ADOPTION OF IMPROVED SHORIMA WHEAT VARIETY AND ITS' IMPACT ON FOOD SECURITY IN ADIYO DISTRICT KAFFA ZONE, SOUTH WEST ETHIOPIA REGION

M.SC. THESIS

BY

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Adoption of Improved Shorima Wheat Variety and Its' Impact on Food Security in Adiyo District, Kaffa Zone South West Ethiopia Region

M.Sc. thesis

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Submitted to the school of graduate studies College of Agriculture and Veterinary Medicine, Department of Rural Development and Agricultural Extension in Partial Fulfillment of the Requirement for the Degree of Master of Science in Rural Development

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STATEMENT OF THE AUTHORS

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BIOGRAPHICAL SKETCH

The author was born in January 12, 1982 E.C in Worafa village Kejekata kebele Adiyo district from his father Deo Gunbaro and his mother Ayelech Angamo. The author had attended his primary education at Dula-lala primary school in 1990 E.C. He had attended his elementary and secondary education at Ameya high school from 1996-1999 E.C. After completion of secondary school education he joined at Agarfa ATVET College in 2003 E.C and graduated in plant science in July, 2005 E.C. After his graduation he was employed in Wolla rural kebele Adiyo district in plant science expert. After one year and ten months later; he joined Jimma University for his B.Sc. degree in 2008 E.C and graduated with agricultural extension and rural development in 2010 E.C. He had worked in Adiyo district agricultural office until he joined to Jimma University in 2014 E.C. for his M.Sc. Degree in Rural Development.

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LIST OF ABBREVIATIONS AND ACRONYMS

ADAO	Adiyo District Agricultural Office
ADAOR	Adiyo District Agricultural Office Report
AGRA	Alliance for a Green Revolution in Africa
ATA	Agricultural Transformation Agency
ATE	Average Treatment Effect
ATT	Average Treatment effect on treated
CIMMYT	International Maize and Improvement Center
CSA	Central Statistics Agency
E.C	Ethiopian Calendar
EEA	Ethiopian Economics Association
FANTA	Food and Nutrition Technical Assistance
FAO	Food and Agriculture Organization
FAOSTAT	Food and Agriculture Organization Statistics
FCS	Food Consumption Scores
FSIN	Food Security Information Network
GDP	Growth and Domestic Product
ICARDA	International Center for Agriculture Research in the Dry Areas
IFPRI	International Food Policy Research Institute
ISWV	Improved shorima wheat variety
IJAAS	International Journal of African and Asian Studies
ISFM	Integrated Soil Fertility Management
Kcal	Kilocalorie
KZAOR	Kaffa Zone Agricultural Office Report
m. a. s. l	meters above sea level
NBE	National Bank of Ethiopia
NGOs	Non-Governmental Organizations
OLS	Ordinary Least Square
PSM	Propensity Score Matching
PSNP	Productive Safety Net Program
SPSS	Statistical Package for Social Science

SSA	Sub-Saharan African
STATA	South Texas Therapy Association
TLU	Tropical Livestock Unit
USAID	United State Agriculture in Development
VIF	Variance Inflation Factors
WFP	World Food Program

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ABSTRACT

Adoption of improved wheat variety is the essential solution to combat food insecurity in Ethiopia. The aim of this study is to analyze adoption of improved shorima wheat varieties and its' impact on food security in Adiyo district. Systematic random sampling technique was used to select 4 kebele among 14 wheat producer kebeles. 302 sample household heads were selected by probability proportional to size for each kebeles'. Qualitative and quantitative data types with primary and secondary sources of data were employed for the study. Primary data were collected through household surveys, focus group discussions, and key informant interview, and secondary data were collected from development agents, office experts, published and unpublished articles, journals, and Google Scholars. Dummy and continuous variables were analyzed by descriptive statistics like frequency, percentage, chi square, and t-tests. Logit model examines the determinants of adoption of improved shorima wheat varieties and Propensity score matching was used to match improved shorima wheat variety adopters and non-adopter households. Descriptive result indicated that; among 302 respondents 46% and 54% were adopters and non-adopters households of improved shorima wheat variety in the study area. The model revealed that; the variables such as: family size, farming experience, credit use, and information access were positively determines the adoption decision of improved shorima wheat variety in Adiyo district whereas; the age of household head and the distance from the market were negatively affected the decision to adopt improved shorima wheat variety in the study area. The Propensity scores matched on kernel bandwidth 0.01. The average treatment effect on treated shows that; the mean food consumption scores for treated and controls was 30.14 &23.29 respectively. The result indicated that; the food consumption scores for adopter household heads were better than non-adopter households. The household food consumption score was improved by adopting improved shorima wheat variety. Therefore; Adiyo district administration office and Adiyo district agriculture, cooperative, and environmental protection office should collaborate on provision and give attention to improved shorima wheat varieties adoption that reduces the challenges of food insecurity in the study area.

Key words: ***improved shorima wheat variety, food consumption score, Propensity score matching***

1. INTRODUCTION

1.1. Background of the studies

Agricultural development is expected to have the potential of supporting in sinking poverty for 75% of the world's poor, who live in rural areas (World Bank, 2013). Agriculture is the backbone of most African countries (World Bank, 2013). The sector plays a significant role in ensuring food security and overall economic growth. It accounts for 40% of GDP, 75% of employment opportunity, and 80% of export earnings of the country (USAID, 2021).

Most of the rural communities in Ethiopia depended on agriculture; as the source of food and income (FSIN, 2017). Agricultural production is the bases for domestic food consumption and one of the mitigating mechanisms for the problem of food insecurity in Ethiopia (Milkias, 2020). Ethiopia is struggling to develop agricultural production and productivity to combat food insecurity. However, Ethiopia is frequently exposed to food shortages due to inappropriate use of improved technologies (Zerihun, 2016) and environmental variability, degradation of soil fertility, and ever increasing population (Ashenafi, 2008). Current food crises in Ethiopia are the failure to invest in sufficient local food production and the collapse of rural livelihoods. As a result, hunger and poverty are prevalent, which leads farmers to be chronically food insecure (FAO, 2015) and around 10 million chronically food-insecure people are targeted to PSNP (FSIN, 2017).

Cereals (such as wheat, corn, teff, sorghum, and millet) make up the bulk of crop production as the main staple food in Ethiopia (ATA, 2018). Among cereals wheat crop has been the most grown cereal crop in the world, and the amount produced is more than that of other cereals, feeding around 40% of the world's population (Acevedo *et al.*, 2018). It is grown on 1.6–1.8 million ha annually, with an estimated 5 million farming household's dependent on the crop (CSA, 2018). Ethiopia is a major producer of wheat in terms of total area grown and total production (CSA, 2017). The country is ranked first in production in sub-Saharan Africa (SSA), followed by South Africa, Sudan and Kenya (Tadesse *et al*., 2019). The major producing areas are mainly found in the mid-altitude 1900 to 2300 and high-altitude 2300 to 2700m.a.s.l regions of the country; that are regarded as high-potential environments due to

their high and reliable rainfall. From the total area of cultivated land in Ethiopia, wheat crop covers estimated to 73% while it provides employment opportunity for about 60% of rural people, and more than 60% of the total caloric intake of the country's population (Brasesco *et al.*, 2019).

Several studies suggested that, better agricultural technology adoptions have a substantial positive influence on household food security (Hailu *et al*., 2021). According to Leake and Adam, (2015), the use of improved variety is considered as the most important input for the achievement of agricultural productivity and food security status of farm households in Ethiopia. Furthermore improved technology adoption contributes significantly to food security by increasing yields and farm revenue (Khonje *et al*., 2015). Therefore, adoption of improved technologies for staple crop production is fundamental to the transformation of rural Africa, thereby to achieve food security, reduce poverty, and improve the well-being of millions of African poor households (Teklewold *et al*., 2013). Improved technological adoption contributes significant impact to food security by increasing yields and farm revenues (Shiferaw *et al.,* 2014; Khonje et al., 2015).

However; the provision of high productive agricultural technology can critically combat food insecurity and increasing the economy of the households'. According to Tolossa (2014), increasing yield and meeting the high demand has become the focus of the Ethiopian government's agricultural policy and extension activities. There is an interest to deliver farmers on the utilization of appropriate technologies to assure agricultural growth. Based on these; Ethiopian government provides ecological fit and high productive improved wheat varieties to assure food security. High productive improved wheat variety plays critical roles for reduction food insecurity in Adiyo woreda. Producing high yielding wheat technology is the mandate to ensure food security in Adiyo district. There are more high yielding wheat varieties such as; Check, ETBW 6095, Gossay, Hoggana, and Shorima were high yielding varieties (CMMYT 2011, Fano D. and Tadeos S., 2017). Among the high yielding varieties shorima was the highest yielding variety and fit with agro-ecology of Kaffa Zone especially in Adiyo District. Additional most of famers were prefer to produce shorima wheat variety in Adiyo district. It was produced in both high land and temperate land at an altitude between

1900-2600 m.a.s.l. Therefore, the study is expected to come up with the impact of improved shorima wheat varieties adoption on household food security in the study area.

1.2. Statement of the problem

Food security is one of the major challenges the World has been fighting for long (Menale *et al*., 2015). Food insecurity and malnutrition remain serious issues across the country, with an estimated 20.4 million people in need of food assistance currently (WFP, 2022). Recent data shows that close to 0.8 billion people in the World are undernourished (FAO, 2013). About 28% of these are living in sub-Saharan Africa and of which more than half are living in East Africa (FAO, 2015). The utilization of improved agricultural technologies is one of the priority areas of food security program in Ethiopia that reduces the risk of food insecurity crises, threats, and disasters (Berhane *et al*., 2014). Another studies by, Erkossa, (2018) agreed that the utilization of improved variety and fertilizers was increased by 25 % and 11 % over the last five years. In Ethiopia smallholder farming is the dominant livelihood activity and the source of vulnerability to poverty and food insecurity (Kidane *et al.,* 2006). Ethiopia has cultivated local varieties in most; that have resulted in low production and low disease resistant which is limiting the yield of the crop. The low production and productivity is the core problem that brought food insecurity for households, and country as whole. There is a responsibility on agricultural policies to increase the adoption status of improved agricultural technologies as strategies of enhancing production and productivity in the field of agriculture that required increasing wheat production and productivity, and to combat food insecurity in the country. The country has been following on various strategies for varietal development and replacement. Thus, more than 74 different improved wheat varieties have been released in Ethiopia to satisfy growing and cultivation demands of the farmers in Ethiopia (Moti *et al*., 2014).

Wheat was the mainly grown cereals in Adiyo district that has high potential by its' area coverage and production. The mainly cultivated seed in the district was; digelu, kekeba, Hidase, kumsa, and shorima. Among the improved wheat variety most farmers in the area prefer shorima wheat variety due to its suitability of ago-ecology and high. Suitable agro-ecology and high productivity of the variety has been initiated to conduct the study on

improved shorima wheat variety. Several studies are conducted so far on the adoption of improved technology and its' impact on households' food security in different part of the study areas. Of course, Endalel *et al*., (2019) looked food insecurity status and analysis of factors affecting food security in households of Amhara Regions; Muche M. *et at*., (2014), analyzed determinants of households' food security among south west Ethiopia rural households'; Wondim A. *et al*., (2022) studied determinants of food security status of household in Amhara Region; Adanech B. *et al*., (2023) seen status of household food security, its' determinants, and coping strategies in south western Ethiopia; Tesfaye M., (2012) impacts of adoption of improved technology on households' food consumption in South East Ethiopia. Another study by Hiwot and Degefu, (2022); Kassie, *et al* (2014), conducted on impact of adoption of improved wheat variety on households' food security in Oromia Region. Even though; they did not go far to exploring the adoption of specific wheat varieties, and its' impact on households' food security in Adiyo district. However, this study has initiated due to unavailability of the empirical data about specific shorima wheat varieties adoption, and its' impact on food security in study area. Hence, this study aims to generate the empirical data about the adoption of improved shorima wheat varieties, and its' impact on households' food security. The result of this study will add our understanding on food security and can inform on strategies for addressing food insecurity problem in the study area.

1.3. Objectives

1.3.1. General Objective

- To examine adoption of improved *shorima* wheat variety and its impact on food security in Adiyo district, South West Ethiopia Region.

1.3.2. Specific objective

- To assess the adoption status of improved *shorima* wheat variety in the study area
- To analyze the determinants of adoption of improved *shorima* wheat variety in the study area
- To evaluate the impact of adoption of improved *shorima* wheat variety on food security in the study area

1.4. Research Questions

This research prepares answers for the following research questions:-

1. What is the adoption status of improved *shorima* wheat varieties in the study area?
2. What are the determinants of adoption of improved *shorima* wheat varieties in the study area?
3. Does adoption of improved *shorima wheat* varieties impacts on food security?

1.5. Significance of the study

The findings of the study could provide detail information on the adoption status of improved shorima wheat varieties with its' determinants, and its impact on food security. Moreover; the findings were guiding: research institutions, development organizations, farmers, policymakers, and extension service providers. Also, the findings can provide future directions for those who are in the field of agricultural activities and other related areas of study. Furthermore, the study would provide directions on the adoption of improved technology and enhancing household food security.

1.6. Scope and limitation of the study

The scope of these studies did not cover all kebeles in Adiyo district. The studies were conducted in only four kebeles in the district. The study proceeded with demographic, socioeconomic, institutional, technological, and environmental factors that determine the adoption decision of farmers' to improved shorima wheat variety and its impact on food security in the district. The sampled HHs for the study was 302 respondents; among them 139 were shorima wheat varieties adopters, and 163 were non-adopter households in the study area. The household food security can be measured by different measures. However, this study was employed on food consumption scores/day as measures. The scope of the study would be limited by household coverage, materials, budget, and time.

1.7. Organizations of the paper

This thesis was organized in five chapters. The first chapter justifies the introduction and background parts. The second chapter explains about the review of relevant literatures. The third chapter describes the materials and methodologies of the study. The fourth chapter indicated the interpretation of the results of the study, and the last chapter, exploring about summary, conclusion, and recommendation.

2. LITERATURE REVIEW

2.1. Definitions and Concepts of Terminology

Adoption: refers to the stage in which a technology is selected for use by an individual or an organization. Many authors have defined the term adoption at different times. As defined by Rogers (1962), adoption is the decision-making process in which an individual passes from first hearing about an innovation to final adoption. Adoption is a mental process through which an individual passes from first knowledge of an innovation to the decision to adopt or reject and to confirmation of this decision (Rogers, 1962). According to Feder *et al*., (1985) adoption refers to the decision to use a new technology, method, practice, etc.by a firm, farmer or consumer. It is defined as the degree of use of a new technology in long run equilibrium when a farmer has full information about the new technology and it‘s potential.

As indicated by Dasgupta (1989), adoption is not a permanent behaviour. An individual may decide to discontinue the use of an innovation for different reasons such as personal, institutional or social, and the availability of an idea or practices that is better in satisfying his or her needs. However, adoption is either at a farm-level (individual) or at an aggregate level. Adoption at the individual's level is defined as the degree of use of a new technology in the long-run equilibrium when the farmer has full information about the technology and its potential uses while aggregate adoption is measured by the aggregate level of use of a specific new technology with in a given geographical area or within a given population. Therefore a distinction exists between adoption at the individual farm level and aggregate adoption within a targeted region (Feder *et al*., 1985).

Adoption of Agricultural Technology: The adoption concept is critical to evaluate the impact of agricultural technologies on food security. Thus an impact evaluation is possible especially for this study when farm households adopt agricultural technologies, especially improved shorima wheat varieties, and the concepts also help to analyze factors affecting the adoption of improved shorima wheat varieties to estimate the propensity scores.

Different authors have defined the adoption of agricultural technology in different ways. In the context of technological innovation, adoption is characterized as the process by which an

agricultural producer replaces a previously unknown process with another. This necessitates the development of new information and the alteration of its production function (Seré and Estrada 1990). According to Hailu (2008), the adoption decision also involves the choice of how many assets arrive to be allocated to the improved and traditional technologies if the technology is not separable. The area allocation and the level of utilization depending on the technology sort can measure the adoption of technology.

In the adoption process, farmers make preferences for technology that depend on different criteria. According to Tadesse (2008), before adoption choices are made, a farmer makes a set of several interdependent decisions. Generally, adoption is a decision made by farmers depending on different factors to adopt or not adopt the technology within a specified time and measured by area allocation based on innovation type. As a result, farm adoption refers to the realization of a farmer's decision to implement new technology. According to Hasan (1996), before adopting choices, a farmer makes a set of several interdependent decisions. Different factors and their associations influence the adoption decisions of different technologies across space and time. Factors such as personal, socioeconomic, institutional and psychological factors determine the probability of adoption of improved wheat technology. The adoption and diffusion of technology are two interrelated concepts describing the decision to use or not to use and the dispersion of a given technology among economic units over a period. Two approaches to agricultural technology adoption have been documented in the literature. The first stresses whole-package adoption, whereas the second emphasizes step-by-step or sequential adoption of package components. There is a great tendency in agricultural extension programs of developing countries to promote technologies as a package, and farmers are expected to adopt the whole package (Hailu, 2008).

According to Degefu *et al*. (2017), the Ethiopian government has been promoting a package-driven extension that combines credit, fertilizers, improved seeds, and better management practices. Adoption studies that depend on a single component of the innovation package have difficulty obtaining a clear understanding of the adoption of technology bundles. In general, adoption is a decision made by farmers to use or not use technology within a given time frame based on numerous factors and quantified by area allocation or level of use based on technology type. According to Yirga and Alemu (2016), rivals of the whole bundles approach

strongly argue that agriculturists do not adopt innovation as a package but rather adopt a single component or some appropriate innovation, and the sequential adoption of components of the technological package is a rational choice for farmers who have limited cash. The focus of this study was on impact assessment of adoption of improved wheat variety on food security. Additionally, Rogers (2003) defined adoption as a mental process through which an individual passes from first hearing about an innovation to final adoption. With regard to this idea, the adoption process includes five stages: awareness, interest, evaluation, trial and adoption.

Wheat: is one of the main cereal crops grown in different agro-ecology. It has been the most cultivated cereal crop in the world, and the quantity produced is more than other cereals, feeding about 40% of the world population (Adhiena, 2015). According to ECORDIS (2016), globally it is the leading source vegetal in human food, having protein content of 13%, which is relatively high compared to other major cereals and an important source of carbohydrates. These are essential nutrients needed by human being to have better health and to be active. It is a significant food for human nutrition, particularly in the developing countries where wheat products are primary foods (Shewery, 2015).

Improved *shorima* wheat varieties

Improved *shorima* wheat variety is released varieties that have the characteristics of early mature, high yield, and diseases resistance variety that released from kumsa research center in 2011 G.C (F. Dargo and Tadesse S., 2017). Having characteristic of; early maturity period, high amount of yield and dry season resistance (Dayrell *et al*., 2017). According to Cho (2013), improved seeds are defined by dividing them into pieces as open-pollinated seeds, which are those, produced from natural, random pollination. Hybrid seeds result from crossbreeding two parent plants that have desirable traits. Improved wheat varieties are drought resistant, early matured, high quality and high yielding. Improved wheat varieties together with improved agronomic practices have been introduced and disseminated to wheat farming communities in different parts of Ethiopia through the extension system operated by the government (Tsegaye and Bekele, 2012). Using quality seeds and other farm inputs can increase the yield potential of the crop by a significant fold and is the most economical input

to agricultural development (FAO, 2015). Improved agricultural technology adoption can help enhance quality and efficiency in the amount of output. They require technology adoption in agriculture, in addition to expanding factors' efficiency, to recover from the natural risks faced by the sector. Enhancing rural households‟ income and food security through improving access to improved agricultural technologies is a key development strategy in Ethiopia. Consequently, successive governments of Ethiopia have taken a keen interest in establishing, supporting and nurturing a dynamic national agricultural research system (NARS) capable of adapting and developing improved agricultural technologies suited to the diverse agro-ecologies and socioeconomic conditions of the country (Yirga and Alemu, 2016).

Concepts of food security: Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life". (World Food Summit, 1996) This widely accepted definition points to the following dimensions of food security.

Food availability: The availability of sufficient quantities of food of appropriate quality, supplied through domestic production or imports (including food aid).

Food access: Access by individuals to adequate resources (entitlements) for acquiring appropriate foods for a nutritious diet. Entitlements are defined as the set of all commodity bundles over which a person can establish command given the legal, political, economic and social arrangements of the community in which they live (including traditional rights such as access to common resources).

Utilization: Utilization of food through adequate diet, clean water, sanitation and health care to reach a state of nutritional well-being where all physiological needs are met. This brings out the importance of non-food inputs in food security.

Stability: To be food secure, a population, household or individual must have access to adequate food at all times. They should not risk losing access to food as a consequence of sudden shocks (e.g. an economic or climatic crisis) or cyclical events (e.g. seasonal food insecurity). The concept of stability can therefore refer to both the availability and access dimensions of food security.

Food security is having enough food in terms of quantity and quality for all people is an important factor for a healthy and productive life (FAO, 2014). Getachew, (1995) defines food security in the context of subsistence farmers as "ability to establish access to production resources such as land, livestock, agricultural inputs and family labor combined to produce food or cash. According to Hussein, (2013) food security is adequate availability and access to food for households to meet the minimum energy requirements as recommended healthy life. Furthermore, Jrad *et al*., (2010) elaborated on four dimensions of food security as availability, accessibility, utilization and stability. Food security analyzed at the household level is determined by a household's own production and members' ability to purchase food of the right quality (Meskerem, 2011). Household food security status was determined by: Demographic, bio-physical, productive asset/resources, infrastructural and socio-cultural factors.

Food insecurity is defined as a situation where people, individuals at all times, lack physical and economic access to sufficient, safe, and nutritious food needed to maintain a healthy and active life (FAO, 2010). It exists when people do not have access to an adequate and safe supply of food on a stable basis (FAO, 2005). According to Frongillo and Nanama, (2012) household food insecurity results when food is not available, cannot be accessed with certainty in socially acceptable ways, or is not physiologically utilized completely.

2.2. Theories of technology adoption models

Some of the models are widely used among practitioners, such as 'the diffusion of innovation' DOI, 'the technology lifecycle theory' and 'the rational choice theory'. Others are more commonly used in the academic world, such as 'the Theory of Reasoned Action' TRA, 'the Theory of Planned Behaviour' TPB, 'the Technology Acceptance Models' TAM, and the unified model UTAUT.

2.2.1. Diffusion theories

"Diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social system." (Rogers 1995), thus diffusion of innovation is the theory how, why, and at what rate new ideas and technologies spread

through a defined community. Rather than other theories the diffusion theories had gone to see the adoption rate of improved shorima wheat variety in Adiyo district.

Diffusion of innovation (DOI)

Most famous and most widely used is the diffusion of innovations theory from Rogers (1962); which has become the basis for widely used practitioner models. While he discusses a theory for innovations, which can be an idea, a practice, or an object, most of his examples are technological innovations (Rogers, 1995). According to this theory, many determinants influence the diffusion of an innovation. In order to capture this complexity, Rogers breaks the process down into a series of theories that interact to influence the diffusion process. The innovation, the communication channels or how information about the innovation is communicated, the innovation decision processes and the innovativeness of an individual, as well as the nature of the social system into which the innovation is being introduced. The speed of diffusion of an innovation depends primarily on the attributes of the technology, a good diffusion network that starts by word-of-mouth, and continues by imitation, supported by change agents and stakeholders (Rogers, 1995).

Innovation-decision process

The innovation-decision process is the process through which an individual or a decision-making-unit DMU of an organization passes through stages from first knowledge of an innovation, to forming an attitude towards the innovation, to a decision to adopt or reject, to implementation of the new idea, and to confirmation of this decision (Rogers 1962).

Rate of adoption

Variables that determine the rate of adoption include perceived attributes of an innovation, the type of innovation decision, communication channels, and the nature of the social system and change agents' promotion efforts ((Rogers 1995).

Perceived attributes of an innovation

Perceived attributes of an innovation states that potential adopters judge an innovation based on their perceptions in regard to five attributes of the innovation, which are: relative

advantage; compatibility, complexity, trialability, and observability. This theory says that an innovation will diffuse faster if one or more of the following factors apply: When the adopter perceives a relative advantage over other technologies or over not using the new technology; when the cognitive or sensitive concept of the innovation is compatible with existing practices and values; when it is not overly complex; when it can be tried on a risk- free basis; when its results can be observed, ideally prior to implementation (Rogers, 1995).

The nature of the social system

This aspect includes social norms and the diffusion networks, which represent the degree of network interconnectedness. Social systems are defined as "a set of interrelated units that are engaged in joint problem-solving to accomplish a common goal", and social norms are seen as established behavioural patterns for the members of a social system. Thus, they define a range of tolerable behaviour and they serve as a guide and standard for behaviour. Opinion leadership is addressed and the quality of network links is analyzed (Rogers, 1962).

An innovation starts with a slow, gradual growth before experiencing a period of relatively dramatic and rapid growth. This will then gradually stabilize and eventually decline (Surry 1997); can be classified into adopter categories dependent on when they first begin to use an innovation. Innovativeness indicates overt behavioural change, the degree to which the individual or other unit of adoption is relatively earlier in adopting new ideas than other members of a system. The curve starts with the innovators that are earliest to jump on a new technology, followed by early adopters, followed by an early majority, a late majority and at the end come the laggards. This means that statistically, a random sample of any given market or population must contain 2.5% innovators, 13.5% early adopters, 33.4% early majority, 33.4% late majority, and 16.0% laggards (Rogers, 1962).

2.2.2. Theories of food security

Demographic Theories Population Growth & Food Availability: Thomas Malthus, who developed the idea that rapid population growth linked to terrorism was a cause of food shortages (Malthus, 1798). The basic point of neo Malthusian theory is that the supreme power of society for general expansion must be governed by the demand for food and other

necessities of life, the production of which cannot always increase rapidly. Therefore, hunger and other forms of human poverty and suffering are inevitable consequences of population growth pressures on the limits of productive capacity (Millman and Kates, 1990). Boserup (1965) sees population growth as a force that enables the adoption and diffusion of technological innovations that increase agricultural production, thereby reducing the effects of food shortages and famine. He argues that the best effect of focusing on people is to invest as much as possible in infrastructure: water and irrigation, energy, transportation and productive technology (Boserup, 1965).

Neo Malthusian Theory and Theory of Access Connection to Food Security:

NeoMalthusian Theory Ehrlich, (1990); Ophuls (1992) expanded on Malthus' (1826) earlier hypothesis that population growth would increase faster than agricultural production. So society will fail to solve hunger problems. In this context, Neo Malthusians view agricultural production negatively, saying that a society cannot fulfill its capacity to support its inhabitants. Therefore, the most pressing problem facing food is food insecurity, which further hinders food access and use and increases poverty. Food availability is critical to preserving resources to support sustainable production and economic development.

The concept states that people may have the right to access certain resources. However, they may not have the ability to be efficient in using such resources due to lack of knowledge, capital, markets, markets, technology, identity, access to work and good relationships (Ribot, 2003). Access to produce can therefore improve the productivity and livelihoods of smallholder farmers, which inevitably contribute to sustainable food, supply (Liniger *et al*., 2011). However, inadequate access to productive crops can leave smallholder farmers facing food insecurity and vulnerable livelihoods (Mckay *et al*., 2016).

Climatic theory: drought and flood

Droughts or floods cause crop failure and can cause famine in rain-fed agricultural areas. Harrison (1988), states that 21 African countries experienced a serious drought between 1984 and 1985, which caused a serious famine on the continent at that time. Drought is reflected

not only in the reduction of production, but also in the negative effects it brings in terms of reduced rural employment and a sharp increase in food prices in the market.

Environment, natural resources and food production: Soil fertility is an important issue limiting agricultural productivity in sub-Saharan Africa from an agricultural perspective (Upton *et al*., 2020). Fertilizers are needed due to severe nutrient constraints in African agricultural systems (Upton et al., 2020: SSA, 1997). This has led to the development of the Sustainable Soil Fertility Management (ISFM) approach, which emphasizes the need for nutrient management and the use of crop residues and manures, as well as organic fertilizers (Sanchez, 2002). ISFM also believes that good crop varieties and agricultural management are important to increase productivity and efficient use of nutrients.

2.3. Empirical literature review

2.3.1. Wheat production and productivity in Ethiopia

Improvement of production requires paving the way to the problems that arise, and food demands needed because of increase in population. Thus, the current level of crop productivity might be difficult to feed the population in the developing world, especially in Africa, where the population is growing at an alarming rate (FAO, 2017). So, in the coming years feeding the whole population will be difficult in areas especially in Africa. The agricultural sector plays a significant role in ensuring food security and overall economic growth. It accounts for 40% of GDP, 75% of employment opportunity, and 80% of export earnings of the country (USAID, 2021).

Ethiopia is an agrarian country where more than 80% of the total population livelihood depends directly or indirectly on agriculture (Tsegaye and Bekele, 2012). Agriculture is the backbone of Ethiopia's economic development. Since Ethiopia continues to rely on subsistence farming, the state of this sector has a direct impact on economic growth, employment, food security, and the reduction of poverty (S Gebre-Selassie, 2023). Wheat crop is one of the most important cereals produced in the country as it provides approximately 15% of the caloric intake of the population of more than 90 million (FAO, 2015a). Ethiopia can be produced by both small farmers and large commercial farms (Tadesse *et al*., 2018).

Ethiopia is the second largest producer in sub-Saharan Africa after South Africa (FAO, 2015b). Therefore, sustainable enhancing wheat production and productivity is requiring significant attention to maintain food security and to feed the rapidly growing population (AF Senbeta, 2023).

Nutritional importance of crops: the total production on 232 million hectares worldwide is 721 million tones, accounting for 30% of cereal production, making the most important source of nutrition for humans (FAO, 2018). It is one of the most important of all cultivated crops, has the highest nutritional value among wheat, and remains an important source of nutrients for the human diet (Curtis, 2002). Its role in human nutrition places it in the first category among the world's food plants. It is the most important protein source in developing countries where 1.2 billion people depend on for their livelihood (CIMMYT, 2011). The world's major food crops have played an important role in feeding the world's hungry people and improving the world's food supply (Shifteraw *et al*., 2013). Total and per capita wheat consumption increased in Ethiopia. The most common use of is food approximately 10% of production is used for planting. The average household nutrition in Ethiopia is 200kcal/day in urban areas and 310kcal/day in rural areas. Food Security Situation in Ethiopia

Ethiopia is facing an enormous drought and food insecurity crisis over the period of the years. According to ADB (2014), Ethiopia is one of the most food-insecure and famine-influenced countries. Drought, poor adoption of technology, and traditional farming systems are recurring food shortages and famine is a major problem faced by Ethiopian people. Food insecurity has been a critical challenge to Ethiopia for decades. Efforts made during the past 30 years to improve food security status in the country have resulted in improvements both in food security and health. But, the problems of food security and nutrition, and health status is continued to be a challenge yet (USAID, 2019).

The food security situation in Ethiopia is highly linked to recurring food shortages and famine in the country, which is associated with recurrent drought, crop failure, land degradation, livestock disease, internal conflict and impact of COVID 19. According to FAO (2018), more than 29.1% of the Ethiopian population lives below the poverty line. As indicated by the Global Hunger Index (GHI) score Ethiopia still faces high level of food security, ranking as a

one of the hungriest countries in the world which is 32.1 million people. This makes it, the fourth African county scoring 35.1 percent of the population being undernourished in hunger (CSA, 2020:2021).

Despite the attempts made to improve the food security situation, the actual number of people exposed to food shortages in Ethiopia has remained significantly high. A rapidly increasing population, low technology adoption, slow productivity growth, and climate-related disasters such as droughts increase food insecurity. Thus, the agricultural sector of the country has been unable to produce sufficient food to feed the ever-growing population of the country. In recent years, commercial food import and food aid have been accounting for a significant proportion of the total food supply in the country (WFP, 2022)

2.3.2. Determinants of improved wheat technology Adoption

Factors determining technology adoption differ from one sector to another and from one place to another place. Especially, dealing with agricultural technologies where the sector has its own peculiar characteristics like seasonality of production and its high dependence on the vagaries of natures' makes it different from place to place. Moreover, there is a significant difference in terms of the characteristics of agriculture in developing and developed countries. In developing countries, the agricultural sector is characterized by its high dependence on natural phenomenon, highly constrained by shortage of resources and undertaken by less educated farmers. Adoption of improved technology was measured; by the status of farmers who adopted such technology in different areas. While the recommended levels of some technology components, were easily identified for estimating adoption levels (Abera, 2013).

Several factors have been found to affect technological adoption. These include market factors, demographic factors, and institutional factors. Therefore, in this study the determinants of adoption improved shorima wheat varieties can be influenced by their current status of demographic factors: - age of household, sex of household, family size, educational level of household and farm experience, institutional factors: - extension contact, participating on training, access to credit, distance to market, socio-economic factors: - total annual income, farm size, and livestock ownership (Degefu *et al*., 2017).

2.3.3. Impacts of improved wheat technology on household food security

In Ethiopia; the agricultural sector is the engine of development that propels the entire economy, evaluating the effects of the adoption of improved agricultural technology has high opportunities. Applying new agricultural technologies has a positive impact on a country's economic development. Several studies were conducted on the impact of adopting improved crop varieties and other supporting technologies demonstrate a positive impact on smallholder farmers' income generation, daily caloric intake, and food security. The use of improved agricultural technologies has intensified effect on household food security as evaluated by many indices, as shown in the literature studies that follows.

The study was used a cross sectional survey data that collected from selected sample households. Systematic random sampling technique was employed to select 139 improved shorima wheat variety adopters and 163 non-adopters from four sampled Kebeles in the study area. The previous study model output indicated that the adoption of wheat row planting by farmers in the study area was affected positively and significantly influenced by number of educated family member, use of improved seed and extension contact, but age of household and distance from development centers affected negatively and significantly adoption of wheat row planting. The study by Tesfaye *et al*. (2018) on impact of adoption of improved wheat varieties on crop productivity affirms that improved wheat variety has a positive and significant in crop productivity in smallholder farm household. The study by Misgana (2018) on impact of adoption of improved wheat varieties on crop productivity in Ethiopia asserts that adoption of improved wheat varieties crop productivity and the mean difference is statistically significant.

Several studies have undertaken in several areas on adoption of improved varieties in improving food security (Meskerem, 2011; Menale *et al*., 2014; Victor, 2016). The current research was undertaken in view of contributing to the endeavor of filling the empirical data gap on this topic area. Adiyo district is one of wheat producing district, which has benefited from researches on impact of improved shorima wheat variety on food security. The above studies indicated that the impact of improved wheat variety adoption on household food security in another area whereas; they did not go to analyze the impacts of specific improved

technologies on food security. However; this study has been designed to fill this research gap. Therefore; the result of this study provides available inputs with empirical data and identifying the impact of improved shorima wheat varieties adoption on food security in the study area.

2.4. Impact evaluation

2.4.1. Measurement of determinants of the adoption of improved wheat varieties

To study adoption behavior most commonly used models were logit and probit models (Feder *et al*., 1985). Logistic regression, sometimes called the logistic model or logit model, analyzes the relationship between independent and dependent variables and estimates the probability of a rate of an event by fitting data to a logistic curve. There are two models of logistic regression: binary logistic regression and multinomial logistic regressions. Logit regression analysis is a bivariate method that predicts a binary dependent outcome from a set of independent variables, allowing for the estimation of the probability that an event will occur or not. To study adoption behavior most commonly used models were logit and probit models (Feder *et al*., 1985). Logistic regression, sometimes called the logistic model or logit model, analyzes the relationship between independent and dependent variables and estimates the probability of a rate of an event by fitting data to a logistic curve. There are two models of logistic regression: binary logistic regression and multinomial logistic regressions. Logit regression analysis is a bivariate method that predicts a binary dependent outcome from a set of independent variables. As Hosmer and Lemeshew (1989) pointed out, a logistic distribution (logit) has advantages over the other in the analysis of dichotomous outcomes variable in that it is an extremely flexible and easily usable model from mathematical point of view and results in a meaningful interpretation. Therefore; logit model was selected to analyze adoption of improved shorima wheat varieties and its' determinants. The outcome variable food security of improved shorima wheat variety adopters and non-adopters households could be evaluated by different matching methods; of them some were followed bellow:-

Difference-in-Differences (DID): the method in which one compares a treatment and comparison group (first difference) before and after a project (second difference), it is panel

data-based. In this method program, impacts are estimated by calculating the difference in outcomes between treatment and control groups after program implementation minus the difference in outcomes between treatment and control groups prior to the implementation (Baker, 2000).

The regression discontinuity (RD): This method is used to estimate program impacts in situations in which candidates are selected for treatment based on whether their value for a numeric rating exceeds a designated threshold or cut-point (Jacob *et al*., 2012). It allows us to account for observed and unobserved heterogeneity. It initially assigns scores for the intervention unit and then compares the outcome of individuals above the cut-off point with a group of individuals below it. Individuals around the cut-off point are similar (Buddelmeyer and Skoufias, 2004). However, it remains impossible to make a true causal inference with this method alone, as it does not automatically reject causal effects by any potential confounding variable.

The instrumental variable (IV): This method deals directly with the selection of unobservable variables. The ATT of IV is identified if the researcher finds a variable, which affects the selection in to treatment but is not directly related to the outcome of interest of or with the unobserved variables that determine it. The main disadvantage of instrumental variables is capture only unobservable heterogeneity, but the assumption is that the parallel shift of the outcome variable can be considered a treatment effect (Shiferaw *et al*., 2014; Ahmed *et al*., 2017).

Propensity Score Matching (PSM): This method was pioneered by (Rubin, 1973). It consists of comparing the results of a treatment group (adopters) to a control group (non-adopters). For every unit in the treatment group, a match with the non-treatment group was performed. The choice of the match is dictated by observable characteristics. It is used when it is possible to create a comparison group from a sample of non-treated closest to the treated group using observable variables. Both groups are matched based on propensity scores and predicted probabilities of participation given some observed variables. The choice of the match is dictated by observable characteristics. The mean effect of the treatment can then be

calculated as the average difference in outcomes between the treated and non-treated units after matching (Ravallion, 2005).

Randomized selection methods (RSM): are the processes of randomly selecting both groups; treatment and control, from a clearly defined population to evaluate the outcome of an intervention. Based on this, the control group is similar to the treatment group, with the main difference being participation in the needed program (Abadie *et al*., 2004).

The endogenous switching model (ESR): It accounts for both observable and unobservable characteristics, thus controlling for a 'hidden bias that can arise while estimating the impact of technology. These methods enable us to reduce selection bias and assure consistent results by capturing both the observable and unobservable heterogeneity that influences the outcome variable (Shiferaw *et al*., 2014; Ahmed *et al*., 2017). Ignoring the endogeneity of adoption of improved technology would result in biased estimated parameters (Wabwile *et al.,* 2016).

2.4.2. Measurements of food security

Household food security can be measured by different methods; such as: Dietary diversity and food frequency Calorie Intake, Household Caloric Acquisition, Individual Dietary Diversity Score, Household Dietary Diversity Score, Food Consumption Score, Anthropometry, and Dietary Intake Acquisition.

Food consumption score: the index of diversity and balanced food consumption is called Food Consumption Score. Food consumption score is the core indicator of consumption and it is a composite score based on dietary diversity, food frequency, and relative nutritional importance of different food groups. It compares food consumption across geography and time, target households in need of food assistance, monitor seasonal fluctuations in food consumption, and provide key diet information (WFP, 2008). A complete analysis of food security should include more comprehensive measures of food availability and utilization. Food consumption score has been used in several report and analysis around the world apart from being the selected indicator for the most recent analysis of the food security in Yemen (WFP, 2008). Its' score is calculated using weighted frequency of consumption of nine food groups consumed by a household during the seven days before the study. The weights for

each group of foods are listed in the world food program-vulnerability assessment, monitoring and are based on the; nutrient density analysis. Higher or lower weights are assigned in terms of caloric density and macro and micro nutrient content (WFP, 2008: 2012).

1. Sum up all the consumption frequencies of foods belonging to the same food groups (there is a total of 9 groups, as listed in WFP's FCS guidelines). Recode the frequency value of each food group above 7 as 7 (e.g. if the summed up frequency value is 10, recode it as 7).

2. To create new weighted food group scores, multiply the value obtained for each food group by its "importance weight" specified in WFP's FCS guidelines.

3. Multiplying the value obtained for each food group by its' weight (the standard weights for main staples 2, pules 3, vegetables 1, fruit 1, Meat and fish 4, milk and dairy products 4, sugar 0.5, 0.5, condiments 0) and create new weighted food group scores.

4. Sum the weighed food group scores, thus creating the food consumption scores FCS) and classifying households with food consumption scores 0-21, 21.5-35, and >35 scores and above is characterized as poor, borderline, and acceptable household food consumption (WFP), 2008: 2012).

5. Calculate the percentage of households with "acceptable" FCS by dividing the number of households with FCS higher or equal to 35.5 scores by the total number of surveyed households and multiplying the result by 100.

Food Consumption Score is commonly used in World Food Programme food security surveys and monitoring systems. It is a composite score based on dietary diversity, food frequency (number of days during the past seven days) and the relative nutritional importance of different food groups, in particular considering protein quality content. The FCS aggregates household- level data on the diversity and frequency of food groups consumed over the previous seven days, which is then weighted according to the relative nutritional value of the consumed food groups. For instance, food groups containing nutritionally dense foods, such as animal products, are given greater weight than those containing less nutritionally dense foods, such as tubers. Based on the standard thresholds within a country context, households are classified into three categories of food group consumption: poor, borderline or acceptable.

According to a validation study conducted by WFP (Lovon and Mathiassen 2014), IFPRI associates the kcal cut-off of 2,100 to borderline FCS. The Food Consumption Score (FCS) aims at providing information on dietary diversity and access to caloric intake, helping to determine whether HHs have access to a diet of acceptable energy quantity and quality.

In order to compute FCS that are; comparable across different areas, the same weights should be adopted across all areas. If diets across areas are different, different cut-offs are adopted. In particular, if diets are rich in sugar and oil (i.e. both items are consumed every day), the cut-offs are increased by seven units, and therefore the lower threshold is 28 (rather than 21), while the upper threshold is 42 (rather than 35). The FCS cut-offs of 28 and 42 to be used when sugar and oils are eaten daily should be carefully applied after consideration of intake of oil and sugar. As a result, the standard numeric FCS cut-offs are the following: Acceptable >35, borderline 21.5 -35 and poor ≤ 21. In context with high sugar add oil consumption the corresponding cut-offs are: >42 acceptable, 28.5 – 42 borderline, and ≤ 28 poor. It is also possible to develop further cut-offs to account for other characteristics of local diets, although these two sets of cut-offs are the ones most commonly used. Same cut-offs of 'acceptable', 'borderline' and 'poor' are applied in both IPC Acute and Chronic analyses in order to keep alignment between the two classifications, and because alternative cut-offs do not exist for food consumption score.

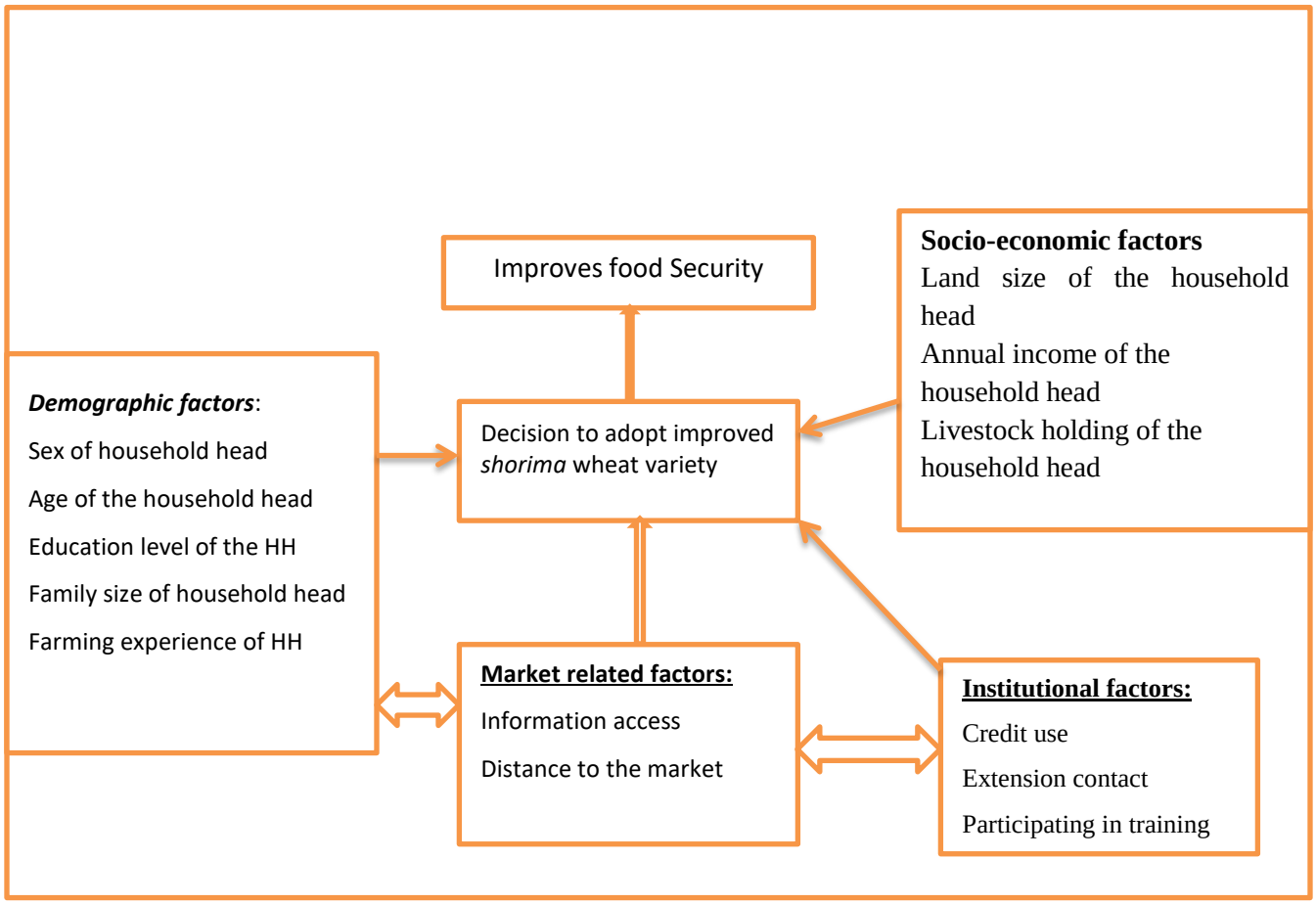
2.5. Conceptual Framework

Based on previous literature, a wide range of factors can determine the decision to adopt improved *shorima* wheat varieties. Increasing crop production is critical to improve income and for attaining food security (FAO, 2014). The variable that determines the adoption decision of farmers included socio- economic characteristics, institutional and market related factors (Tsegaye and Bekele, 2012; Shifera *et al*, 2014; Ejigayehu, 2016).

Below framework that shows the relationship of variables. The questionnaire in this study was developed through using dependent variables (adoption of improved *shorima* wheat varieties), outcome variable (Food Security) and independent variables included in the following framework. It consists of different socioeconomic, institutional, and market related factors that determine the adoption decision of improved *shorima* wheat varieties, thus determines the

scene of the households' food security. As depicted in the diagram the decision to adopt improved *shorima* wheat varieties which affect production could lead to improvement of food security.

Conceptual framework of the study



Conceptual framework: 1

3. MATERIALS AND METHODS

3.1. Description of the study Area

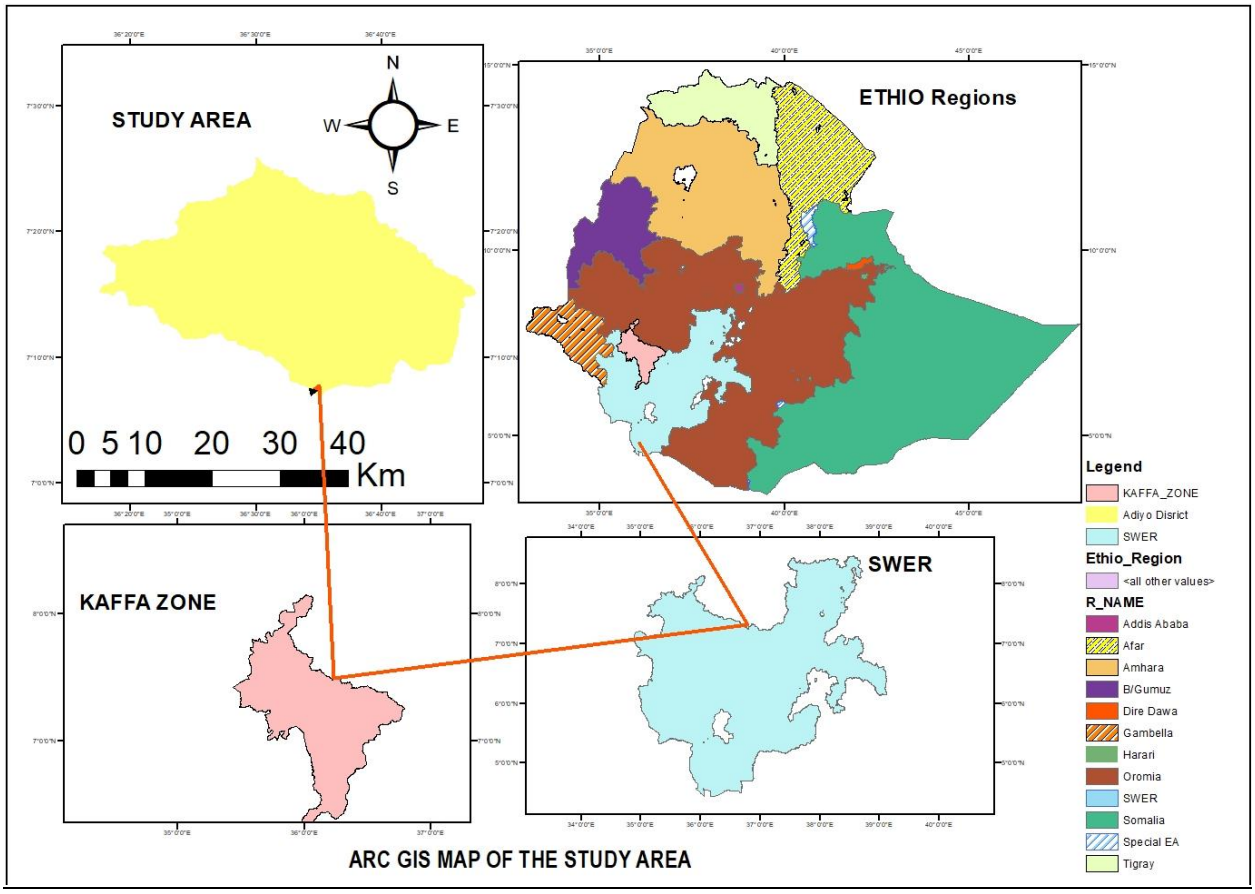


Figure: 2 Map of the study area

The study was conducted in South West Ethiopian Regional State Kaffa Zone Adiyo district. The town of Kaffa Zone is Bonga which is 451kilometres from Addis Ababa the capital of Ethiopia. It has 10602.7 square kilometer and it lies at an altitude ranging from 500-3500masl. The min and the max annual temperature of the zone ranges from 10.1 to 27.5°C and the min and max annual rainfall of the zone ranges from 1001 to 2200 mm respectively and it occupies three climate conditions such as: dega, Woina-dega, and cola. The average annual rainfall is 1750 millimeters. It has total population of 2,151,716, of whom 1,411,778 are men and 739, 938 women: 152, 036 or 7.44% are urban inhabitants CSA (2007). Kaffa Zone has seventeen districts. Among seventeen districts, Adiyo is one of the districts in Kaffa Zone;

where the study would be undertaken. It is bordered on the south by Telo, on the southwest by Decha, on the west by Gimbo, on the north by the Gojeb River and on the east by Konta zone and the town of the district is Kaka.

According to a 2004 report, Adiyo was 56 kilometers far from Zonal town. It found at latitude $7^0$16’60.0’’N and longitude 36^0 34’00.0E and the altitude between 1400-3069masl. Temperature ranges 3℃to 36℃with minimum and maximum rain fall of 900 & 1400 millimeter respectively. Total area is 1, 127, 127Km^2 with total population of 109,224, 559; men 53,405, 689 women 55,819, 870, out of the total population 2.65% are urban dwellers (Google scholar, 2023).

Agro ecologically the district has Dega 35%, Woinadega 55%, kola 10% and land use; permanent crop 18,847.425ha, farming land 31,728.75ha, unsuitable for farming activity 15,948.875ha, forest 25,152.25ha, others 3,315ha (Adiyo Woreda Agricultural Development Office report, 2022 G.C). Of the total area cereals in the year 2022/23 G.C was 20, 900.5ha: off this wheat account 5,617.375ha, Barley 2,309.875ha; Teff 5,249.875ha; Sorghum 799.625ha; Rice 19.875ha; Pearl millet 158.625ha, faba bean 4,120.875ha, and Pea 2,624.75ha (Adiyo Woreda Agricultural Office report, 2014). Major crops in the district include: Cereals, Tubers, Fruits, Condiments, and Coffee beans. Cereals were the main crops which grown in the Adiyo district. Among cereals wheat was the most grown crop in the district; especially improved shorima wheat variety. Adiyo district has high potential for improved shorima wheat variety production (KZAO 2022 G.C). There were many improved wheat varieties that were grown in the district; among them: Check, ETBW 6095, Gossay, Hidase, Hoggana, Kakaba, Shorima wheat varieties. From these all improved wheat varieties; the high productive wheat varieties were; Check, ETBW 6095, Hoggana, and Shorima wheat variety. Among the above improved wheat varieties; the district farmers had preferred improved shorima wheat variety due to its’ fit agro-ecology and high productivity. This motivates most households’ to grow improved shorima wheat variety. Furthermore; most of the households’ were preferred improved shorima wheat variety cultivation.

3.2. Research Design

Cross-sectional survey research design with both qualitative and quantitative methods would be employed. The study design would mainly depend on the objective and nature of variables collected from 302 household heads. In this regard, the qualitative data were designed to interpret the data source of interviews, focus group discussion, and key informant interviews. Whereas; the quantitative data were designed the collected data through questionaries' and express the relationship between variables.

3.3. Sampling design and procedure

Multi-stage sampling procedure was used for this study. In first stage the district was selected purposively by its' high wheat production potential (KZAOR, 2022/23 G.C). Secondly; due to its agro-ecology; 28 Kebeles' were clustered into high land and temperate land (ADAOR, 2022/23 G.C). From 2 clusters 4 Kebeles' were selected through systematic sampling techniques. The selected kebeles' were: 1st Boka and Mediwuta; 2nd Gindacha and Kochiyo. The first two kebeles were high lands ''dega'' and the second two kebeles were temperate ''woina dega'' respectively. In the third stage; 302 respondents were identified by PPS from sampled Kebeles'. Finally; 139 adopter and 163 non-adopters were identified by collected data.

Total population of the sample kebeles were used as the sampling frame and the sampling units were the household heads. Hence, to improve accuracy level, desired level of confidence with limited resources, desired margin error, the finite population is known Yamane sampling determination is proposed by Montaquila *et al*., (2011). To make it simpler and to compute the sample size without over estimating it; when the given population is known Yamane, (1967) proposed the following formula:

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

Where: n = the required sample size

N= Total population size in the study area; N=1,241; e: margin of error =0.05.

Therefore: Sample size determination: is follows as:

$$n = \frac{N}{1} + N(e^2);\ n = \frac{1,241}{1} + 1,241(0.05^2;\ \ n = \frac{1,241}{1} + 1,241(0.0025),$$
$$n = 1,241 + 3.105;\ n = \frac{1,241}{4.105};\ n = 302.31 \sim 302$$

Probability proportional to size

Probability proportional sampling is used in survey research when the sampling units vary in size. The size measure can be a measure of population size or geographical size of the sampling units or a composite measure for other related information about the sampling units, depending on the purpose of the survey.

This would be expressed by:

$Probability\ Proportional\ to\ Size = \frac{(n*s)}{N} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..2;\ n = number\ of\ population\ in\ individual\ kebele(HH), s = samle\ size\ of\ the\ kebele$

Table 1 Sample size (PPS) of the HH head in the sample kebele

Sampled kebeles	Population.	Probability Proportional to Size	Sampled Adopters			Sampled Non-adopters		
			Male headed households	Female headed households	Total household	Male headed households	Female headed households	Total households
Boka	342	83	26	9	35	36	12	48
Gindacha	383	93	28	13	41	41	11	52
Kochiyo	235	57	23	4	27	24	6	30
Mediwuta	281	69	30	6	36	23	10	33
Total	1,241	302	107	32	139	124	39	163

Source: own survey, 2023

3.4. Data type and sources

For the study; both quantitative and qualitative data types were collected from primary and secondary data source. Primary data gathering involves the incorporation of household survey, focus group discussion and key informant interview. Similarly, an observation technique was also utilized to verify the data. Similarly; primary data were gathered from:

Kebele elders, kebele kabines', Development Agents, District experts, and 302 sampled adopter and non-adopter households of sampled kebeles in the production year of 2022/2023 G.C. Secondary data were collected from Zonal Agriculture office reports, District Agriculture Office reports, relevant literature, organizational reports, published and unpublished articles, Journals, reviews, and Google Scholars. To ensure data quality, data collectors were well-trained, questionnaires were pretested, completed surveys were checked daily, logistic regression and PSM measuring models were employed and calibrated.

3.5. Method of data collection

3.5.1. Household survey

Household survey was questionnaires that were given to 302 sampled households in a population in the form of interviews. A survey could be used to collect data in the form of figure/quantitative data from sampled households. It was more costly both in terms of time and budget than that of the questionnaire and it was also more flexible. . Household survey and a direct observation was also utilized to verify the provided data on demographic, socio-economic, institutional, technological, and environmental factors on the adoption status, determinants of adoption of improved shorima varieties and its' impact on food security.

In this regard, interview was used to communicate directly with the sampled households. An interview had been successful; rapport was generally required and readily established when the interviewer was nonjudgmental, supportive, and understanding. We had achieved sufficient control over social interactions so that the interviews had more homogeneous. An exploratory method of interview had been good to generate ideas and hypotheses that was later be tested by the use of other methods. The data were collected through observation of household.

3.5.2. Focus Group Discussion

There was one focus group discussion for each of four sampled kebeles'. The FGD contains 8-14 members including kebele kabines', kebele elders, development agents, and development leaders. Group discussions were intended to foster collective and creative enthusiasm, which leads to the sharing of new ideas and concepts with an outsider who

becomes acquainted with them (Chambers, 1992). Four group discussions would be conducted in each of four sampled kebeles by using a checklist. During the focus Group discussion individual respondents have reactions of the concerning their detail experiences and their perceptions of the technology and their problem. Focus group discussion employed to bring common understanding in the same issues from different background by clarifying and cross-checking different ideas, opinions, experiences and arguments. Based on this ideas, opinions and arguments the detail information would be gathered and correct recommendation and conclusion that would be drawn for the study.

3.5.3. Key Informant Interviews

The key informants were selected based on their best backgrounds to participate in providing information to the study. Thus, the Interview was held with 7 (6 males and 1female) were selected from woreda Agriculture office (Extension communication expert, crop production experts, and development agents who work at kebele level. The key informants have been taken qualitative in-depth interviews with the sampled households that who know what has been happing in the community.

3.6. Method of data analysis

Descriptive statistics and econometric models were used to analyze the collected data from sample households. Data analysis was performed by using Statistical Package for Social Science (SPSS version 20) and Computer Software (Stata Version 13).

Quantitative type of data were analyzed by using frequency, minimum, maximum, mean and standard deviation, t-test, chi-square and binary logistic regression, odds ratio, and Propensity Scores Matching. Narrative and interpretation was applied for qualitative data collected from focus group discussion, key informants, and observation. Furthermore; Multicolinenary test was employed to check quality test of an exact linear relationship between two independent variables and outcome variables had perfect multicollinearity.

3.6.1. Descriptive statistics

The collected data were analyzed by descriptive statistics such as mean, frequencies; standard deviation, maximum, minimum, chi-square, and t-test were used to describe farmers' adoption status of improved shorima variety in the study areas.

3.6.2. Inferential Statistical methods

Inferential statistics such as the Chi-Square and t-test were run to measure the association between categorical variables with independent variable, whereas t-test was run to assess whether statistically significant differences exist in the mean values of continuous variables for adopters and non-adopters.

Household food security measurement

Household food security can be measured by different measures; such as: Dietary diversity and food frequency Calorie Intake, Household Caloric Acquisition, Individual Dietary Diversity Score, Household Dietary Diversity Score, Food Consumption Score, Anthropometry, and Dietary Intake Acquisition.

Food consumption score is a composite score based on dietary diversity, food frequency, and relative nutritional importance of different food groups. Its' composite score, measuring food frequency and dietary diversity, can be used in a variety of ways, including to: compare food consumption across geography and time, target households in need of food assistance, monitor seasonal fluctuations in food consumption, and provide key diet information (WFP, 2008). A complete analysis of food security should include more comprehensive measures of food availability and utilization. The index of diversity and balanced food consumption is called Food Consumption Score, is the core indicator of consumption. It has been used in several report or analysis around the world apart from being the selected indicator for the most recent analysis of the food security in Yemen (WFP, 2008).

The food consumption score is calculated using weighted frequency of consumption of nine food groups consumed by a household during the seven days before the study. The weights' for each group of foods are listed in the world food program-vulnerability assessment,

monitoring (VAM) and are based on the nutrient density analysis. Higher or lower weights are assigned in terms of caloric density and macro and micro nutrient content (WFP, 2008).

Having all this information, Food Consumption Score is calculated according to the following ways:

Sum all the consumption frequencies of food items of the same group, and recoded the value of each group above 7 as 7 then multiply the value obtained for each food group by its weight and sum of the weighted food groups scores.

Food consumption score is more complex indicator of a household food security status, as it considered not only dietary diversity and food frequency but also the relative nutritional importance of different food groups (WFP, 2008). According to the above empirical evidences; food consumption score is advantages over other measurements. Therefore; Food Consumption Score was used for this study to evaluate the food security status of improved shorima wheat variety adopter and non-adopter household.

Impact evaluation (PSM) methods

Propensity score matching (PSM) and Endogenous switch regression model are impact analysis models (KC Adjin · 2020). The results from two models are different. For selection bias correction: if the main concern is correcting for selection on observed characteristics, PSM is more appropriate (KC Adjin · 2020). Propensity score matching estimators are widely used to estimate treatment effects when all treatment confounders are measured (Rosenbaum and Rubin, 1983). Propensity score matching is one, increasingly utilized, method to help account for such imbalances, allowing for a more accurate estimation of the influence of treatment on outcome (JH Badhiwala · 2021). Propensity score matching (PSM) has several advantages over other methods of adjusting for confounding factors in quasi-experiments. It can reduce the dimensionality of the covariates, making it easier to balance them across the treatment and control groups. The observation was divided into two groups: the treated group, which received therapy, and the control group, which did not. Treatment D is a binary variable that determines whether or not an observation has received treatment. The treatment observation has $D = 1$ and the untreated observation has $D = 0$. PSM attempts to reduce the

bias due to confounding variables that could be found in an estimate of the treatment effect obtained from simply comparing outcomes among units that received the treatment versus those that did not (Paul R. Rosenbaum et al., 1983). It consists of comparing the results of a treatment group (adopters) to a control group (non-adopters). For every unit in the treatment group, a match with the non-treatment group was performed. Therefore, for its selection correction and bias reduction PSM is appropriate to this study for impact evaluation. PSM method used to match the adopters of improved *shorima* wheat varieties and non-adopter household.

3.6.3. Testing for Multicollinearity

Multicollinearity refers to the existence of more than one exact linear relationship, and collinearity refers to the existence of a single linear relationship. But this distinction selected variables into the logit model, it is necessary to check for the existence of multicollinearity among the continuous variables and verify the associations among discrete variables. The reason for this is that the existence of multicollinearity would be affected seriously the parameter estimates. If multicollinearity turns out to be significant, the simultaneous presence of the two variables would attenuate or reinforce the individual effects of these variables.

The coefficients of the interaction of the variables indicate whether or not one of the two associated variables should be eliminated from model analysis (Gujarati, 2004). In this study a Variance Inflation Factors (VIF (Xi) technique was employed to detect the problem of multicollinearity for continuous variables (Gujarati, 2004). Each selected continuous explanatory variable (Xi) is regressed on all the other continuous explanatory variables, the coefficients of determination (R2) being constructed in each case. If an appropriate linear relationship exists among the explanatory variables, then this should show up as a 'large' value for R2 in at least one of the test regressions. A popular measure of multicollinearity associated with the VIF (Xi) is defined as:

$$\text{VIF (xi)} = \frac{1}{1 - R^2} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots 3$$

Where, R2 is the coefficient of multiple determinations when the variable Xi is regressed on the other explanatory variables. A rise in the value of R2 that is an increase in the degree of multicollinearity, does indeed lead to an increase in the variances and the standard errors of the OLS estimators. A VIF value greater than 10 (this will happen if R2 exceeds 0.90) is used as a signal for the strong multicollinearity (Gujarati, 1995).

Similarly, there may be also interaction between two qualitative variables, which can lead to the problem of multicollinearity or association. To detect this problem, coefficients of contingency were computed from the survey data. According to (Gujarati, 2004), contingency coefficient is a chi-square based measure of association where a value 0.75 or above indicates a stronger relationship. The contingency coefficient is computed as follows: $CC = \frac{\sqrt{x^2}}{N+x^2}$ 4

Where, CC = Coefficient of contingency, n = total sample size and $\chi 2$ = a chi- square value.

3.7. Specification of Models

3.7.1. Logit and probit models

The logit and probit are the two most commonly used models for assessing the effects of various factors on the probability of adoption of improved maize technology. These models can also provide the predicted probability of adoption. The logit model follows a logistic distribution function, whereas the probit model follows a normal distribution function. Yet both models usually yield more or less similar results. As Hosmer and Lemeshew (1989) pointed out, a logistic distribution (logit) has advantages over the other in the analysis of dichotomous outcomes variable in that it is an extremely flexible and easily usable model from mathematical point of view and results in a meaningful interpretation.

The study would be attempted to identify factors influencing the decision to use or not use improved shorima wheat varieties by utilizing a logistic regression model. The dependent variable for this study is adoption of the improved shorima wheat variety and is a dummy variable that takes a value of one if the sample household would use improved variety during the survey period and before, and zero otherwise. The outcome variable is household food

security, which is a discrete variable for a single attribute the outcome Y is a scalar which can take only two values, assigned the values 0 and 1. In this case we have: Yi = 1 if households' food secures, Yi = 0 otherwise.

If the response of the i^th^ farmer to the question of adoption was denoted by a random variable Yi and a corresponding probability (i.e., probability of adopting improved variety or not by Pisuch that the probability of adoption (Yi = 1) = Pi and the probability of non-adoption (Yi − 0) = 1 –Pi the logistic model is specified by:

$$\text{Yi} = \beta 0 + \beta i Xi + Ui \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..5$$

Where:

Yi be a dichotomous outcome random variable with categories 1(adoption) and 0 (non-adoption); Xi denotes the collection of P - predictor variables; Ui Denotes to the error term, which has an independently distributed random variable with a mean of zero.
According to (Gujarati, 1995) the logistic distribution function for the adoption of improved variety can be specified as:

$$\text{pi} = \frac{1}{1 + e^{-zi}} = \frac{1^{zi}}{1 + e^{zi}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.6$$

Pi = is the probability of being adopter of improved varieties for the i^th^ farmers and it is ranges from 0-1(i.e. binary variable, p=1 for an adopter, p=0 for non-adopter).

e^{zi}=stands for irrational numbers, e for the power of zi,

zi = a function of n-explanatory (independent) variables which also expressed as:

$$\text{zi} = \beta 0 + \beta 1X1 + \beta 2X2 + \beta nXn \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 7$$

Where, Zi = is a function of n-independent variables β0 = is the intercept or constant term

β0 is the intercept (constant term), β1, β2 … βn are the logit parameters (slopes) of the equation in the model. X1, X2, Xn = explanatory variables. The slopes tell how the log-odds ratio in favor of adoption of improved variety changes as an independent variable changes. The unobservable stimulus index Zi assumes any values and is actually a linear function of

factors influencing adoption decision of improved variety. It is easy to verify that Zi ranges from -∞ to ∞, Pi ranges between 0 and 1 and that Pi is non-linear related to the explanatory variables.

3.7.2. Impact evaluation methods

3.7.2.1 Propensity score matching (PSM)

Two groups would be matched based on propensity scores predicted probabilities of participation given some observed variables (Abadie *et al*., 2004). Propensity score matching (PSM) is a quasi-experimental method in which the researcher uses statistical techniques to construct an artificial control group by matching each treated unit with a non-treated unit of similar characteristics. Using these matches, the researcher can estimate the impact of an intervention. In PS matching, a subject in the treatment group (adoption) is selected randomly and matched with an untreated (controls) group base on their propensity score (Rosenbaum PR, Rubin DB, 1983). The PS selection algorithm: **nearest neighbor, caliper, radius matching, and kernel method** (M Caliendo, 2005). The common implementation of propensity score matching is one-to-one matching, in which pairs of treated and untreated subjects have similar values of the propensity score. To generate statistically acceptable matched pairs between adopter and non-adopter, the PSM probability model was used. The logic behind propensity score methods is that balance observed covariates through careful matching on a single score (Thoemmes, 2012). PSM helps to adjust for initial differences between the two groups by matching each adopter unit to a non-adopter unit based on similar observable characteristics (Rosenbaum and Rubin 1983).

Numerous algorithms can be applied to match members and non-members of similar propensity scores. PSM model are sensitive to a particular specification and matching method (Imbens, 2004; Caliendo and Kopeinig, 2008). In order to estimate the average treatment effect on treated (ATT) by using PSM method the following steps such as estimation of the propensity scores, choosing a matching algorithm, checking on common support region, testing the balance of propensity scores and covariance before and after matching and sensitivity analysis were employed. There are four matching approaches in propensity scores: the nearest neighbor matching, caliper matching, the kernel matching, and the radius

matching. The nearest neighbor matching (NNM) algorithm was implemented with a caliper of 0.01. Specifically, the estimated ATT is: ATT (Z) = E [Y1 | M = 1, Prob (Z)] − E [Y0 | M = 1, Prob (Z)],

Where, Y1 represents the outcome indicator of the food secure, ATT=Average Treatment effect on the Treated, Y0 is the outcome indicator of food insecure; Mi is a binary variable that equals 1 if household is IWV adopter and zero otherwise. Finally, we checked the robustness of our estimates by using the Rosenbaum (2002) bounding approach. The main assumption behind matching is selection on observable variables. However, if there are unobserved variables that affect both adopter and the outcome variable, a hidden bias might arise and affect the estimates of matching estimators (Rosenbaum, 2002). In particular, the hidden bias could lead to both positive and negative unobserved selection. Rosenbaum's method is based on the sensitivity parameter that measures the degree of departure from random assignment of treatment. Two households with the same observed characteristics may differ in the odds of belonging to farmers by at most a factor of considering the upper bounds; the factors are incrementally computed until the threshold of 10% of p-values is reached. The relatively higher is the factor; the more robust is our model regarding hidden bias due to unobserved confounders. This sensitivity analysis is based on the Wilcoxon sign rank test. Propensity score matching step were: - propensity score estimation, choosing matching algorithm, checking for common support region, effect estimation and sensitivity analysis.

Estimation of propensity scores

The first step in PSM is estimation of propensity scores that derives for large sample distribution of PSM and proposes an adjustment to the large sample variance of propensity score matching estimators (Abadie and Imbens, 2009). It has been applied to achieve the adoption status and impact food security. Propensity scores estimation was employed by logit model for adoption of improved shorima wheat variety in treated (adopter) and control (non-adopter) households. Dependent variable was a dummy variable that takes a value of 1 for adopter (treated) household or 0 for non-adopter (control) households. The model has been used to match improved shorima wheat variety adopter and non-adopter households.

Choosing matching algorithm

The choice of matching algorithm was based by various methods of balancing test, the low Pseudo-R2 for all balancing test and highest frequency of matched sample size were used for selection of matching algorithm (Dehejia and Wahba, 2002). Balancing test means frequency of independent variables with no statistically significant mean differences between matched groups of treated and control households.

Checking the common support region

The common support region is the region that captures the minimum propensity scores of treatment and maximum propensity scores of control group of households. The common support region showed all characteristics observed in the treated group and among the control group (Bryson *et al*., 2002). The minimum and maximum values of adopters and non-adopters does not include in the matching.

Testing the balance of propensity scores and covariance before and after matching

After choosing the best performing matching algorithm and common support condition, the next step is checking the balancing of propensity score and covariate using different procedures by applying the selected matching algorithm. The balancing powers of the estimations are determined by considering different test methods such as the reduction in the mean standardized bias between the matched and unmatched households, equality of means using t-test and chi- square test for joint significance for the variables used. Accordingly; Rosenbaum and Rubin (1985), the standardized difference has been calculated, that is, the size of the difference in means of conditioning variables (between the adopter and non-adopters). Rosenbaum and Rubin (1985) recommend that a standardized difference after matching of 20% or more should be viewed as large.

Estimation of treatment effect on treated

Estimation of treatment effect on treated evaluates results on dependent variable of improved shorima wheat variety on the outcome variable of food security. The estimation employed by nearest neighbor, radius, kernel, and caliper matching; indicated the food consumption scores

for unmatched treated and unmatched controls and the food consumption scores of average treatment effect on treated (ATT) and for controls.

Sensitivity analysis for hidden bias

PSM controls for observable differences between treatment and control groups, but is vulnerable to unobservable differences (Smith and Todd, 2005). According to Dehejia (2005), sensitivity analysis is the final diagnostic that must be performed to check the sensitivity of the evaluated treatment effect to unobserved characteristics which affect both assignment in treatment and the outcome variable. Rosenbaum (2002) proposes that using Rosenbaum bounding approach in order to check the sensitivity of the estimated ATT with respect to deviation from the conditional independence assumption. If a given study is not affected by unobserved characteristics, the effect of unobserved variables is zero. As a result, the adoption probability determined only by observed characteristics. But, if there is unobserved bias, even if the two individuals with similar observed characteristics have different chance of receiving the treatment.

3.8. Definitions of Variables and Hypothesis

Defining the Variable is one of the tasks during the research work. The data would be included the essential information regarding to demographic, socioeconomic characteristics, institutional, and technological related points of production and determinants of adoption technology in the study area. Both continuous and dummy (categorical) variables were used. Based on this to investigate the research questions of this study, the following variables are identified.

3.8.1. Dependent Variable

Dependent variable is the adoption of improved *shorima* variety. It is a dichotomous/dummy in nature. It takes the value of 1&0, if the household head adopts improved shorima wheat variety takes 1, and otherwise 0.

3.8.2. Independent (Explanatory) Variable

The explanatory variables which hypothesized to have an influence on adoption of improved *shorima* wheat variety is; age of a household head, education level of the household head, family size of the household head, livestock holding of household, farm size, total annual income, farming experience, extension contact, participation in training, access to information, distance to market, and access to credit service.

Defining explanatory variables

Sex of Households: it is a dummy variable that takes the value of 1&0. Several studies suggested that; male headed household had better access to information and training which motivates male headed household to adopt improved technology easily than female headed household (Degefu, *et al.,* 2017). In this study male headed household hypotheses positively influence the adoption of improved variety.

Age of Households: It is a continuous variable measured by number of years. younger farmers were more eager to adopt modern technology than older farmers' (Adesina & Zinnah, 1993); due to younger farmers had more access to information and they characterized as innovative which enables them to make decision on adoption of new agricultural technology (Bonabana-Wabbi, 2002). The young age of households has positive influences on improved technology adoption.

Education status: education is a continuous variable measured in years of schooling. Education has been understood the means of production and productivity enhancement without extra-explanation. Educated farmer are better able to search and get information for appropriate technology to enhance their production (Mahdi Egge *et al*., 2012). Adoption studies by Bezu *et al.,* (2014); Rahman and Haque, (2013); and Khonje *et al.,* (2015) witnessed that adoption of a given agricultural technologies is positively and significantly affected by education level of the household head.

Household size: it is the continuous variable measured by 'adult equivalent'. It determines adoption decision, a larger household size have the capacity to relax the labor constraints

required during introduction of new technology (Mignouna *et al*., 2011). Larger family size has positive influences on new technology adoption.

Farm size: It is continuous variable measured by hectare. the adoption decision of improved variety was interrelated with large farm size (Solomon & Endrias, 2018); when the farmer had large farm size were adopted improved varieties easily and apply the technology on his/her own farm. If respondent has small farm size he/she has low preferences to adopt improved technology. This shows small farm size has negatively influences improved technology adoption.

Farming experience: It is a continuous variable that adjusted by frequency. According to (Gedefa, 2014), adoption decision of maize and teff technologies were significantly influenced by farming experience of the household head. Then more farming experience has positively influences technology adoption.

Extension contact: it is a continuous variable measured in frequencies of times. Household's contact with extension agents helps to adopt new agricultural technology (Simtowe *et al*., 2011; Bezabih, 2012; Awotide *et al.,* 2016). This indicated that high frequency of extension contact has positive influences on the adoption of improved variety adoption.

Total Livestock holding: It is a continuous variable that shows the total livestock unit. When the farmer had high number of oxen/cow he/she had adverse the risk easily and had adopted any new agricultural technology easily (Solomon & Endrias, 2018). This shows that high number of livestock holding has positively significant.

Participation on training: Participation is a dummy variable that takes the value of 1 and 0. The household has participated on training 1 and otherwise 0. Participating on training has been expected to positively influence farmers‟ adoption behavior (Mesfin, 2017).

Access to information: It is dummy variable that takes the value of 1 and 0. The household has access to information 1 and otherwise 0. Information access can contribute for facilitating advisory services with development agents. This result is consistent with the study by (Solomon *et al*., 2011) who find out that ownership of mobile phone positively and significantly affected agricultural technology adoption.

Distance to market: continuous variable measured by kilometer. If the households located near to market tend to buy improved agricultural inputs and they can have easy access to sell their product in the market and it was hypothesized to be positively related to the probability of adoption of innovation (Sisay, 2016).

Credit use: this is dummy variable that takes the value of 1 and 0. The household has credit access 1 and otherwise 0. The household that get credit had motivated to adopt technology (B. Kassa, *et al*, 2014). The credit use of the household head has positively significant to the adoption of improved variety.

Total annual income: The farm income refers to the total annual earnings of the family from the sale of agricultural produce such as the sale of crop, livestock and livestock product after meeting family requirements. This is believed to be the main source of capital for purchasing agricultural inputs. Thus, those households with a relatively higher level of farm income are likely to purchase improved seeds or other essential agricultural inputs (Alemitu, 2011).

Table: 2. Hypothesis of independent variables:

No	Variables	Nature of the variable/unit	Definition of the variables	Hypothesis
1	Sex	Dummy	If male=1; female=0	+/-
2	Age	Continuous	Age in year	-
3	Education status	Continuous	Measured in years of schooling.	+
4	Household size	Continuous	household size measured in adult equivalent	+/-
5	Farm size	Continuous	Hectares	+
6	Farming experience	Continuous	In year	+
7	Contact with extension agent	Continuous	Measured in frequency of day, week, and month	+
8	Livestock holding	Continuous	In TLU	+
9	Participation on training	Dummy	If participate on training: 1=Yes; 0=No	+
10	Information access	Dummy	If information access:1=Yes; 0=No	+
11	Credit use	Dummy	If credit use:1=Yes; 0=No	+
12	Distance to market	Continuous	Kilometer	-
13	Total annual income	Continuous	In Ethiopian birr	+

4. RESULT AND DICUSSIONS

4.1 Descriptive statistics

This chapter presented the results of analysis of the data collected through survey questionnaire, key informant interviews and focus group discussions. The first section about the descriptive statistics of the survey results, and the second part interpreted about the econometrics result based on the determinants of adoption of improved *shorima* wheat varieties and its impacts on food security. The socio-economic characteristics of the sample households analyzed and presented using statistical tool such as mean, standard deviation, frequency and percentage. Whereas, inferential statistics such as t-test for continuous variables and Chi-square test for dummy and categorical variables are utilized to compare adopters and non-adopter households. In addition, the impact of improved shorima wheat varieties on food security is presented by different matching algorithms.

4.1.1. Descriptive statistics for adoption status of the HH for iswv

In the production year 2022/23 G.C the district farmers' cultivated various cereal crops. The cultivated cereals were: beans, peas, barley, improved shorima wheat, local wheat, oat, sorghum, teff, and others. In production year 2014/15 Adiyo district totally; 68,085.75 ha land covered by different varieties of crops (ADAOR 202023G.C). Among total cultivated land coverage: beans 13,472.75 ha, peas 8,504.5 ha, wheat 18,521.625 ha barley 14,812 ha, teff 10, 850, and 2,824.875 ha others. Wheat was high cultivated crops in the district by its land coverage; of total improved *shorima* wheat variety cultivated land 8,122.5ha and the rest 10,399.125ha was local varieties and other improved varieties (ADAOR 2022/23 G.C). Therefore; in the district the productivity of improved shorima wheat varieties were high with the comparisons to other varieties. While; from total wheat cultivated land improved shorima varieties covered small hectare; the reasons for small area coverage and cultivation improved shorima varieties was raised at the time of focus group discussion, and key informant interviews. They respondents informed the problems; the unavailability and ecological appropriate varieties, fluctuation of price of inputs, unused of credit service, inaccessibility of roads.

Based on survey data collected in 2023; among 302 sample household heads 54% were non-adopters whereas 46% of the respondents were adopters of improved shorima wheat varieties

in the study area. Among non-adopter categories 76% were male headed households whereas 24% were female headed households. Among adopter categories 76.98% were male headed households whereas 23% were female headed households. The result revealed that, the percent of non-adopters were greater than non-adopter household heads in the study area. Thus the respondents on focus group discussion pointed out different problem for low number of adopters and their adoption rate on improved shorima wheat variety. In addition to the above the low adoption of improved shorima wheat variety in the study area were: - high price of inputs, no training for farmers, importing of the same varieties for different agro ecology, insufficient crop management techniques, no extension contact, and no round visit and no incentives for model farmers, and in-acceptance on application of new technologies were the major problems which reduced the adoption rate of improved shorima wheat variety in the study area.

Table3: Adoption status of the respondents

Variables	Sampled households		Male headed Household s		Female headed households	
	Freq.	%	Freq.	%	Freq.	%
Non-adopter	163	54%	124	76	39	24
Adopters	139	46%	107	76.98	32	23.02

Source: Own Survey result of 2023

4.1.2. Descriptive statistics for dummy variables

Participation in training: The finding pointed out; from the total respondents 197(65.23%) were trained and 105(34.77%) did not train. Among both groups 98 and 99 respondent had trained adopter and non-adopter respectively. Among both groups 64 and 41 respondent do not trained adopter and non-adopter respectively. The Chi2-test confirmed that the association between adopter and non-adopters had positive and was significant at 1% probability level (table 4).

Credit use: from total sample households 45.37% had credit users whereas; 54.63% households did not credit users. The survey result indicated that from non-adopters categories 81(49.7%) had credit user and 50.3% were not credit users while from the adopters 60.43% had credit users and 39.57 % had not credit users. The chi-square test shows; there is a

positive association between credit use and the adoption of improved shorima variety at a 1% significant level (table 4).

Information access: from total sample households 57.95% had information access and 42.05% had no information access respectively. Out of adopters 64.03% had information access and 35.97% had no information access whereas 47.24% non-adopters had no information access. The chi-square test shows that; there is a statistically positive association between access to information and the adoption of improved shorima variety and the variable is significant at 1% probability level (table 4).

Table 4: Descriptive statistics for dummy variables

Variable		Adopter households		Non-adopter households		Total sample households		X^2	P-value
		Freq.	%	Freq.	%	Freq.	%		
Sex of HH	Male	107	77	120	73.6	227	75.17	0.4534	0.501
	Female	32	23	43	26.4	75	24.83		
Participation in training	yes	98	70.5	99	60.74	197	65.23	5.256	0.002
	No	41	29.5	64	39.26	105	34.77		
Credit use	Yes	84	60.43	81	49.7	165	54.63	16.3	0.000
	No	55	39.57	82	50.3	137	45.37		
Information access	Yes	89	64.00	86	52.76	175	57.95		0.001
	No	50	36.00	77	47.24	127	42.05	10.11	

Own survey: 2023 data; Note: ***, ** represents 1% & 5% significance level respectively.

4.1.3. Descriptive statistics for Continuous Variables

Below table represents the results for continuous variables regarding household demographic characteristics.

Age of the household head: The mean age of the respondent was 43 years with Std. Dev. 11.05. The minimum and maximum ages of respondents were 20 and 85 years, respectively. The mean age of adopters and non-adopter households were 40.8 and 45.4 years, respectively.

The Std. Dev. of adopters and non-adopters were 9.33 & 11.95, respectively. T-test results revealed that, there is statistically significant age difference between adopter and non-adopter households' at 1% probability level.

Household size/number of family: The mean household sizes of the respondent household adult equivalents were 5.52 with Std. Dev. 1.598. The minimum and maximum adult equivalents were 1.75 and 7.75, respectively. T-test results revealed that, there is statistically significant difference between adopter and non-adopter households' on adult equivalent at a 1% significant level.

Distance of the household from the market: The mean distance of the respondent household head from the market was 6.03 km with Std. Dev. 2.67. The minimum and maximum distance of the respondents' household from the market was 1.25 and 15.69kms respectively. The mean distance of adopters and non-adopter household from the market was 4.75 and 7.12 km with Std. Dev. 1.79 and 2.82, respectively. T-test results confirmed that; there is statistically significant difference between adopter and non-adopter households' mean distance at a 1% significant level.

Annual income of the household head: The mean annual income of the household head was 24477.53birr with Std. Dev. 3843.938. The minimum and maximum annual income of the household head was 2100 and 30890 birr respectively. The mean annual income of adopters and non-adopter household was 25320 and 23759.11 birr with Std. Dev. 3709.371 and 3821.598, respectively. T-test results confirmed that; there is statistically significant difference between adopter and non-adopter households' on mean annual income of the household a 1% significant level.

Table 5: Descriptive statistics for continuous variables

Variables	Obs.	Mean	Std. Dev.	Non-adopter household		Adopter household		T-test	P-value
				Mean	Std. Dev.	Mean	Std. Dev.		
Age the household	302	43.3	11.04	45.4	11.95	40.84	9.33	3.6***	0.002
Education status of the household	302	2.04	1.05	1.895	0.997	2.22	1.09	-2.722	0.996
Family size the household	302	5.52	1.598	5.72	1.646	5.276	1.509	2.47***	0.007
Farm size of the household	302	5.439	2.07	5.445	2.098	5.43	2.044	0.044	0.482
Faming experience the HH	302	4.20529	1.017	4.0613	1.052	4.374	0.950	-2.6913	0.9962
Freq. of extension contact	302	0.543	0.499	0.534	0.5	0.554	0.498	0.1235	0.725
Market distance from the household	302	6.01	2.67	7.117	2.82	4.75	1.79	8.5***	0.000
Total Livestock holding of the household	302	5.82	1.63	5.85	1.62	5.79	1.65	0.317	0.375
Total annual income the household	302	24477.53	3843.938	23759.11	3821.598	25320	3709.371	-3.585***	0.0002

Own survey: 2023 data; Note: ***, represents at 1% significance level.
Note: obs. Means observation

4.1.4. Descriptive statistics for food consumption scores of the households

The descriptive result of the respondent household food security status has been measured by food consumption scores. The mean of the respondent household food consumption score is 26.45 per day. The mini and maxi food consumption scores of the respondents were 14.08 and 39.85/day. The mean food consumption score for adopter household is 30.16 /day whereas; for non-adopter households 23.29/day. The difference between adopter and non-adopter household of the respondent was 6.87. The adopter household food consumption score was 6.84 higher from non-adopter household food consumption score. There is positive mean difference between improved shorima wheat variety adopters and non-adopters food consumption scores; this difference resulted from adopting of improved *shorima* wheat varieties. This means that; if the adopters do not adopt the improved shorima wheat variety their food consumption score has decreases by 6.87%.

Table 6: Descriptive statistics for outcome variable (Food Consumption Scores)

Variable	Group	Observation	Mean	Std. Dev.	Mini	Maxi
Food consumption scores of the HH	Non-adopter	163	23.29	4.61	14.08	35.43
	Adopter	139	30.16	5.94	16.25	39.85
	Combined	302	26.45	6.38		
	Difference		-6.87			

4.2. Econometric test

4.2.1. Multicollinearity test

According to Gujarati (2004), before data analysis, the variables were tested for their multicollinearity, which is useful to omit variable with variance inflation factors (vif) value exceeds 10 that happens and show high correlation between variables. Based on this, the data were checked for the occurrence of multicollinearity problem for continuous variables were applied variance inflation factor (vif). If the value of vif exceeds 10, it is used as a signal for existence of strong multicollinearity between continuous explanatory variables. But the value of vif for continuous variable is less than 10. Accordingly, in this study; the mean vif for continuous variables were 1. The presence of multicollinearity was also checked for dummy variables by using Contingency coefficient. Contingency coefficients can be used to estimate the extent of the relationship between two variables, or to show the strength of a relationship. As a rule of thumb variable with contingency coefficient below 0.75 shows weak association and above indicates a strong association of variables. On this regards, the value of Contingency coefficient is 1.07(in appendix). This means that, there is no sign of the presence of multi-colinearity among the explanatory variables included in the model.

4.3. Determinants of adoption of improved shorima wheat variety in the study area

The logistic regression model was used to analyze the determinants of adoption of improved shorima wheat variety. The model result indicated that out of 13 explanatory variables six explanatory variables were significantly affected the adoption of improved shorima wheat variety in the study area. Those variables were: - family size, farming experience, credit use, and annual income of the household head has a positive and significant joint with adoption of improved *shorima* wheat varieties whereas; the variables: age of the household head and

distance from the market of the household head have negative joint with adoption of improved *shorima* wheat variety.

Age: the age of the household has a negative and significantly influences the adoption of improved shorima wheat varieties at 5% probability level. The odds result shown; as the age of the household head increases by one year, the probability of adoption of improved shorima wheat variety decreased by 1.099%. This means that; the older household head has low decision to adopt improved *shorima* varieties than younger age headed household. Older farmers are inactive to adopt improved agricultural technologies. The result is agreed with what has been reported by (Hailu *et al*., 2008; Zhera, 2014), as the age of farmer increases; their interest for improved agricultural technology adoption will decreases. The result found that there is a negative relationship between age and adoption of improved varieties.

Farming experience: A farming experience has positive and significantly affected the adoption of improved shorima wheat variety at10% probability level. The odds result implies; improved shorima wheat variety farming experience of the household head increases by a year; the probability of adoption of improved *shorima* wheat variety increased by 1.327%. Furthermore, the household who has farming experiences on improved *shorima* wheat variety; the household can easily adopt IWV than those households who have no farming experience of improved *shorima* wheat variety. This result is similar with finding of Tesfaye, (2001), the farming experience of the household increases the adoption decision of the household for improved shorima wheat variety has also increases.

Participation in training: the variable has positively significant at 5% probability level. The odds ratio result revealed that; a unit of participation in training increases the probability of adoption of improved shorima wheat variety by 2.266%. This implies that; the farmers who have participation in training have an advantage for the adoption of improved shorima wheat variety than that farmers who do not participating in training. The finding obtained from this study on participation in training of farmers is corroborated with the finding by (Tariku, 2012).

Market distance: the variable negative and significantly influences the adoption of improved shorima wheat variety at 1% probability level. The odds ratio result indicated that, when the

distance of the household head increases by one km; the adoption decision of the HH for improved *shorima* wheat variety decreases by 0.589%. This implies that; as the distance of the market increases; the adoption decision of the household will decrease. This result is in line with studies by Shifera *et al*., (2014); the farmer who has far from output markets is negatively correlated with adoption of improved agricultural technology.

Credit use: the variable positive and significantly influences the adoption of improved shorima wheat variety at 1% probability level. The odds ratio result indicated that, a unit increasing in credit utilization; increases the adoption of improved *shorima* wheat variety by 3.975%. The households that get the credit services can purchase easily improved agricultural inputs and they can avail for other purposes. Similar research result by Tesfaye, (2001); shows credit use is counted as a positive opportunity that increases the purchasing power of the households in the time of agricultural input buying.

Annual income of the household: the variable positively significant influences the adoption of improved shorima wheat variety at 1% probability level. The odds ratio result indicated that, an income of the household increases in one unit; the adoption of improved *shorima* wheat variety increases by 1%. The households that may obtain income from different source may have driven the use of new technologies since they can be used to buy different types of agricultural input. A similar finding by Hassen *et al*., (2012) stated that; households with higher income are more likely to enjoy better adoption and improve the capacity to adopt agricultural innovations.

Table 7: Logit model results for determinants of adoption of ISWV

Variables	Coefficient	Std. Error	Z	P>z	Odds ratio
Sex	.0945	.3494909	0.27	0.787	1.099121
Age	-.0377504	.0154211	-2.45**	0.014	.9629533
Education status	.1519402	.1530222	0.99	0.321	1.164091
HH size/no. of family	-.1372598	.0942608	-1.46	0.145	.8717437
Farm land size	-.0049	.080	0.06	0.951	.9951059
Farming experience	.2836649	.154609	1.83*	0.067	1.327988
Extension contact	-.0457297	.2983895	-0.15	0.878	.9553002

Participating in training	.6573674	.3003205	2.19 *	0.029	2.266296
Market distance	-.5287636	.0820742	-6.44***	0.000	.5893332
Credit use	1.380217	0.3797	3.63***	0.000	3.975763
Information access	.39	.319	1.23	0.219	1.480967
Total livestock holding	-1.112	.0915	-1.22	0.221	.8939142
Annual income	.0001089	.0000407	2.68**	0.0007	1.000109

Number of obs = 302, LR chi2 (14) = 190.08, Prob > chi2 = 0.0000, Log likelihood = -113.33508, Pseudo R2 = 0.4561
Note: ***' **' *represents 1%, 5% & 10% significance level respectively.

4.4. Impact of adoption of improved shorima wheat variety on household food security

4.4.1. Estimation of prospensity scores

The estimation of propensity scores that derives for large sample distribution of PSM and proposes an adjustment to the large sample variance of propensity score matching estimators (Abadie and Imbens, 2009). The steps in PSM followed by: propensity scores estimation, choosing matching algorithm, checking for common support region, effect estimation and sensitivity analysis. Propensity scores estimation was employed by logit model for adoption of improved shorima wheat variety in treated (adopter) and control (non-adopter) households.

4.4.2. Choosing matching algorithm

The next steps to estimation of prospensity score matching is the choice of matching algorithm. In this case the improved *shorima* wheat variety adopter households were matched with non-adopter households. The choice of matching algorithm was based by various methods of balancing test, the low Pseudo-R2 for all balancing test and highest frequences of matched sample size were used for selection of matching algorithm (Dehejia and Wahba, 2002). Balancing test means frequency of independent variables with no statistically significant mean differences between matched group of treated and control households. The following table shows that, the estimated results of tests for matching quality accordingly the above performance criteria. Therefore; kernel band width (0.01) is the best estimator for the data on hand based on the above criteria. Thus, the following estimation results and interpretations are the results from kernel band width (0.01).

Table 8: Matching algorithms performance criteria

	Balancing tests	Pseudo R^2 after matching	Matching sample size
Nearest Neighbor(NN)			
Neighbor (1)	14	0.060	302
Neighbor (2)	14	0.071	302
Neighbor (3)	14	0.075	302
Neighbor (4)	14	0.073	302
Neighbor (5)	14	0.083	302
Caliper matching (CM)			
Caliper 0.01	14	0.061	302
Caliper 0.1	14	0.060	302
Caliper 0.25	14	0.060	302
Caliper 0.5	14	0.060	302
Kernel matching (KM)			
With band width of (0.01)	14	0.045	302
With band width of (0.1)	14	0.443	302
With band width of (0.1)	14	0.443	302
With band width of (0.25)	14	0.443	302
With band width of (0.5)	14	0.443	302
Radius matching (RM)			
With band width of (0.01)	14	0.381	302
With band width of (0.1)	14	0.076	302
With band width of (0.1)	14	0.076	302
With band width of (0.25)	14	0.080	302
With band width of (0.5)	14		302

4.4.3. Checking the common support region

The common support region is the region that capture the minimum propensity scores of treatment and maximum propensity scores of control group of households. The common support region showed all characteristics observed in the treated group and among the control group (Bryson *et al*., 2002). The minimum and maximum values of adopters and non-adopters does not include in the matching. In this case; the mini and maxi of adopters and non-adopters pscores were 0.0134421 and 0.9458998 in which the common support would lies. Accordingly; 0.0134421 and 0.9458998 were excluded from this study.

Estimation of propensity scores

Groups	Obse.	Mean	Std.Dev.	Minimum	Maximum
Non-adopters	163	0.216454	0.2569001	0.0000352	0.9458998
Adopters	139	0.7461727	0.2327953	0.0134421	0.99635
Sum	302	0.602649	0.3609787	0.0000352	0.99635

Below tables evaluated, the total treated observation 32 households (10.6%) were off support, whereas 270 households (89.4%) were on support and all the control households were included in the common support region. The graph shows the estimated propensity scores for adopter and non-adopter households. The bottom half of the graph and the upper half of the graph represents the propensity scores distribution for the non-adopters and the adopters respectively. Every treated group is matched only with the control groups whose propensity scores fall in to a predefined common support regions of the propensity scores matching.The households that does not lies in this region are discarded from the analysis because of 32 treated households are excluded from the analysis.

In the table 9 below, out of treated groups 32 households (10.6%) are off support, whereas 107 households (89.4%) are on support and all the control groups are included in the common support region.

Table 9: Psmatch2 of common support region

Psmatch2 treatment assignment	Common support		
	Off support	On support	Total
Untreated(non-adopter)	0	163	163
Treated (adopter)	32	107	139
Total	32	270	302

Source: Output of stata13(2024)

An important step in assessing the quality of matching is to perform tests that check whether the propensity score adequately balances characteristics between the treatment and control group.

Figure: 3 below gives the histogram of the estimated propensity scores for adopter and non adopters of improved shorima variety. The histogram of propensity score is used to check up if there is enough overlap between treated and control groups. In this case the density distributions of the estimated propensity scores for two groups indicates that the common support condition is satisfied: there is substantial overlap in the distribution of the propensity scores of both adopter and non-adopter groups. The bottom half of the graph shows the propensity scores distribution for the non-adopters and the upper half presents the adopters and the densities of the scores are on y-axis.

Figure 3: Propensity score matching

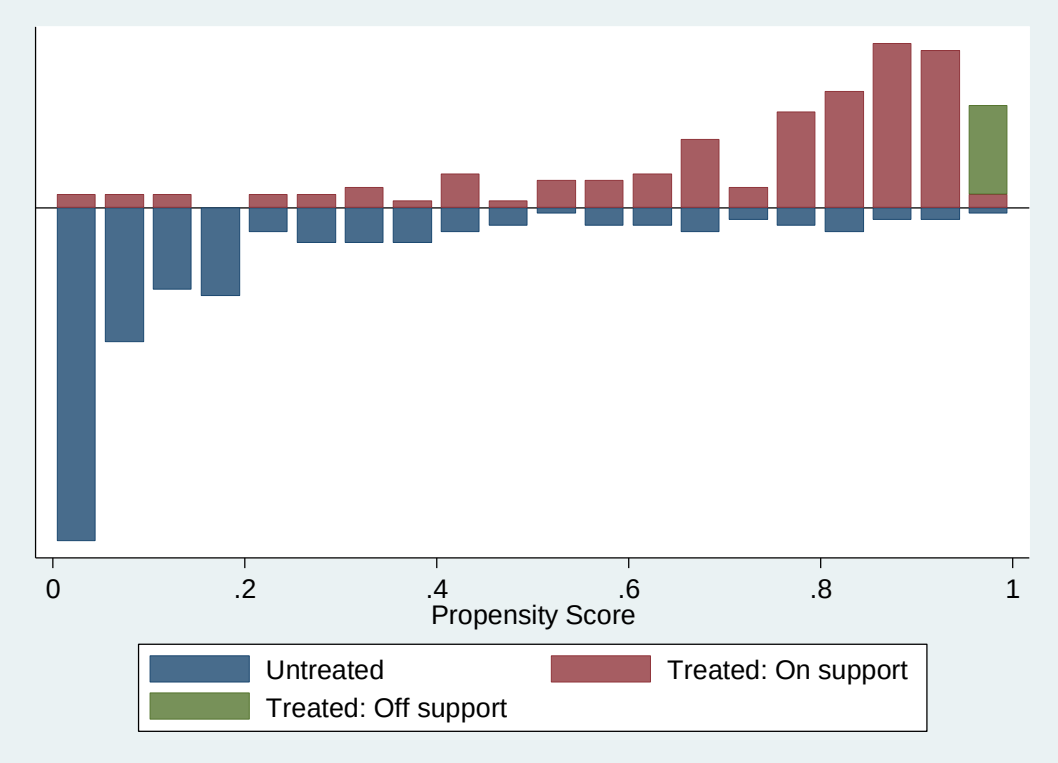


Figure: 3 propensity score, Source: own computation

4.4.4. Testing the balance of prospensity scores and covirance before and after matching

After choosing the best performing matching algorithm and common support condition, the next step is checking the balancing of propensity score and covariate using different procedures by applying the selected matching algorithm. The balancing powers of the estimations are determined by considering different test methods such as the reduction in the mean standardized bias between the matched and unmatched households, equality of means using t-test and chi- square test for joint significance for the variables used. Accordingly; Rosenbaum and Rubin (1985), the standardized difference has been calculated, that is, the size of the difference in means of conditioning variables (between the adopter and non-adopters). In the present matching models, the standardized difference before matching is in the range of 14.5% and 10.6%. Rosenbaum and Rubin (1985) recommend that a standardized difference after matching of 20% or more should be viewed as large.

Accordingly, the remaining standardized difference after matching for all covariates lies between 10.6 % and 14.5% which is below the critical level of 20% (Table 10).

In all methods; the sample differences in the unmatched data significantly exceed those in the samples of matched cases. The process of matching that creates a high degree of covariate balance between the treatment and control samples are ready to use in the estimation procedure.

In this study, kernel bwidth(0.01) matching has been considered. The result indicates that before matching, several variables have statistically significant differences. However, after matching, the covariates in most cases have been balanced and no significant differences have been found. Since the mean difference for all covariates between treated and control group after matching has not been statistically significant (the p-value before matching is >0.022; and after matching is 0.567) the matching has been considered valid match. Based on the consideration, kernel band width matching has provided valid matching for all covariates.

Table: 10. Propensity score estimation and covariate balances

Variables	Unmatched Matched	Mean			t-tes		V(T) /V(C)
		Treated	Control	%bias	T	p>t	
Pscores	U	0.72253	0.27417	183.1	13.89	0.000	0.77
	M	0.71123	0.71149	0.3	0.02	0.985	1
Sex	U	0.77778	0.73438	10	0.77	0.442	
	M	0.79439	0.79166	0.6	0.05	0.961	
Age	U	41.23	44.219	-27.9	-2.22	0.027	0.65
	M	41.486	38.476	28.1	2.26	0.025	0.88
Mastatus	U	1.7302	1.6719	5.2	0.4	0.693	0.91
	M	1.729	1.974	-22	-1.45	0.148	0.63
edustatus	U	2.2302	1.96	25.8	1.88	0.061	1.61
	M	2.2336	2.4173	-17.6	-1.15	0.25	0.82
Familsize	U	5.2651	4.5	45.5	3.47	0.001	0.69
	M	5.2589	5.32	-3.8	-0.26	0.792	0.56
Farmsiz	U	5.4917	5.4819	0.5	0.04	0.792	1.56
	M	5.4386	5.4838	-2.2	-0.18	0.971	0.56
Farmexp	U	4.9444	4.6016	64.3	6.44	0.000	0.33
	M	4.9533	4.9559	-0.5	-0.08	0.938	1.93
extcont	U	0.57143	0.49219	-15.9	1.21	0.938	1.93
	M	0.58879	0.61826	-5.9	-0.44	0.228	
training	U	0.46032	0.3125	30.4	2.32	0.021	-
	M	0.46729	0.36095	21.9	1.58	0.115	
distomark	U	4.9289	6.2033	-54	-5.29	0.000	0.86
	M	5.004	5.22	-9.1	-0.95	0.342	1.75
acctocrdt	U	0.30159	0.14844	36.7	2.8	0.005	-
	M	0.29907	0.23213	16	1.1	0.271	
infoacces	U	0.388	0.2578	28.2	2.14	0.034	-
	M	0.383	0.386	-0.6	-0.04	0.964	
tlu	U	5.7856	5.8517	-4	-0.30	0.767	1.07
	M	5.842	5.4314	25.1	1.74	0.084	
anfarincme	U	24222	23290	26.7	1.96	0.051	1.09
	M	24197	24552	-10.2	-0.71	0.478	1.21

The p-values of the below table showed that the significance of the covariates was rejected after matching (0.567) but, it was never rejected before matching (0.022). The pseudo R2 was dropped significantly from 8% before matching to about 4.5% after matching. Also the bias was reduced by the range of 14.5% to 10.6 through matching. This low pseudo R2, low standardized bias, high total bias reduction, and the insignificant p-values of the likelihood ratio test after matching suggests that the explanation for the propensity score is successful

based on its' balancing distribution of covariates between treated and control groups. The result has gone with matching algorithm that has been selected is relatively going with the obtained data. Accordingly; it is best to continue estimation of ATT for households.

Table 11: Propensity score matching (quality test)

	Pseudo R^2	LR chi^2	P>chi^2	Mean Bias	Med Bias	B	R	%Var
Before matching	0.080	27.99	0.022	16.9	12.6	68.5	1.45	30
After Matching	0.045	13.46	0.567	10.9	9.1	50.9	1.06	40

Source: own survey 2024

4.4.5. Estimation of treatment effect on treated

Estimation of treatment effect on treated evaluates results on dependent variable of improved shorima wheat variety on the outcome variable of household food security. Rather than other model, the propensity score matching has be employed by kernel band width 0.01 indicated that, adoption of improved shorima wheat variety has made significant and positive impact on household food security. The food consumption scores for unmatched treated and controls was 30.16 & 23.29 respectively. Whereas; the food consumption scores of average treatment effect on treated (ATT) for traeted and controls was 30.14 & 23.71 respectively. There was significant food consumption difference between improved shorima wheat variety adopter and non-adopter household. The food consumption scores of the adopter household had been better than non-adopter households. The finding is conformity with (Menale *et al*., 2014), the food consumption score of improved wheat variety adopter household was better from non-adopter households. Therefore; the adoption of improved shorima wheat variety had play critical role and brought positive impact for improving household food security.

Table 12: Average treatment effect on the treated (ATT)

Variable	Sample	Treated	Control	Difference	Std. Error	T-stat
Food Consumption Scores	Unmatched	30.16	23.29	6.87	0.61	11.3
	ATT	30.14	23.71	6.43	1.28	5.03

Source: own computation 2024

4.4.6. Sensitivity analysis for hidden bias

PSM controls for observable differences between treatment and control groups, but is vulnerable to unobservable differences (Smith and Todd, 2005). Several researchers increasingly aware that it is important to test the robustness of results to departures from the identifying assumption. Since with out a sensitivity analysis it is not possible to estimate the magnitude of selection bias with non-experimental data. According to Dehejia (2005), sensitivity analysis is the final diagnostic that must be performed to check the sensitivity of the evaluated treatment effect to unobserved characteristics which affect both assignment in treatment and the outcome variable. Rosenbaum (2002) proposes that using Rosenbaum bounding approach in order to check the sensitivity of the estimated ATT with respect to deviation from the conditional independence assumption. If a given study is not affected by unobserved characteristics, the effect of unobserved variables is zero. As a result, the adoption probability determined only by observed characteristics. But, if there is unobserved bias, even if the two individuals with similar observed characteristics have different chance of receiving the treatment. Based on this concepts the sensitivity analysis was conducted. The result in appendix 7 shows that, improved shorima wheat varieties adoption on households' food security was not altered even though adopter and non-adopter households have been allowed to differ in their odds of being treated up to gamma =2 in terms of unobserved covariates. This implies that, for outcome variable computed at different level of critical value of gamma, the p-critical values were statistically significant. Therefore the impact estimation (ATT) of this study is insensitive to hidden bias and is a pure effect of adoption of improved shorima wheat variety.

5. SUMMARY, CONCLUSION AND RECOMMENDATION

5.1. Summary

The study was conducted in Adiyo district South West Ethiopia region to examine the determinants of adoption of improved shorima wheat variety and its impact on food security. Among 14 wheat growing kebeles in Adiyo district, 4 kebeles such as Boka, Gindacha, Kochiyo, and Medwuta were selected from geographical clusters of high land and temperate clusters. Totally, from 4 kebeles 302 household heads were selected using systematic random sampling technique and categorized in to adopter and non- adopter by probability proportional to size for each kebeles.

For this study both primary and secondary data were employed with primary and secondary data that were collected through questionnairies. To complement the formal household survey focus group discussions was organized by 8-14 kebele leaders. Whereas secondary data were collected from relevant literature, orgaizational reports, and google scholars, and articles. Cross-sectional research design was employed with multi-stage sampling techniques; four kebeles were selected based on their wheat production potential and grouped into high land and temperate areas.

Both descriptive statistics and econometrics model were employed to analyze collected data. Descriptive statistics was employed by the mean, percentage and standard deviation as well as chi-square and t-test were also used to analyze the mean difference of the adopter and non-adopter households. On econometric model, PSM was employed to identify determinants of adoption of improved shorima wheat variety and its impacts on food security. According to descriptive statistics results, the study identified 46% and 54% of improved shorima wheat variety adopters and non-adopter household heads respectively. Moreover; the variables such as age of the household head, family size, farming experience, participation on training, credit use, information access, frequency of extension contact, distance from the market, and annual income of the household head of adopters and non-adopter show significant difference. Among the variables; age of the household head and distance from the market of the household have negative influence on the adoption of improved shorima wheat variety whereas, variables such as; family size, farming experience, participation on training, credit use, information access, frequency of extension contact, and annual income of the household head have positive and significant influences on improved shorima wheat variety adoption.

Further, based on the criteria of selecting matching algorithm the average treatment effect on treated is calculated using propensity score matching model. The food consumption scores for treated was 30.16 whereas, for controls 23.29. The food consumption score difference between adopters and non-adopters household head was 6.87. The result revealed that; there is positive food consumption score difference between improved shorima wheat variety adopter and non-adopter household heads. The food consumption score difference is resulted from adopting improved shorima wheat variety. The result confirms that; adopting improved shorima wheat variety has a positive and significant impact on household food security.

5.2. Conclusion

The results of logistic regression model revealed that among 13 explanatory independent variables six variables were affected the adoption of improved shorima wheat variety. Thus variables were: family size, farming experience, credit use, and total income of the household head has positive relationship with the adoption of improved shorima wheat variety whereas variables such as: age and distance of the household from the market had negative relationship with adoption of improved shorima wheat variety in Adiyo district. The result of the study indicated that,food consumption scores of adopter household had 30.14/day whereas, non-adopter households had consumed 23.29/day. There was significant food consumption difference between improved shorima wheat variety adopter and non-adopter households; that differences was resulted from the adoption of improved shorima wheat variety. The result indicated that; the food consumption scores of improved shorima wheat variety adopter household head have better than non-adopter households.

From the findings of the study, it is possible to conclude that, households with high number of family size, more farming experience, participation in different training, credit use, getting agricultural information, and diversifying the sources of income are the variables that motivate to adopt improved shorima wheat variety. Furthermore, households who could adopt improved shorima wheat variety would improve their food consumption status. Generally, the adoption of improved shorima wheat variety has positive significant on improving household food security.

5.3. Recommendation

The above conclusions bespeak the following recommendations for concerned bodies:

- District adiminstration and agricultural office should provide training for young (productive) age.
- The district human resource management should provide training on labour use.
- The district adminstration and road and transportation office should give attention on road access and make collaboration for the farmers to increase their productivity through the adoption of improved shorima wheat variety·
- District adiminstration should provide training on credit use and donation of cash on hand to resist the price fluctuation of agricultural inputs and should involve in the activity.
- The district gov't and agricultural office should made livelihood diversification for farm household to increase their income.
- For further studies; Adiyo district adiminstration office and Adiyo district agriculture, cooperative, environmental protection office should pay attention to conduct the research on the same area of studies on adoption of improved shorima wheat variety which plays critical role on improving households food security in societal, cultural, economical and environmental contexts.

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7. APPENDIX

Jimma University College of Agriculture and Veterinary Medicine Department of Rural Development and Agricultural Extension

Dear respondents: the purpose of this questionaries' is to collect reliable data for master thesis on **adoption of improved *shorima* wheat varieties and its' impact on food security** in Adiyo district South West Ethiopia region. You are selected to generate the required information to addressing the objective of the study. Your response to the questionnaire will be an input for the success of the study. All generated information will be kept confidentially and the response is for academic and research purpose only.

Thanks for your cooperation.

Researcher: **Abuye Deo +251921692411**

Note: The respondent for this questionnaire should be the HH head or his/her partner.

1. The demographic characteristics of the respondents

1: Adopter 0: Non-Adopter

Date of interview_____ HH Code_____

Name of the Interviewer: _____Sex 1. Male 0. Female Age ———Sign.—— Marital status of the HH head (1.Married 2. Single 3. Divorced 4. Widowed) Kebele____ Village__

Education level of the respondent in year (grade in year)_____

2. How many family members do you have? _____Male _____ Female _____

In which age category are they found?

Table 13: Age classification of family numbers

No.	Age classification of family size	M	F	T
1	under 10			
2	Between 10 to 13			
3	Between 14 to 16			
4	Between 17 to 50			
5	Above 50			

3. Do you have farm land? 1= Yes 0 =No,

If yes total land_____ ha.

4. Do you have wheat farming experience? 1= Yes 0 =No.

If yes how many years have you grown improved Shorima wheat variety? _____

5. Do you have extension contact? 1. Yes 0. No.

If yes how frequently do the extension agent visited you per month 1 once in a week, 2 twice in a week, 3 once in a month

6. Have you attending in training?

1. Yes, 0. No If yes, how many times ————————, and who provided for you?

1. Agricultural Office 2. Research 3.NGOs 4.Others

7. How far is your household from the market ———————— km.

8. Are you a member of saving and credit cooperative group? 1. Yes 0.No

If yes, what service you are getting being members of cooperatives? 1. Credit in cash 2. Input price information 3.improved seed 3. Others

9. Have you received any type of credit? 1. Yes 0. No

If yes, how many birr you borrowed? ————————

For what purpose did you borrowed?

1. Wheat variety purchase 2. For oxen purchase 3.Household Consumption 4. Other

10. Have you grown improved Shorima Variety from year 2022/2023 G.C?

Table 14: wheat production in 2022/23

Types of Varieties	Quantity	Land size	Yield obtained	Amount sold	Amount consumed
Shorima variety					
Local variety					
NPSB/DAP					
Urea					

Note: 1 Kilogram, 2 Quintal, 3. Fersula

How many birr did you sold wheat Yield in year 2014E.C._____?

11. Do you have information access? 1. Yes 2. No. If yes from where you have received the information? 1. Television, 2.Radio; 3. Mobile Phone, 4. DAs.

12. Household's annual farm income from sell of crops

Table 14: Annual income of the household in 2022/23

S/n	Crop type	Obtained yield	Consumed yield	Sold yield	Price
1	Wheat				
2	Barley				
3	Maize				
4	Teff				
5	Faba Bean				
6	Peas				
7	Sorghum				
8	Enset				
9	Root crop				
10	Vegetable				
11	Fruit				
12	Coffee				
13	Total income				

Note: 1 Kilogram, 2 Quintal, 3. Fersula

13. Do you have livestock? 1. Yes 0:No (TLU and income from sell of livestock in 2023G.C.)

Table 16: Household livestock holding in 2022/23

S No.	Livestock holding	amount of livestock and its' sell price	
		In number	Price
1	Oxen		
2	Cow		
3	Bulls		
4	Calves		
5	Heifer		
6	Goat		
7	Sheep		
8	Poultry		
9	Donkey		
10	Horses		
11	Mule		
12	Chicken		

How many times you have eaten the following food groups in the past 7 day?

Table 17: food groups eaten by the household in past seven day

No.	Food groups/items	Freq.	Weight	FCSs
1	Cereals: barley, maize potatoes, sorghum teff, and wheat		2	
2	Pulse (beans, lentils, peas)		3	
	Vegetables: cabbage, onion, lettuce, pepper, spinach, tomatoes		1	
4	Fruit: bananas, guava, orange		1	
5	Beef: goat, sheep, fish, poultry, and egg		4	

6	Milk: yogurt, including all daily products		4	
7	Sugar		0.5	
8	Oil		0.5	
	Total FCSs			

Checklists for focus group discussions

1. Which wheat variety do you prefer to produce?
2. In your area all farmers should produce improved shorima wheat variety?
3. If yes; in 2014/2015 E.C how many farmers were grown improved shorima wheat varieties?
4. Is there advantage of producing improved shorima wheat variety rather than other improved wheat varieties?
5. What are the determinants for adopting improved shorima wheat variety in the district?
6. What are the solutions for those determinants?
7. What is the measurements' for household food security?

Questions for key informants

1. Is there capacity building training for agricultural production in the district? If yes who provided it?
2. In this district the agricultural information are available for farmers'?
3. By what method the information are reach to the farmers? _____
4. In this district agricultural inputs are available on time for the farmers?

If yes how? _____

If no why? _____

5. In your suggestions producing improved shorima variety has an impact on household food security in the district?
6. What are the determinants that affect the adoption of improved shorima wheat variety in the district?
7. What strategies have made to ensure food security in this district?

Figure:4 FGD and KII




Table: 18 conversion factor of family size in to adult equivalent

Age group in years	Male	Female
<10	0.6	0.60
11–13	0.9	0.8
14–50	1	0.75
> 50	1	0.7

Source: Storck et al., (1991)

Table: 19 conversion factors for estimating tropical livestock unit

Livestock type	TLU	Livestock type	TLU
Ox	1	Horse	1.10
Cow	1	Donkey	0.70
Bull	0.5	Donkey young	0.35
Heifer	0.75	Camel	1.25
Calf	0.25	Goat, and Sheep	0.06

Source: Storck et al., (1991)

Table: 20 VIF for continuous variables

Variable	VIF	1/VIF
age	1.16	0.860781
edustatus	1.14	0.880733
farmexp	1.09	0.918664
familsize	1.08	0.922864
distomark	1.05	0.952958
farmsiz	1.04	0.958661
anfarincme	1.03	0.971523
tlu	1.03	0.974957
extcont	1.02	0.975640
Mean VIF	1.07	

Table: 21 logit model output for independent explanatory variables

adonoad	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
sex	.2029707	.3452673	0.59	0.557	-.4737409	.8796822
age	-.0419718	.0166102	-2.53	0.012	-.0745272	-.0094164
edustatus	.1201554	.1521082	0.79	0.430	-.1779712	.4182819
familsize	-.0936757	.0951923	-0.98	0.325	-.2802491	.0928977
farmsiz	-.0540813	.0788118	-0.69	0.493	-.2085495	.1003869
farmexp	.2836649	.154609	1.83	0.067	-.0193633	.586693
extcont	.0360978	.3011881	0.12	0.905	-.5542201	.6264157
training	.6573674	.3003205	2.19	0.029	.06875	1.245985
distomark	-.5159757	.0813929	-6.34	0.000	-.6755028	-.3564486
acctocrdt	1.364136	.3722731	3.66	0.000	.6344938	2.093778
infoacces	.5165791	.3259837	1.58	0.113	-.1223373	1.155496
tlu	-.135067	.0914726	-1.48	0.140	-.31435	.0442161
anfarincme	.0001089	.0000407	2.68	0.007	.0000292	.0001886
_cons	1.100551	1.753379	0.63	0.530	-2.336008	4.53711

Table: 22 Coefficients for dummy variables

```
. correlate adonoad sex mastatus training acctocrdt infoacces
(obs=302)
```

	adonoad	sex	mastatus	training	acctoc~t	infoac~s
adonoad	1.0000					
sex	0.0387	1.0000				
mastatus	0.0319	-0.6463	1.0000			
training	0.1319	-0.0109	0.0119	1.0000		
acctocrdt	0.2327	-0.0112	0.0305	0.1230	1.0000	
infoacces	0.1830	0.0546	-0.0454	0.0972	0.0718	1.0000

Appendix 8: Rosenbaum bounds