)	10(4.9)	16(7.9)	5(2.5)	**1.6**
The formal seed system supplies quality wheat seed.	20(9.9)	31(15.3)	30(14.8)	64(31.5)	58(28.6)	**3.54**
A formal seed system supplies wheat seed at a fair price.	75(36.9)	101(49.8)	9(4.4)	13(6.4)	5(2.5)	**1.88**
The formal seed system supplies wheat seed at an optimum distance.	38(18.7)	85(41.5)	24(11).8	31(15.3)	25(12.3)	**2.61**
A formal seed system provides seed information before the sale.	55(27.5)	62(30.5)	26(12).8	30(14.8)	30(14.8)	**2.6**
Cumulative Percentage	33.66%	30.3%	9.03%	15.76%	11.25%	
Aggregate mean						**2.4**

Note:SD=strongly disagreed, D=disagree, N=neutral, A=agree, SA=strongly agree and their value 1,2,3,4 and 5 respectively

Source: field survey,2023

The formal seed system supplies a sufficient quantity of wheat seed

The study result (table_6) reveals among sample respondents, the highest response frequencies 85 (41.9%) selected strongly disagreeing with formal seed supply systems accessing a sufficient amount of wheat seed for a wheat farmer. Also, their perception mean score falls in the disagreement interval (1.81-2.6). This implies that the formal seed supply system has not been

fulfilling the demanded quantity of grower farmers. Bishaw & Alemu, (2017) and Bogale et al., (2018) volume of seed supplied from the formal sector does not meet the required amount by farmers. As a result, they incur costs to obtain the demanded seed quantity from different localities and sources. Hence farmers dislike seed sources that lack the availability of seed in the required amount.

The formal seed system supplies wheat seed on time during the planting season

The study result(Table_6) indicates the majority of sample respondents, 137 (57.5%), strongly disagreed with the formal seed supply system delivering wheat seed at planting season. Their perception index falls within the range of 0-1.8, which strongly disagrees. This shows that, in contrast to the alternative wheat seed supply system, the formal seed supply system does not supply wheat seed during the planting season. They consequently had a negative perception of the system. Bogale et al., (2018) pointed out that farmers appreciate seed supply systems that provide the needed seeds on time because they relate the planting time to the local weather conditions forecast.

The formal seed system accesses wheat seed at a fair price

The result of the study (Table_6) reveals the majority of households 101(49.8%) said that the formal seed system does not provide wheat seed at the best price when compared to the local seed system, and the mean score value of their responses also fall within that range (1.81–2.6), this means that the formal seed supply system charges a high price for wheat seed. Bogale et al., (2018)showed that farmers perceive the seed source favourably, considering that it ensures the availability of high-yielding varieties and good quality seed at a reasonable seed price among the supplier

The formal seed system provides seed information before the sale

Concerning the wheat seed market information deliverance of the formal seed system, the highest frequency respondents 62 (30.5%) selected disagreement, and the perception index (mean score) was also at an interval of 1.81–2.6, which lay on the disagreement level. This implies that the formal seed supply system does not disseminate available wheat seed information to wheat growers before they buy the seed. Ullah et al., (2022), reported that extension agents are commonly not able to reach all farmers to deliver information on the prices and quality of new agricultural technologies appropriately. On the other hand, they mostly focused on model farmers by inviting

them to easily accessible extension information centers; this resulted in small-holder farmers having a lower awareness of improved agricultural technologies and having low trust and adoption.

Moreover, among six indicators in terms of sufficient seed quantity, seed supplying time, seed price, and seed information accessibility farmers negatively perceived the formal wheat seed supply system relative to the informal seed supply system but among the remaining two indicators regarding seed supplying distance farmers neither positively nor negatively perceived the supply system while farmers positively perceived seed quality of formal supply system. Besides, the highest cumulative percentage (33.66%)of the six indicators' frequencies indicated on strong disagreement point. Additionally, the summative mean score value of indicators is 2.4(Table_6) which falls under the range of disagreement. This shows that farmers negatively perceive the existing formal wheat seed supply system.

4.4. Factors affecting smallholder wheat-producing households' use of wheat seed sources in the study area

Before running the bivariate probit model fitness of the model was tested using the chi2 test. The chi-square distribution represents (108.27) with a p-value of 0.000 (Prob > chi2 = 0.0000), which is less than the 1% level of significance. This indicates variables included in the model to explain FWSS and IWSS for wheat source use fit the bivariate probit model at less than 1% probability level. Furthermore, it suggests that the joint null hypothesis that all of the explanatory variables included in the model had coefficients of zero was disproved. The bivariate probit model result (Table_7) rho is negatively and significantly different from zero at less than a 1% probability level; it implies that there is a negative correlation between the two seed sectors (chi2(1) = 33.4221, Prob > chi2 = 0.0000)

Out of 17 (seventeen) variables used in the model, seven variables (education, social position, seed accessing time, sufficient seed quantity, seed quality, credit use, and extension contact) significantly affected HH participation in FWSS at 1%, 5%, and 10% significance levels. Among them, education, social position, credit use, and extension contact positively affected HH's participation in FWSS, while the remaining three variables negatively affected HH's participation in FWSS(Table_7).

Regarding IWFSS, seven variables (education, social position, farm experience, seed price, credit use, extension contact, and seed market distance) significantly affected HH's participation in IWSS at 1%, 5%, and 10% significance levels. Among them, seed market distance and seed price significantly and positively HH's participation in IWSS, while the remaining five variables negatively affected HH's participation in IWSS.

Among seventeen (17) explanatory variables used in the bivariate probit model, five (5) variables (education, family size, seed quality, sufficient quantity of seed, extension contact) that are significantly and jointly affected farmers' participation in both formal and informal wheat seed sources identified(Table_7). But as the value of the correlation coefficient (rho) indicates, the two seed sectors have a negative relation to each other. Result of that interpreting their marginal impact together is difficult(impossible). Hence interpretation focused on the coefficient and marginal impact of the seed sectors concerning explanatory variables independently by leaving joint marginal impact interpretation.

Table 7 bivariate probit regression model result of factors affecting

Variables	FWSS[1] Coef.(Std.Err.)	FWSS[1] dy/dx	IWSS[2] Coef.(Std.Err)	IWSS[2] dy/dx	Joint dy/dx
Sex	-0.271(0.437)	-.1069597	-0.422(0.611)	-.040622	-0.148
Education	0.084(0.029)***	.0325314	-0.078(0.038)**	-.0097698	0.023**
Marital status	-0.298(0.331)	-.1152995	0.403(0.485)	.050772	-0.065
Socialpostion	0.407(0.233)*	.1556344	-0.700(0.311)**	-.0843913	0.071
Family Size	0.053(0.051)	.0204253	0.094(0.074)	.0118869	0.032*
FrmExperien	-0.002(0.021)	-.0007683	-0.044(0.026)*	-.0055499	-0.006
Supply time	-0.764(0.398)*	-.2970177	0.439(0.402)	.0712543	-0.226
Seed price	-0.462(0.309)	-.1816641	1.107(0.327)***	.2218186	0.040
Seed Quality	-0.895(0.306)***	-.3452745	-0.005(0.327)	-.0006024	-0.346***
Seed quantity	-0.452(0.271)*	-.1771009	-0.054(0.296)	-.0066705	-0.184*
Extn contact	0.285(0.054)***	.1102783	-0.187(0.058)**	-.0234853	0.087***
Credit Use	0.715(0.357)**	.2793446	-0.690(0.389)*	-.1255919	0.154
Total income	1.67e-06	6.46e-07	-2.66e-06	-3.34e-07	3.11e-07
Land Hold	0.021(0.156)	.0082867	0.003(0.188)	.0003403	0.009
TLU	0.026(0.056)	.0099224	0.048(0.064)	.0060474	0.016
Market informa	0.435(0.334)	.1604498	-0.046(0.352)	-.0056922	0.155
Market Distance	-0.179(0.234)	-.0694511	0.642(0.278)**	.088237	0.019
_cons	-0.054(1.128)		1.233(1.387)		
Rho			-1	1	

No of observation =203

Wald chi2(34) = 108.27

Prob > chi2 = 0.0000

Log likelihood = -125.02902

LR test of rho= 0: chi2(1) =33.422, chi2>prob=0.000, source: field survey,2023

Note: FWSS[1] represents for formal wheat seed supply source and IWSS[2] represents for informal wheat seed supply source. *** for significance at 1%, ** for significance at 5% and * for significance at 10%

Educational level: As indicated in Table_7, education significantly and positively affected HH participation in the FWSS at the 1% significance level. When HH's education increases in one year, they are more likely to participate in FWSS. The marginal impact result shows that when school attainment increased by one year, the probability of HH accessing wheat seed from FWSS increased by 3.25%. This is because HH, who had attained an additional educational year, increases the probability of understanding and analyzing the relative advantages of wheat seed sourced from formal seed sectors. This may have resulted from the higher probability of getting information from different written, electronic, and personal communications, which builds better knowledge about the advantages of using improved wheat seed delivered from FWSS. This finding is in line with the research findings of Tassew Arficho, (2017); Hagos & Hadush, (2017); Leake & Adam, (2015); Wosene & Ejigu, (2021) pointed out that when increasing the level of education the household would be well informed to use improved wheat seed and the utilization of other market opportunities tends to be higher, due to having wide information accesses and they eagerly to accept new ideas.

On the other hand, wheat producers' household educational level negatively and significantly affected their participation in the IWSS at a 5% significance level. When the school attainment of HH increases by one year, wheat-producing HH is less likely to participate in wheat seed delivery through IWSS. As a marginal impact result showing when school attainment increased by one year, the probability of HH participation on the IWSS decreased by 0.0097%. This is because they would have a higher probability of getting information about the comparative advantages of FWSS over IWSS regarding their wheat farm.

Social position: Social position significantly affects the probability of participating in wheat see d supply sources (formal and informal) at the 10% and 5% significance levels respectively. HHs who have a social position in kebele, community level, and religious institutions were more likely to participate in FWSS and less likely to participate in IWSS compared to HHs who have no social position in the community, kebele, or religious institutions. The marginal impact result shows that compared to HH who has no social position, HH who has a social position in society their participation probability increases by 15.6% in the FWSS. Whereas, when compared to HH who have no social position in society, HH who have a social position in society the probability of accessing wheat seed through IWSS decreased by 8.4%. This is because HHs, who have a social

position in their community, religious institutions, and kebele, have better access to capacity-building training and social affairs, including agricultural productivity improvement. These create better awareness about using improved wheat seed delivered through FWSS. The result is consistent with the finding of FOLA et al., (2020); and Jaleta et al., (2023) which explains that farm households who have a social position in their community have better access to capacity-building training and information on other social affairs, which creates a better understanding for the new technologies.

Farm Experience: The farm experience of HH negatively and significantly affects the use of wheat seed supplied through IWSS at the 10% significance level. When HH's farm experience increases by one year, he/she is less likely to participate in IWSS to get his/her wheat seed. The marginal impact result indicates that with a one-year increase in farm experience, the probability of wheat farmers' utilization of wheat seed delivered through IWSS decreased by 0.55% (Table_7). This is because when HH stayed longer in farming activity, they became more aware of agricultural farming practices like agronomy, farming frequency, soil condition, and input selection. This result is consistent with the findings of Amare Tesfaw (2015)**;** and Tassew Arficho (2017) showed that the longer a household head engages in farming, the better his knowledge about production systems as he acquires experiences of land use systems, land suitability, soil characteristics, and the right types of agricultural inputs including improved seeds because they developed advanced awareness of its benefits.

Seed supply time: Seed supply time negatively and significantly affects HH participation in FWSS to get their wheat seed at a 10% significance level. Compared to HH who do not perceive the delay of seed accessing time as a problem of the formal wheat seed supply system, HH who perceive the delay of wheat seed accessing time as a problem of the formal wheat seed system are less likely to participate in FWSS. As marginal impacts result (Table_7) reveals that compared to wheat-producing farmers who did not consider seed access time delay as a problem, HH who considered wheat seed accessing time delay as a problem probability of participation on FWSS were decreased by 29.7%, keeping other factors constant

This is due to farmers knowing based on agro-ecology and crop-specific planting calendar, which they relate to productivity, disease and pest prevalence, wild animal attack and rain distribution.

For that, they are very sensitive to the planting calendar of their crops. Hence they prefer to get seed during their planting season and if they face a delay in seed access time, they shift their seed needs to other alternative seed sources to meet their planting calendar. The result is consistent with the findings of Abebe & Lijalem, (2011); Begna et al., (2015); Yitayew et al. (2023); Kusse & Kassu, (2019), who indicated that farmers are very focused on their planting calendar hence they prefer the seed institution that delivers seed on their needed time but they complain formal seed supply sources due to it usually challenges them for seed delivery time to meet their planting calendar. The consequence of this majority of farmers search for information on alternative seed sources.

Wheat Seed price: Seed price positively and significantly affects wheat-producing HH participation on the IWSS at the 1% significance level. When compared to HH, who perceived that improved wheat seed prices were not expensive, HH, who said prices were expensive, more likely to participate in the IWSS to get their wheat seed. The marginal impact result indicated that when compared to wheat-producing HH who responded as improved wheat seed price not expensive, HH who responded as expensive, their participation probability on the IWSS increased by 22.2%. The higher price charged for improved seed may have resulted from the associated transaction costs of seed transportation and distribution from the regional seed centre to the kebele. On the other hand, farmers are rational sellers and buyers, and they commonly face financial problems, so they give more value for a small amount of market price difference. For that reason, they use IWSS to get a comparative seed price advantage. This result is consistent with the research findings of Tassew Arficho, (2017); and Yitayew et al. (2023) who indicated the price of improved wheat seed varieties is very expensive that, the farmers haven't used the required amount of improved wheat seed from seed suppliers.

Seed Quality: The seed quality problem negatively and significantly affects wheat farmers' participation in the FWSS at the 1% significance level. Compared to wheat farmers who said there was no seed quality problem, farmers who said there were quality problems unlikely to participate in the FWSS. Also, the marginal impact result (Table_7), reveals their participation probability on the FWSS decreased by 34.5%. Even if the formal seed distribution system has guiding procedures to control seed quality, the wheat seed quality problem is facing wheat producers. This problem may result from not operationalizing seed quality control procedures due to defects in controlling

and supervising tasks at seed institutions. So farmers who accessed seed from formal seed sources in one year did not prefer those seed sources for the next year. According to data from FGD and key informant interviews, farmers commonly face seed quality problems even if seed is accessed from formal seed sources. As they indicated, seed quality problems were evaluated at the germination rate, pest and disease tolerance, and productivity of crops. The result agrees with Kusse & Kassu, (2019); and Teressa (2019 showing that Ethiopia's formal seed system is unable to fulfil the the right quality seed to farmer.

Seed quantity: A shortage of sufficient wheat seed quantity negatively and significantly affects farmers' participation in the FWSS, at the 10% level of significance**.** Compared to HH, who said the shortage of wheat seed quantity was not a problem, HH, who perceived it as a problem, was unlikely to participate in the FWSS. The marginal effect result (Table_7) reveals that their participation probability on the FWSS decreased by 17.7%.

This may happen because the amount of seed that farmers can purchase from FWSS takes into account the amount of land held by the individual wheat farmer by considering its limited accessibility, but farmers are mostly practising land contracting and harvest-sharing farming practices. Hence, the way of getting wheat seed amounts exceeding farmer-head registered land amounts is not regularly permitted by FWSS as a regular practice. So farmers participate in other alternative seed sources that deliver the required seed amount without limiting purchase amounts. The result is consistent with the findings of Begna et al.,(2015); Bishaw & Alemu, (2017); Tarekegn & Mogiso (2020); Yitayew et al., (2023) showed that seed quantity provided from formal seed sources is quite low to meet farmers' seed demand due to the inefficiency of the formal seed system to produce and supply seed on time and the weak production and distribution processes along the seed supply chain.

Extension contact: Frequency of extension agent contact with wheat farmers positively and sign ificantly affects wheat farmers' participation in sourcing seed from FWSS at a 1% significance level. On the other hand, extension contact negatively and significantly affects wheat farmers' participation in sourcing seed from IWSS at a 5% significance level. When extension contact frequency increased by one number, wheat farmers were more likely to participate in FWSS and less likely to participate in IWSS to get their wheat seed. Extension contact frequency increased

by one number, the probability of farmer participation in FWSS increased by 11.02%, and the probability of farmer participation in IWSS decreased by 2.34% when keeping other factors constant (Table_ 7).

This is because when agricultural extension workers contact wheat producer farmers, they teach them about the relative advantages of operationalizing recommended wheat technology packages and the right sources of seed, which helps farmers have a better understanding of the advantages and increases their motivation to source their seed from FWSS rather than IWSS. However agricultural extension workers more frequently contacting and less frequently contacting farmers do not have equal awareness levels of FWSS. Thus, the contact frequency differences result in an awareness difference among wheat farmers. This result is consistent with the research findings of Haftu (2013); Leake & Adam, (2015); and Amare Tesfaw (2022) who pointed out that regular visits from an extension agent are necessary to increase participation rates in improved agricultural technologies by giving farmers the knowledge, skills, and information they need. This is due to contact with extension agents increasing availability of information about the improved technologies to farmers, hence farmers can learn more about the technology.

Credit use: Credit utilization by wheat farmers positively and significantly affects wheat farmers' participation in sourcing seed from FWSS at a 5% significance level. On the other hand, credit utilization by wheat farmers negatively and significantly affects wheat farmers' participati on in sourcing seed from IWSS at a 10% significance level. When credit utilization increased by one unit, wheat farmers were more likely to participate in FWSS and less likely to participate in IWSS to get their wheat seed. credit amount increased by one unit, the probability of farmer participation in FWSS increased by 27.9%, and the probability of farmer participation in IWSS decreased by 12.55% when keeping other factors constant (Table_7).

This may result in most of the farmers having a financial shortage to purchase all required inputs. So when credit is accessible to them their inputs purchasing power is stronger relatively, they prefer better inputs including seed for their wheat farm. The research result of Haftu, (2013); Bello et al., (2021); and Wosene & Ejigu, (2021)confirms that credit utilization is an important factor in the adoption of new agricultural technologies due to it builds the input purchasing capacity of farmers.

Seed market distance: Seed market distance positively and significantly affects wheat farmers' participation in IWSS at the 5% significance level. With a one-kilometre increase in improved wheat seed market distance, wheat-growing farmers are more likely to participate in IWSS. marginal effect (Table 7) shows, that as the improved wheat seed market increased by one kilometer, the probability of wheat grower participation in the IWSS increased by 8.82%.

This is due to the distance from the seed market to a wheat farmer's home becoming long, which creates high transaction costs. Hence, farmers mostly depended on near-distance alternative seed sources. FGD participant farmers indicated that improved wheat seed distribution occurs most commonly around woreda centers and is rarely delivered at kebele. Before getting seed, there is a repetitive round of trips starting with pre-paying, checking the arrival of seed, and seed-getting sessions. This repetitive trip consumes high transaction costs making wheat farmers select informal seed sources. This result agrees with the findings of Gedefaw & Sisay, (2020); and Yitayew et al., (2023)who indicated that distance to the main market is negatively correlated with farmers' participation in recommended wheat-producing packages because of the increased transaction costs associated with purchasing inputs. because of the additional transaction costs associated with the distance.

4.5. Impact of Improved Seed on the wheat Productivity of smallholder farmers

4.5.1. Factors affecting farmers' use of improved wheat seed

Before estimating the impact of formally sourced wheat seed (improved seed) on wheat productivity relative to informally sourced wheat seed (local wheat seed) probit regression was run to get the probability of covariance affects the use of formally sourced wheat seed (improved wheat seed) among participant farmers on improved wheat sources. The probit regression result (Table_8) shows, that twelve (12) variables were used, among them five (5) variables become statistically significant at 1%, 5% and 10% significance levels. From them, education, social position, and extension contact positively affect farmers' participation in formal seed sources (use of improved seed) whereas sufficient quantity and market distance negatively affect farmers' participation in formally sourced wheat seed (improved wheat seed).

The model result(Table_8) shows the model fitness, LR chi2(12) 131.87 with a p-value (chi2>P) 0.0000, which tells us probit regression model as whole statistically significant (model fitted wit

h variables) compared to the model with no predictors. Also, Pseudo R2 0.5636(56.36%), implies 56.36% of formally sourced wheat seed (improved seed) usage is explained by variables included in the model, which implies the model fitted with data.

Table 8 logit regression model output for factors affecting improved seed usage

variables	Coef.	Std. Err.	z	P>z	dy/dx
Gender	-.3776917	.6119985	-0.62	0.537	-.0931384
Education	1.175719	.2737595	4.29	0.000***	.2929126
SocialPo	1.279167	.5723999	2.23	0.025**	.3092161
FamilySi	.0156224	.0994444	0.16	0.875	.0038921
MarketDi	-.8944807	.5335581	-1.68	0.094*	-.2187581
Seedpric	-.3908522	.7286835	-0.54	0.592	-.0961135
SeedAcce	-1.290078	1.011169	-1.28	0.202	-.2851213
SeedQtity	-3.14171	.8072171	-3.89	0.000***	-.5615797
Extensio	.7952131	.1787493	4.45	0.000***	.1981153
CreditUs	.5725135	.9550654	0.60	0.549	.1381374
Totalinc	4.97e-06	4.65e-06	1.07	0.284	1.24e-06
LandHold	.0916044	.3055898	0.30	0.764	.0228218
_cons	-1.684002	1.862227	-0.90	0.366	

Number of observation=203
LR chi2(12) = 131.87
Prob > chi2 = 0.0000
Pseudo R2 = 0.5636

Source; Field survey,2023

Education: Education affects the use of formally sourced wheat seed(improved) positively and significantly at a 1% significance level. When education increased by one year, wheat farmers likely use formally sourced wheat seed (improved seed). Education increased by one year formally sourced wheat seed use probability increased by 29.29%. This is due to related to information getting probability of households increases with increasing educational year, it was more explained related to consistent findings (Table_7) regarding bivariate probit regression output.

Social position: The social position of HH positively and significantly affects the use of wheat seed sourced from formal sources (improved seed) at a 5% significance level. Compared to HH with no social position in the community, kebele and religious institution, HH has a social position likely to use formally sourced wheat seed (improved seed). Their participation probability in

formal seed sources increased by 30.92%. This is due to HH who have a social position in their community getting information access more frequently by attending capacity building training and other social issues as a representative, as a result, they know more about the advantages of using wheat seed delivered from formal sources. The issue is more elaborated and cited consistent findings (Table_7) related to bivariate probit results of the same issue.

Seed market distance: Seed delivering distance negatively and significantly affects the use of improved wheat seed delivered from formal seed sources at a 10% significance level. When improved wheat delivering distance is increased by one (1) kilometre, wheat-producing HH uses less improved wheat seed delivered from formal seed sources. Their participation probability in formal seed sources decreased by 21.87%. This happened due to wheat farmers preferred seed sources found in short distances by relating to increased transaction costs to get the improved wheat seed. This issue is a more elaborated finding (Table_7) relating to bivariate probit results.

Seed quantity: The shortage of seed quantity negatively and significantly affects the use of improved wheat seed delivered from formal seed sources at a 10% significance level. When the supply quantity of improved wheat seed from formal seed sources decreases by one unit, wheat-producing farmers are less likely to use improved wheat seed delivered from formal seed sources. Accompanied by a one-unit reduction in the quantity of improved wheat seed supply, the probability of wheat-producing HH using improved seed delivery from formal sources decreased by 56.16%.

Extension contact: Frequency of extension contact positively and significantly affects the use of improved wheat seed delivered from the formal wheat source at a 1% significance level. The frequency of extension agents' contact with wheat-producing HH increased by one number, HH was more likely to use improved wheat seed delivered from formal sources. Their participation probability in formal wheat seed sources increased by 19.81%. This implies that when extension agents contact wheat-producing farmers become more aware of the advantages of using improved wheat seed delivered from formal seed sources. Regarding the issue explained in detail (Table_7) relating to bivariate probit regression output.

4.4.2. Overlap and common support regions

After the estimation of propensity scores the next step is ensuring the existence of common support between improved wheat seed users and local wheat seed user farmers. Sufficient overlap in propensity scores for treated and control is required to ensure the estimation of treatment impact is not biased. To check the common support area and sufficient overlap of propensity score density kernel matching algorism was used. Accordingly, as shown (Table -9), the predicted propensity score for improved wheat seed users had a minimum of .048783 and a maximum of 1 with a mean propensity score of .7980889. On the other hand, the predicted propensity score for local wheat seed users had a minimum of .0000869 and a maximum of .9478141 with a mean propensity score of .185334. Thus, using the method of comparing the minima and maxima of the propensity score in both groups, the minimum propensity score of the improved wheat seed user was .048783 and the maximum propensity score of the local wheat seed user was .9478141, the common support region is (.048783 to .9478141). This means households with propensity scores less than the minimum (.048783) and larger than the maximum (.9478141) are off-support and not considered for matching and estimation of average treatment impact. Based on this, among 203 sample households,73(35.96%) sample households were out of the support region. This also implies the study has enough support region and satisfies the requirement of sufficient overlap and support

Table 9 Summary of propensity score

Treatments	**Mean**	**Std.**	**min**	**max**
Improved wheat seed user	.7980889	.2481981	.048783	1
Local wheat seed user	.185334	.2363376	.0000869	.9478141
Total	.4790213	.3905426	.0000869	1

Source: own survey, 2023

The density of the scores is shown (Figure _4). The densities of the propensity scores are on the y-axis and propensity scores are on the x-axis. As it is shown in the kernel density graph, the density distribution of estimated propensity scores for improved wheat seed user (treated) and local wheat seed user (untreated), the assumption of common support condition was satisfied, and there exists enough overlap in the distribution of propensity scores of the two groups. Treated in support region indicated that these households in the group of improved wheat seed user households found a suitable match from local wheat seed user households to estimate its impact appropriately,

whereas treated off support region indicated that these households in the group of improved wheat seed user household who did not found a match from local wheat seed user households.

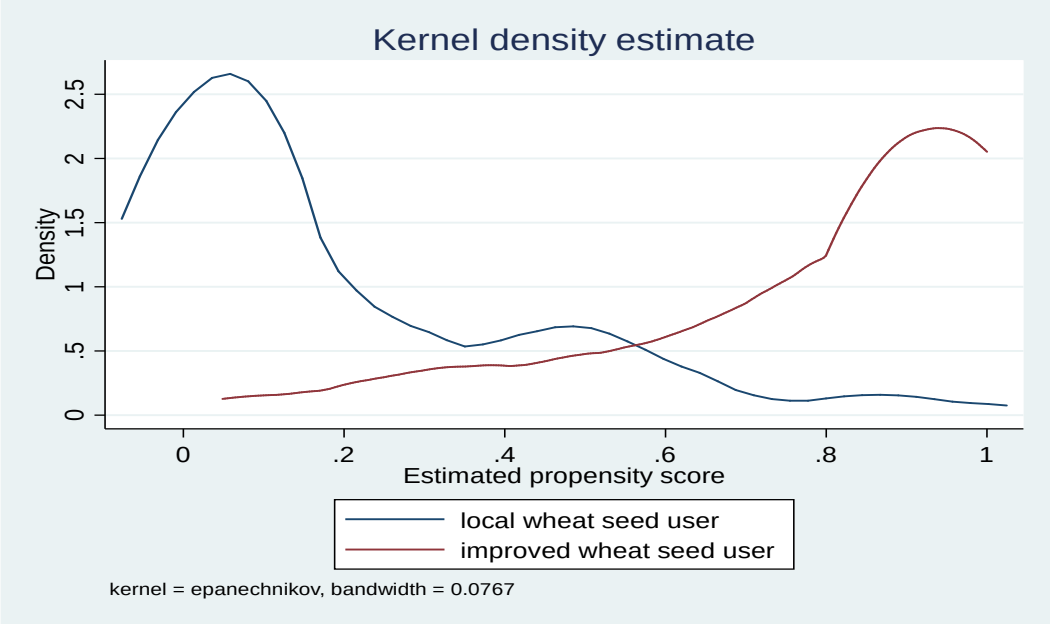

Figure 4 Kernal density graph of propensity score

4.4.3. Impact estimation (ATT) of formal wheat seed source (improved seed) use on productivity

After estimating propensity score, matching propensity scores(probability) between improved wheat seed delivered from formal seed sources (treatment group) and local wheat seed delivered from informal seed sources (control group) by using different matching algorisms, in fact, nearest neighbour matching, radius matching, stratification matching and kernel matching algorisms. Even if one matching algorism can show ATT of improved wheat seed delivering through formal seed sources, for the sake of the accuracy of the provided result three algorisms were employed. Also, one matching algorism (radius matching) was left due to a large number of sample households cut out at matching and the t-value was insignificant. To evaluate the impact (ATT) of using improved wheat seed on wheat productivity in 2014 wheat yield of sample HH was used.

Table 10 Impact of improved wheat seed on wheat productivity

Matching algorism	Treatment	Control	ATT	Std. Err	t
Nearest neighbour method	81	15	11.108	2.760	4.291***
Stratification method	81	49	11.08	4.032	2.456***
Kernel Matching method	81	49	10.86	3.395	3.214***
Average ATT			11.016		

Note: * significance at 1% significance level, Source: field survey,2023**

The study result(Table_10) reveals ATT of all matching algorism significant at a 1% significance level. Their ATT falls between 9.903 quintals of wheat productivity per hectare to 11.845 quintals of wheat productivity per hectare. As indicated in table ATT (average treatment impact on treatment) shows that improved wheat seed users (treatment group) gain an average additional 11.016 quintals of wheat productivity per hectare compared to control groups (local wheat seed user farmers), besides the t-test result shows that this impact was statistically significant at 1% significance level. This implies that using improved wheat seed delivered from formal seed sources has a positive and significant impact on household wheat productivity per area.

The result agrees with Tesfaye et al.,(2018) who indicated that improved wheat variety seed adop ted HH gains 30 up to 38% of wheat productivity advantages compared to non adopters. Tarekeg n & Mogiso (2020) indicated that compared to local seed user farmers, improved seed users had an estimated 35 % higher overall productivity per hectare. S. Tesfaye et al., (2016)reported that improved wheat technology adopters gain 10-11 quintals of additional wheat productivity per hectare compared to the non-adopters. Hagos & Hadush, (2017)indicated that the smallholder farms that had adopted improved wheat seed technology on their marginal farmland gained on average 14 quintals of additional wheat yield per hectare, compared to non-adopters. Melkamu et al., (2022) indicated that the impact of adopting rust-resistant improved wheat varieties increases on average 16.62 quintals of additional wheat productivity per hectare, compared to non-adopters. Belay, (2020), indicated that on average full adopters of improved wheat technology packages get significantly higher in productivity, ranging from 61 to 67%, than their counterparts, the non-adopters. Zeleke et al., (2022)showed that adopting improved wheat verities enhances on average 0.63 tons/ha wheat productivity per hectare, compared to non-adopters.

4.4.4. Simulation-based sensitivity analysis for Estimator

If there are unobserved variables(confounders) that simultaneously affect the assignment into treatment and the outcome variable, this hidden bias might arise to which matching estimators are not robust (Rosenbaum, 2002). Hence Sensitivity analysis of average treatment effect is important to check whether or not inference about treatment effects may be altered by unobserved factors. For this study, the simulation-based sensitivity analysis through the "Sensatt" package was used to assess the sensitivity analysis of estimators on the average treatment effects for unobserved covariates. In this way, the ATT of baseline (ATT with no confounder) and simulated ATT (ATT with confounder) were compared to check hidden bias(confounder). Accordingly (Table-11) the result reveals that the potential confounder (U) explains 1.123%,6%,10.3% and 11.4% of baseline ATT regarding algorisms of attr,attk, attnw, and attnd respectively. This implies the resulting ATT difference (wheat productivity difference among improved and local seed users) due to the usage of improved and local wheat seed. On the other hand, there is no or very small effect of other factors used that leads to wrong interpretation of treatment effect among wheat producers. Therefore, relatively all the matching output strengthens the outcomes' robustness

Table 11 Simulation-based sensitivity analysis for estimators

Matching algorism	Baseline ATT(A1)	Simulated ATT(A2)	Outcome effect	Selection effect	Absolute difference (A1-A2)	Difference percentage (A1-A2/A1)
attr	11.52	11.378	219.207	7.389	0.148	0.0123
attk	10.86	10.208	10.111	6.894	0.652	0.060
attnw	11.108	9.964	57754.008	6.699	1.144	0.103
attnd	11.108	9.844	15.301	6.709	1.264	0.114

Source: field survey,2023

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1. Summary

Seed is a fundamental unit to improve agricultural productivity but smallholder farmers are seed insecure. Hence this study was focused on the analysis of the wheat seed supply system in the Gedeo zone, to identify available wheat seed sources and actors, to assess farmers' evaluative perception of formal seed supply sources, to determine factors affecting farmers' utilization of improved wheat seed from formal sources, and to measure wheat productivity impact from formal seed sources.

A multistage sampling technique was employed to select sample woreda, kebele and Households. using the Yamane formula to determine sample size. Based on this, 203 sample households were selected from four kebele (Gubeta, Galcha, Dibadinbe and Kabeta Gubeta). The required data were collected through a questionnaire from sample households. checklist was used to collect key informant and FGD data. Socio-economic and demographic data of household, seed source and farmers' perception data were analyzed through descriptive statistics. Whereas determining factors of farmers' use of available seed sources were analyzed by bivariate probit and measured improved seed impact on wheat productivity analyzed by propensity score matching models. South and Ethiopia seed enterprises and Hawasa Agricultural Research Centre are identified as formal seed sources. Also, farmers and local traders are identified as informal wheat seed sources. Among Likert scale items seed quantity, seed time, seed price, and seed information fall in the negative range of farmers' agreement level while seed quality and seed supplying distance farmers' agreement level fall in the neutral range. Bivariate probit model output showed education, social position, credit use, and extension contact, the seed quantity, quality and access time of wheat seed significantly affected wheat-producing household utilization of improved wheat seed from formal sources. Propensity score matching model output shows improved wheat seed users gain on average an additional 11.016 quintals of wheat productivity per hectare compared to local wheat seed user farmers.

5.2. Conclusion

The study mainly focused on the analysis of seed sources and their impact on the wheat productivity of smallholder farmers. To conclude the issue statistical and econometric analysis tools were used. Based on their outputs the following conclusion was made.

Although formal wheat seed supply sources are important seed supply systems, the majority of smallholder wheat producer farmers commonly depend on informal seed sources in the study area. These sources specifically farmer-owned saved seed, farmer-to-farmer seed exchange and local market sales are important seed sources. This mainly is due to the limited availability of formal seed provider institutions in the area. On the other hand, some smallholder wheat producer farmers use wheat seeds from public seed institutions like seed access from South and Ethiopia seed enterprises and seeds provided by the Southern Agricultural Research Institute for research purposes.

Formal seed supply systems are typically designed to reduce farming households' seed insecurity by providing more reliable seed services, but regarding seed services they obtained from formal seed institutions farmers in the study area had a negative perception of the existing formal wheat seed supply system.

The bivariate probit model result showed education, social position, credit use, and extension contact significantly and positively affected wheat-producing farmers' use of improved wheat seed from formal sources. On the other hand, low seed quality, late supply time and shortage of seed quantity significantly and negatively affected wheat-producing household use of improved wheat seed from formal sources in the study area.

Smallholder farmers in the study area obtain their wheat seeds from both formal and informal wheat seed sources but there is a wide wheat productivity difference between improved wheat seed and their counterparts. As measured the PSM model result showed improved wheat seed has a positive and significant impact on household wheat productivity per hectare.

5.3 Recommendations

Based on major findings, this study recommends the issue be focused on the improvement of wheat seed access for smallholder farmers. In the process, the following points need to be considered.

1. To increase the horizon of improved wheat seed accessibility to smallholder farmers, woreda and zone agricultural development offices need to focus on the establishment of farmer seed cooperatives by creating awareness among farmers and inviting private seed enterprises.

2. Agricultural research institutes, seed enterprises and agricultural extension offices at regional, zonal and woreda levels need to pay attention to overcoming problems in formal seed supply systems which manifested mainly in late delivery, shortage of seed quantity, high prices, and information inaccessibility by creating a common communication and supervision platforms to improve the service quality of seed system to reach all wheat producers appropriately thereby to change their negative attitude toward the supply system.

3. The educational level and social position of smallholder wheat-growing farmers significantly affect the use of formal seed sources of wheat seed which is directly related to seed information access, so to reach all smallholder wheat-producing farmers through information access, agricultural extension personnel at the zone, woreda, and kebele levels, in addition to seed enterprises, must expand the scope of information dissemination through awareness creation training, experience sharing via field days and field visits, and accessing seed market information of improved wheat seed.

4. Frequency of extension contact positively affects improved wheat use by farmers, so to increase extension agents' support to smallholder farmers, agricultural extension personnel at region, zone and woreda levels need to work on supporting them by transportation means, building living rooms at the kebele center and employing periodic supervision teams for extension agents.

5. Credit use positively affects improved wheat seed usage by farmers, hence to increase the horizon of credit accessibility from governmental and non-governmental microfinance organizations to smallholder farmers, government bodies need to work on a policy framework that fits with farmers' conditions, particularly reasonable repayment time, farmers' asset fitting collateral and affordable interest rate to get credit.

6. Low Seed quality negatively affects smallholder wheat farmers' participation in formal wheat seed sources. Hence to improve seed quality, seed enterprises and supervising bodies of the seed system need to give due attention to strengthening wheat seed quality control and supervision tasks at each stage of the seed passing chain up to end users.

7. Improved wheat seed usage has a significant and positive impact on the wheat yield of smallholder farmers, however, late supply time and shortage of improved seed quantity of improved seed has significant and negative effects on its use by farmers. So to meet farmers' improved seed demand with sufficient quantity at the right time thereby enabling farmers to get appropriate economic benefit from their wheat farm, regional, zonal and woreda agricultural extension personnel and seed enterprises need to give due attention to adjusting improved seed delivery times by creating a strong communication and supervision linkage among seed actors. Besides policymakers need to pay attention to incorporating a new policy framework that encourages the entry of new seed enterprises and the expansion of existing seed enterprises' capacity by reallocating their structure to zonal and woreda levels.

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APPENDIXES

Appendix-I Questionnaire and Checklists

Questionnaire for data collection

Questionnaire for **Analysis of improved Wheat Seed Supply system** Gedeo zone, Southern Ethiopia

Introduction

Dear respondents, I am **Merknehi Bekele** student from Hawassa University College of Agricultu re, Department of Rural Development. I am conducting a study on „Analysis of Wheat Seed Supply System; the Case of Gedeo Zone **".** I would like to assure you that confidentiality will be maintained throughout the study (no identification such as the participant's name will appear in this study) and your honest answers to questions that will be asked are important for the results of this study. Therefore, I request your kind cooperation in responding to this interview for the completion of this study. Thank you in advance. For more information, please contact me through the following contacts:

Merknehi Bekele Cell phone: +251984187685

Email: merknehibekele@gmail.com

INSTRUCTION TO ENUMERATORS

1. Make a brief introduction to each farmer before starting any question, get introduced to the farmers (locally greet them), get his/her name, tell them yours, the institutions you are working for, and make clear the purpose and objective of your questions.
2. Please ask each question clearly and patiently until the farmer understands
3. Please fill up the questionnaire according to the farmers' reply (do not put your own opinion).
4. Please do not try to use technical terms while discussing with farmers and do not forget the local unit.

QUESTIONNAIRE IDENTIFICATION

Date of interview	
Time started at	
Questionnaire No.	
Enumerators' (Interviewer's)	Name:
	Cell phone:
Respondent's	
Name	
Cell phone	
Kebele	
Village (ketene)	
Altitude	
GPS coordinates	longitude: latitude :

Part one: Questionnaire for Individual respondent sample HH heads

Section A. Respondent's information/socio-economic characteristics

No	***Questions***		Resp
1.	Sex of the respondent 1. Male 0. Female		
2.	Age of the respondent in years_____?		
3.	What is your marital status 1. Single 2. Married 3. widowed 4. divorced		
4.	Family members	What is your total family size …….Male……Female…….	
		Family member below 15……Male……Female……..	
		Family members between 15&64……..Male…….……Female……	
		Above 64……Male……Female……..	
5.	What is your highest level of education? _____?		
6.	Landholding size in (ha)	Total land holding in (hectare)?_____	
		Annual crops (ha)? _____	

		Perennial crops (ha)?_____
7.	Amount of land size allocated for wheat production (ha)_____	
8.	How many quintals of wheat yield harvested from that area? _____quintals	
9.	How long you have been engaged in wheat-producing practice in (years?_____	
10	Which one of the following main purposes of growing wheat? 1. mainly for home consumption 2. mainly for market/cash income	
11	How many livestock do you have in number? 1. Cattle: _____ 2. Small ruminants: _____ 3.Equines: _____ 4. Others /specify:_____	
12	How do you describe your Socio-cultural position in the community? 1. Model farmer, 2. Ordinary farmer, 3. Kebele administrative member, 4. Religious/local leader	

Section B. Available chains and actors in seed supplying system

No	Questions			Resp
1.	Did you buy wheat seed every year? 1-Yes 0-No			
2.	Which variety is the most prevalent in terms of availability? 1-Local 2-Improved 3-Both			
3.	If local specify them……			
4.	Evaluate local wheat seed availability 1. Very scarce, 2. Scarce, 3. Not as required, 4. Sufficient, 5. Excess			
5.	If improved specify them			
6.	Evaluate improved wheat seed availability 1. Very scarce, 2. Scarce, 3. Not as required, 4. Sufficient, 5. Excess			
7.	Who are improved wheat seed suppliers in your area? Local trader 2. Agricultural office 3. Research center 4. NGOs 5. Private investor 6. Farmer cooperative 7.other(specify)_____			
8.	From whom did you access improved	Local traders 1-yes 0-no	Amount in kilograms	
			Price per kilograms	
			Amount in kilograms	

	wheat seed in last year?	Agricultural office 1-yes 0-no	Price per kilograms	
		Research Center 1.Yes 0.No	Amount in kilograms	
			Price per kilograms	
		NGOs 1-yes 0-no	Amount in kilograms	
			Price per kilograms	
		Farmers 1-yes 0-no	Amount in kilograms	
			Price per kilograms	
		Cooperatives 1-Yes 0-No	Amount in kilograms	
			Price per kilograms	
		Private investors 1-Yes 0-No	Amount in kilograms	
			Price per kilograms	
		Own save 1-yes 0-no, if yes, the amount in Kilograms		
9.	Where do they station? 1. In the kebele 2. In the woreda town 3. In the zone town 4. In the region town 5. Other_____			
10.	In what way do you get the wheat seed	Through purchase 1-Yes 0-No		
		Exchange 1-yes 0-no		
		Gift 1-yes 0-no		
		Other 1-yes 0-no		
11.	Have ever participated in the improved wheat seed-producing activity? 1. yes No			
12.	Have you ever participated in the participatory wheat varieties selection chain? 1. Yes 0.No			
13.	Have you ever participated in the improved wheat varieties promotion chain? 1. Yes 0.No			
14.	Have you ever participated in the improved wheat seed quality evaluating activity?1.Yes 0.No			
15.	Have you ever participated in improved wheat seed pricing activity? 1. Yes 0. No			

Section C. Factors affecting smallholder wheat producer farmers' access and use of improved wheat seed

No	Main information			Resp
1.	What are the main problems hindering the availability of wheat seed?	Unavailability of its seed 1-Yes 0-No	If yes, do you mean that you haven't got enough amount of wheat seed as you needed 1-Yes 0-No?	
			If yes, do you mean it is not available at reasonable sowing season?	
		Higher Price 1-Yes 0-No if yes, price per Kg_____?		
		Distance to its market 1. Yes, 2. No		
		Other(specify)_____		
2.	How often do you replace your wheat seed? 1) Every year 2) Every two years 3) Never			
3.	If you are using more than one year, how do you keep the quality of your seed? _____ ___			
4.	Do you get support from any public or private institution regarding wheat seed? 1-Yes 0-No			
5.	If yes for Q4 What kind of support do you get? 1- Improved variety 2-Fertilizer, 3-Agro-chemical, 4-Training. 5-Labour fee 6.others(specify)_____			
6.	Are there any quality-related problems faced you when you the seed you accessed 1-Yes 0-No			
7.	Rank quality of wheat seed 1. Very poor, 2. Poor, 3. Moderate, 4. Good, 5. Very good			
8.	How do you evaluate the wheat seed quality?	Seed with high germination percentage 1-Yes 0-No		
		The seed that is disease-free 1-Yes 0-No		
		Seed tolerant to pest and disease 11-Yes 0-No		
		Other (……)1-Yes 0-No		
9.	How do you see the price of improved wheat seed? Very expensive; 2. Expensive; 3. Fair; 4. Cheap; 5. Very cheap			

10	Have you got an improved wheat variety seed as your choice from available supply sources 1. Yes 0.No	
11	Have you gotten improved wheat seed market information before buying wheat seed? 1. yes 0 No	
12	If yes for Q12 from whom do you get improved wheat seed market information?1.Extsion worker(DA) 2. agricultural researcher 3.Cooperative 4. Local trader 5.NGO 6.Neighbour farmers 7. Mass media	
13	Have you gotten other inputs (agrochemical and fertilizer) on time when you required them? 1. Yes 0.No	
14	How do you see the price of fertilizer? Very expensive; 2. Expensive; 3. Fair; 4. Cheap; 5. Very cheap	
15	Did you face wheat disease last year? 1. Yes 0.No	
16	If yes for Q15 have you used agro-chemicals? 1. Yes 0. No	
17	If No for Q16 why you didn't use agro-chemicals? 1. inaccessible chemicals on time 2. high price of chemicals 3. my financial problem to purchase 4. technical problem to spray 5. others(specify)_____	
18	Did you get extension workers' technical support for your wheat-producing tasks?1.Yes 0 No	
19	If you yes for Q13.how many times extension worker contact you last year? _____days per year	
20	What is the distance of FTC from your home? _____in km	
21	What is the distance of the all-weather road from your home?_____in Km?	
22	Did you utilize credit for wheat seed? 1-Yes 0-No	
23	If yes, how much (in Birr)_____	

Income sources

	Sources	**Annual Income (in Birr)**	**No**	**Sources**	**Annual Income (in Birr)**
1.	Crop yield sale		1.	Sale of animal products	

2.	Livestock sale		2.	Sale of trees and other plantations	
3.	Non-farm income		3.	Income from remittances	
4.	off-farm income		4.	Aids	

Section D. Smallholder wheat producer farmers' evaluative perception towards the improved wheat seed supply system in the study area

No	**Statements**	**Strongly disagree (1)**	**Disagree(2)**	**Neutral (3)**	**Agree (4)**	**Strongly Agree(5)**	**Resp**
1.	The existing improved wheat seed supply system provides me with enough quantity of seed for my wheat farm						
2.	The existing improved wheat seed supply system provides me wheat seed on the required time for my wheat Farm						
3.	The existing improved wheat seed supply system provides me with quality seeds for my wheat produce						
4.	The existing improved seed supply system provides me with improved wheat seed						

	at fair prices for my wheat farm						
5.	The existing improved wheat seed supply system provides me with wheat seed at the nearest distance to my wheat farm						
6.	The existing improved wheat seed supply system disseminates wheat seed marketing information at the right time for wheat producers						

Part two: Checklist (questions) for Focus Group Discussion (FGD)

1. Who are improved wheat seed suppliers in your area?

   _____

   _____

2. What are the advantages and disadvantages of using formal wheat seed supply sources and informal seed sources(regarding seed accessing time, seed quality, disease, grain yield difference and seed price)_____

   _____

3. What are the challenges faced by farmers to use improved wheat seed from existing improved wheat seed supply systems related to seed market, seed information source, infrastructure, financial issues, seed accessibility and availability in your area?

   _____

   _____

4. How do you evaluate the existing improved wheat seed supply system regarding seed quality, accessing time, accessing seed amount, seed price, information information-delivering channels?

_____

_____

Part three: Checklist (questions) for Key Informant (KI) Discussion

Part-III questions for seed suppliers (seed enterprises, cooperatives, unions, research centres, traders)

Name of organization _____

1. From where do you get your pre-basic/basic/certified wheat seed?

   _____

2. For whom did you sell wheat seed last year?

   _____

3. What was the price of wheat seed you sold per quintal in last wheat_____?
4. Last year, how many quintals of wheat seed multiplication/accessing plan were there?

   _____

5. How many quintals of wheat seed were multiplied? _____
6. If there was a gap between multiplication/accessing plan and accomplishment, what were the main causes of the gap? _____
7. Have you ever faced basic/pre-basic seed shortage? _____
8. Have you ever faced seed quality problems with basic/pre-basic seeds you bought?

   _____

   How do you keep your seed quality? _____
9. How many quintals of wheat seed were sold? _____
10. 10. What are the problems/constraints related to wheat seed multiplication and delivering tasks?_____

Questions for key informants (kebele, woreda zonal experts and other stakeholders)

The name of the organization informant comes from_____

1. Who are available improved wheat seed suppliers and which chain of wheat seed supply channels have been farmers involved?

2. What is the total hectare of land allocated to wheat farms in your zone/woreda/kebele in the 2014/2015 production season? _____hectare

3. From it, how much hectare of land is covered by wheat seed? _____ha, among them land covered by improved wheat seed _____ha and local seed _____ha

4. If there was a gap between the plan and accomplishment of wheat farmland coverage, what were the main causes of the gap?

_____

_____

5. In the last year, how much was the delivery price of improved wheat seed per quintal? _____ETB

6. What are constraints related to improved wheat seed production, delivery, storage and use by farmers in your area?_____

_____

7. How do you evaluate farmers' attitudes on the existing improved wheat seed supply system regarding seed accessibility, availability, marketing and price-related issues in your area?

Annex-III, Biography

The author was born on September 10, 1993, in the Wolaita Zone, a kind of Didaye Woreda. He attended his primary school at Kindo Didaye woreda, Halale Primary School. He followed his Secondary school at Sodo General Academic and Preparatory School from 2008–2011. After completing secondary school, he joined Wolaita Sodo University, College of Agriculture, Department of Rural Development and Agricultural Extension in 2012 and he earned his BSc. degree in 2014. After his graduation, he was hired by the Southern Agricultural Research Institute (SARI) at the Hawasa Agricultural Research Center in the position of agricultural technology transfer and communication research. Then he joined Hawasa University to pursue his MSc degree in a program of rural development under the sponsorship of the Southern Agricultural Research Institute in October 2022.