ADDIS ABABA UNIVERSITY

COLLEGE OF DEVELOPMENT STUDIES

CENTER FOR RURAL LIVELIHOOD AND DEVELOPMENT

Impacts of Adoption of Hidase Improved Wheat variety on Wheat Productivity and Income among Households of Siyadebrina Wayu Woreda, North Shewa Zone, Amhara Regional State of Ethiopia

By

Asnake Hailu Debelo

A Thesis Submitted to the School of Graduate Studies in Partial Fulfillment of the Requirement for the Degree of Master of Arts in Development Studies

Advisor: Abrham Seyoum (PhD)

June, 7/2019

Addis Ababa, Ethiopia

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DECLARATION

I, Asnake Hailu, hereby declare that the thesis work entitled ***"Impacts of Adoption of Hidase Improved Wheat variety on Wheat Productivity and Income Among Households of Siyadebrina Wayu Woreda, North Shewa Zone, Amhara Regional State of Ethiopia"*** is Submitted by me in partial fulfillment of the requirements for the award of the degree of Master of Art in Development Studies to the college of development studies center for rural livelihood and development is original work carried out by myself. The matter embodied in this thesis work has not been submitted earlier for award of any degree or diploma to the best of my knowledge and belief.

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Signature: ________________________________

Date:____________________________________

This thesis has been submitted for examination with my approval as a University advisor

Advisor's Name: **Signature**

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This is to certify that the thesis prepared by Asnake Hailu, entitled: ***"Impacts of Adoption of Hidase Improved Wheat variety on Wheat Productivity and Income Among Households of Siyadebrina Wayu Woreda, North Shewa Zone, Amhara Regional State of Ethiopia"*** submitted in partial fulfillment of the requirements for the Degree of Masters of Arts Development Studies complies with the regulation of the university and meets the accepted standards with respect originality and quality.

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Acronyms

AGP (Agricultural Growth Program)

ATT (Average Treatment Effect on Treated)

CC (Contingency coefficients)

CIA (conditional independence assumption)

CSA (Central Statistics Agency)

CASCAPE (CApacity building for SCAling up of evidence-based best practices in agricultural Production in Ethiopia project)

Coef (Coefficient)

DA (Development Agent)

DFID (Department for International Development)

ETB (Ethiopian Birr)

FAO (Food and Agricultural Organization)

FAOSTAT (Food and Agricultural Organization Statistics)

FGD (Focus Group Discussion)

FTC (Farmer's Training Center)

GR (Green Revolution)

HIWV (Hidase Improved Wheat Variety)

HH (Household)

HYV (High Yielding Variety)

Km (Killo meter)

KM (Kenel Matching)

MOA (Ministry of Agriculture)

NGOs (Non-Governmental Organizations)

NNM (Nearest Neighbor Matching)

OLS (Ordinary Least Square)

PSM (Propensity Score Matching)

Q/ha (Quintal per hectare)

RM (Radius Matching))

SM (Stratified Matching))

Std.err. (Standard Error)

Std.dev (Standard Deviation)

TLU (Tropical Livestock Unit)

TOL (Tolerance)

VIF (Variance Inflation Factor

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Abstract

Impacts of Adoption of Hidase Improved Wheat variety on Wheat Productivity and Income among Households of Siyadebrina Wayu Woreda, North Shewa Zone, Amhara Regional State of Ethiopia

Asnake Hailu

Addis Ababa University, 2019

Though, agro ecologically Ethiopia has high potential for wheat production its average productivity is too low compared to the potential productivity and world's average yield/ha. This is on the one hand due to low yielding cultivars and serious wheat diseases like rusts, and on the other hand low adoption rate of high yielding and rust disease resistant wheat varieties. The study conducted in Siyadebrina Wayu Woreda with the objectives of identifying the determinants of adoption of HIWV, and wheat productivity and income impacts of the adoption on adopter wheat producers, using cross-sectional data of the production year 2017.153 sample hhs (97 treated and 56 controlled households) has been determined. The study used both primary and secondary data. The primary data were obtained from a household survey of 153 farmers using a semi-structured questionnaire. About 20 variables considered to influence adoption of improved wheat production technology. These are households' number of oxen, home-farm distance, farm size, extension contact, age of households' head, households' labor size, wheat farming experience, market-home distance, farm fertility, livestock ownership, farm slope, income, source of land ,sex of households' head , level of education of households' head ,HHs numbers of plots , access to credit , field participation and memberships in associations. Of which the first seven variables that fit to the model were used for running probit model. Five of these variables (except home-farm distance and age of households' head) found to be significant at 1% and less than 5% level of significance in determining the probability of adoption. The impact of adoption on wheat productivity and income has been assessed using PSM of probit model. According to PSM result: on average wheat productivity in Q/ha of participant households has been increased by 21.9921 Q/ha – 23.543 Q/ha. Similarly on average income from wheat production of participant households has been increased by 37108.031 - 40769.762 ETB. Generally, overcoming credit market failure and particularly providing credit services to farmers that have fewer oxen and slower rate of adoption; Institutional supports including research and extension services providing to the sector and generating/engendering high yielding varieties that resist wheat diseases and maintain high yielding for a long are recommendations of the study to enhance adoption and productivity and income gains of adoption.

Key words: Adoption, Impact, HIWV, Wheat Productivity, Income and probit

Chapter One: Introduction

1.1 Background of the Study

Agriculture is the core sector of Less Developed Countries (LDCs) in general and Sub-Saharan Africa (SSA) in particular. The situation in Ethiopia, a country with a population of about 100 million, is not different from this fact. More than 85% of the populations derive their livelihood from agriculture. The sector contributes 38.8% to the Gross Domestic Product (GDP) and a major share in export earnings where exports of coffee, oilseeds, Chat (Mild stimulant crop, *Chata edulis* Forsk.), leather and leather products, pulses, and flower alone contribute more than 70% (NBE, 2016). The sector is dominated by smallholder farmers (96%), where about 56% of the smallholder farmers possess less than one hectare of land which is characterized by subsistence production and traditional technologies are predominant. Despite its contribution to livelihood of the people, the GDP and export earnings, the sector's productivity is very low due to, among others; low rate of the adoption of improved technologies (CSA, 2016).

Cereals (mainly teff, wheat, maize, and sorghum) are dominant in different parts of the country satisfying about 70% of the average Ethiopian's calorie intake (Howard, et al 1995). Wheat is among a few crops which have received special attention from the Ethiopian government and NGOs operating in the country. Ethiopia is the largest wheat producer in sub-Saharan Africa (MOA, 2011). Nationally, wheat ranks fourth in both total area coverage (1,627,647.16 ha) and production (3,434,706.122 ton). Among cereals, it is also the third in productivity which is 2.11ton/ha after maize and rice 3.05ton/ha and 2.89ton/ha, respectively. Wheat is the fourth most important cereal crop cultivated after Teff, maize and sorghum; and the third in production after maize and Teff and about 4.7 million farm households are directly dependent on wheat production (CSA, 2013/4)

Technologies are important sources of productivity growth in agriculture. This was practically seen in Asia and parts of South and Central America during the Green Revolution (GR) era. An important manifestation of the Green Revolution was the adoption of yield increasing crop technologies such as improved seeds, chemical fertilizers and pesticides along with expansion of infrastructure such as irrigation, roads and electricity. The widespread adoption of scientific agricultural techniques during this time has increased labor productivity thereby increasing income and reducing poverty. In many parts of the developing world, increasing agricultural productivity through the use of improved agricultural technologies is now an important component of a strategy to increase income and to contribute to other measure of welfare (Owens et al., 2003).

Ethiopia also recently set a clear agricultural production and productivity development policy to tackle the challenge and lift up millions of smallholder farmers. In the last two decades, the agriculture and rural development policy of Ethiopia has been aiming at enabling efficient use of modern agricultural technologies and practices among smallholder farmers for increased production and productivity. Following this strategy, the research and extension system promotes adoption of proven agricultural technologies and practices by smallholder farmers. The Agricultural Growth Program (AGP) and the regular extension system have been making significant efforts to identify and scale up agricultural best practices developed by model farmers. Efforts have been made to spread these practices to all farmers so that average productivity can be transformed to the level of that of model farmers (Tefera Tewodros et .al, 2016). This research also conducted with this purpose, by the financial support of CASCAPE. The research is also about evaluating adoption processes and impacts of the improved wheat variety “Hidase”, which is projected by CASCAPE. These efforts have been supported by research and extension endeavors particularly on improving the production and productivity of major staple crops widely grown by resource poor smallholder farmers. In spite of these efforts, productivity gains are not as such adequate in the country. Low level of adoption of technologies is among the major reasons (Spielman et al., 2010; Hailu et al., 2014).

Ethiopia’s wheat production covers only 75% of the national demand; the remaining 25% of the wheat is obtained through imports (Eyob *et al.*, 2014). So to overcome wheat yield imports and to cut down wheat national demand deficiency conducting considerable research works that contribute positive impact on wheat productivity and production are mandatory. In this regard, the research system, along with the other stakeholders, has to play a major role in improving technologies required to enhance agricultural productivity in Ethiopia (Biftu et al., 2016*;* Biftu and Diriba, 2016).

Siya DebrenaWayu woreda is one of the country’s potential areas for wheat production. The woreda is also one of the areas where Hidase improved wheat is widely used since 2015/16. Adoption of Hidase in the woreda started in 2016 with 16 HHs only. In the next production year (2017), Hidase become very popular and there were 999 Hidase improved wheat variety adopter households, which is about 619% increment from the previous year. This makes nearly 20% of households of the study area are adopters of the new improved wheat variety. As potential area for wheat production in the study area there are a number of improved wheat varieties but their impacts is not studied well.

1.2 Statement of the Problem

Agro ecologically Ethiopia has high potential for wheat production but its average productivity of wheat is 1.84 ton/hectare which is too low compare to the potential productivity of 4 to 8 ton/hectare at farmers' field. However, the production and productivity of wheat in Ethiopia has increased in the last decades, the national average yield is still only about 2.54 ton/ha (CSA, 2013/14). It is lower than the world's average yield/ha, which is about 3.3 ton/ha (FAO, 2014). This is on the one hand due to factors such as use of low yielding cultivars and serious wheat diseases like rusts (Dereje *et al*., 2001) and on the other hand low adoption rate of high yielding and rust disease resistant wheat varieties (MoA, 2013). All these calls for the adoption of productivity enhancing technologies and improvement in the efficiency and productivity of the sector, as it is becoming no longer possible to increase output by expanding the area under cultivation (Asfaw et al. 2012).

In an effort to improve production and productivity, Ethiopia also has released so many improved varieties through its research centers. However the uptake of these wheat technologies in the country is low. For instance, in 2010/2011 cropping season in the country, the use of improved wheat varieties at national level were only 7% which is too low (CSA, 2010/2011).

According to Agriculture office of the Siyadeberena Wayu Woreda wheat productivity of the woreda was 47.7 Q/ha in the production year 2016 when, adoption of Hidase started with 16 HHs only. The productivity grow-up to 53.11 Q/ha in the next production year 2017 when, Hidase become very popular and there were 999 Hidase improved wheat variety adopter households. Since no new variety entered in to the woreda during these times the 5.41 Q/ha increment in the woreda's productivity between 2016 and 2017 attributed by the adoption of Hidase.

Uncover reasons behind rate of adoption of improved wheat variety has a paramount importance in improving and enhancing the uptake of wheat technologies. Not only examining the constraints but incentives influencing the adoption of agricultural technologies and measuring their impact on smallholders' agricultural productivity and wellbeing are also critical. Different studies in Ethiopia show the positive impact of agricultural technologies on the livelihood outcomes. For instance, the study by Tesfaye *et al*. (2016) confirms that adoption of improved wheat varieties increased the wheat productivity of the adopters. Research results of Chilot *et al*. (2014) also suggested that adoption of rust-resistant wheat varieties has a significant and positive effect on wheat productivity and cash earnings of adopting households from sales of wheat grain and seeds. To the best of the researcher's knowledge no published study discussing the impact of the disseminated technologies on households' productivity and income of the Woreda has been found. Therefore, this study has been designed to fill this research gap. Specifically, the study deals with the analysis of the impact of growing improved wheat variety on land productivity and households' income.

1.3 Research Objectives and Questions

1.3.1 Objective of the Study

The General objective of the study is to identify the determinants of adoption of Hidase improved Wheat variety and its impact on wheat productivity and income of wheat producers in SiyadebrinaWayu Woreda. The specific objectives are:

- To identify the determinants of adoption of Hidase improved wheat variety by sample households
- To analyze the impacts of adoption of Hidase improved wheat variety on wheat productivity and income of adopter households

1.3.2 Research Questions

Based on the objectives of the study/research, the following research questions are prepared:

- What determines the probability of adopting Hidase wheat variety?
- How much adoption of Hidase improved wheat variety contributing to wheat productivity of adopter households?
- How much adoption of Hidase improved wheat variety contributing to the enhancement of income of adopter households?

1.4 Working Hypotheses for Outcome Variables

H_1=Adoption of Hidase improved wheat variety has a significant positive effect on wheat productivity of adopter households.

H_0=Adoption of Hidase improved wheat variety has no significant positive effect on wheat productivity of adopter households.

H_1=Adoption of Hidase improved wheat variety enhancing income of adopters significantly.

H_0= Adoption of Hidase improved wheat variety hasn't been increased income of adopters significantly.

1.5 Significance of the Study

Previous studies on technology adoption determinants implicitly assume that the impact of agricultural technologies under consideration is beneficial in terms of enhancing productivity or welfare. However, the empirical evidence on the impact of technology adoption on productivity and welfare is mixed. Agriculture technology adoption literature suggests that most studies have addressed the impact of technology on income from a macro perspective. Recent studies including this one have taken a micro view.

In an effort to improve wheat productivity and its farm income, many stakeholders were engaged in promoting and popularization of newly released improved wheat varieties. This was done along with recommended wheat production in various wheat-growing regions of Ethiopia. However, the impact of these technologies on farmers' productivity and farm income has not been determined and documented adequately, yet information on the impact of adoption of improved wheat technologies is imperative for targeting interventions efficiently.

In the literature, there have been quite a number of adoption studies related to improved agricultural technologies in Ethiopia. Yet, since adoption is dynamic, it is imperative to update the information based on the current technologies being adopted by farmers. More specifically, information on technology adoption is vitally important to undertake impact studies.

Impact figures actually vary across different agro ecologies, socioeconomic contexts, and features of the improved technologies signifying the role of empirical studies. In providing information regarding the adoption of improved wheat varieties and to contribute to the debate regarding the nature and multiple impacts of improved technologies, this study will reveal different sets of factors that determine decisions to adopt of Hidase Improved Wheat variety and its impact on Households Wheat Productivity and farm Income, by considering the varied socioeconomic contexts of the study area.

The importance of adoption study is to quantify the number of technology users over time and to assess impacts or determine extension requirements that would help us in monitoring and feedback in technology generation. It also provides further insights into the effectiveness of technology transfer Augustine and Mulugeta, (2005) cited in (Alemitu, 2011)

1.6 Scope and Limitation of the Study

Impact assessment studies range widely in scope and depth of analysis from an effort to measure the adoption of improved technologies to research quantifying a wider array of impacts of improved technology on production, productivity, equity, poverty alleviation, food security, biodiversity, environment and a variety of social issues. Impact studies are widely applied to evaluate the effectiveness of agricultural research by estimating the rates of return to commodity research investments. Undertaking a more comprehensive economic impact assessment requires considerable financial resources and time that cannot be handled by such study. Therefore, given the budget and time constraints, this study is limited only to the adoption and impact of Hidase improved wheat variety on wheat productivity and farm income at the household level. Other improved technologies livestock, forestry, soil and water conservation, etc. have not been covered in this study.

Although a factor which is found to enhance adoption of a particular technology in one locality at one time might be found to hinder it or to be irrelevant for adoption of the same technology in another locality at the same or different time for the same or different technology or the other way round. From these inconsistent results it is difficult to identify universally defined factors either impeding or enhancing adoption of technology, this study is limited by time, financial constraints and human resources it is restricted to *Siyadebrina Wayu* woreda.

1.7. Organization of the Thesis

This study is organized into five chapters. In chapter one introduction, statement of the problem, research questions, objectives, significance and, scope and limitations of the study are outlined. Concepts, definitions, theoretical and empirical literature review are discussed in chapter two. Chapter three describes the study area and research methodology applied. Chapter four deals with descriptive results and discussions, econometric analysis results and discussions, Chapter five, deal with summary, conclusion and recommendation.

Chapter Two: Review of Related Literature

2.1 Basic concepts

2.1.1 Adoption-diffusion-abandonment, Rate and Intensity of Adoption of new technology

The distinction between adoption and diffusion is important for theoretical and empirical analyses Adoption and diffusion of technology are two distinct but interrelated concepts describing the decision to use or not use and the spread of a given technology among economic units over a period of time. Adoption commonly refers to the decision to use a new technology or practice by economic units on a regular basis. Diffusion often refers to spatial and temporal spread of the new technology among different economic units. Adoption of any innovation is not a one step process as it takes time for adoption to complete. First time adopters may continue or cease to use the new technology. The duration of adoption of a technology vary among economic units, regions and attributes of the technology itself (Hailu, 2008).

Rogers (1983) widely used in several adoption and diffusion studies, made a distinction between adoption and diffusion. He defined diffusion (aggregate adoption) as the process by which a technology is communicated through certain channels over time among the members of a social system. Then he defined adoption as use or non-use of a new to all economic technology by a farmer at a given period of time. This definition can be extended units in the social system.

From Rogers definitions of adoption and diffusion (Hailu, 2008) make out the following four elements: (1) the technology that represents the new idea, practice, or object being diffused, (2) communication channels which represent the way information about the new technology flows from change agents (extension, technology suppliers) to final users or adopters (e.g., farmers), (3) the time period over which a social system adopts a technology, and (4) the social system

Rate of adoption of a technology is a function of the extent of economic merits (profitability) of the technology, the amount of investment required to adopt the technology and the degree of uncertainty associated with it and availability of the technology. Rogers (1983) identified five characteristics of innovations that have an impact on the speed of adoption. Those characteristics of innovations included: relative advantage, compatibility, complexity, divisibility, observability & variations in the cost of adoption.

To deliberate or planned introduction of innovation, categorization of adopters is useful. Categories of adopters in a social system include innovators, early adopters; early majority, late majority, and laggards'. Majority of early adopters are expected to be younger, more educated, venturesome, and willing to take risk. In contrary to this group, the late adopters are expected to be older, less educated, conservative, and not willing to take risks.

Based on the above categorization (Hailu, 2008) identified five stages in the adoption process. These are (1) awareness or the initial knowledge of the innovation (2) interest and persuasion toward the innovation, (3) evaluation or the decision whether or not adopt the innovation (4) trial and confirmation sought about the decision made, and (5) adoption.

Adoption is not a random behavior, but is the result of sequence of events passing through these adoption stages (Rogers, 1983) .The introduction of a new technology consists of two phases. In the first phase, the new technology is introduced to farmers through for instance, demonstrations plots or other means and the new technology will be adopted when found beneficial. The second phase is characterized by declining use of the new technology over time until abandonment (Dinar and Yaron, 1992).

Abandonment (discontinue use) of a new technology is a reflection of either a loss of profitability due to increasing costs of inputs, falling yields or the results of a switch to another more profitable technology. In the case of new improved seeds, abandonment is stopping the use of new variety any more. On the other hand, replacement of the existing improved variety with recently released new one is considered a continuation of use of the improved seed, because the new varieties are substitutes for each other (Hailu, 2008).

The rate of adoption is defined as the percentage of farmers who have adopted a given technology. The intensity of adoption is defined as the level of adoption of a given technology. The number of hectares planted with improved seed (also tested as the percentage of each farm planted to improved seed) or the amount of input applied per hectare will be referred to as the intensity of adoption of the respective technologies (Nkonya *et al*., 1997).

2.2 Theoretical Literature Review on Approaches and Models of Adoption

Factors determining technology adoption differ from one sector to the other and from one region to the other in the same sector. 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 the other sectors. 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 (Abera, 2013)

A variety of studies are aimed at establishing factors underlying adoption of various technologies. There is an extensive body of literature on the economic theory of technology adoption. More other factors have been found to affect technological adoption. These include government policies, technological change, market forces, environmental concerns, demographic factors, institutional factors and delivery mechanism (ibid).

2.2.1 Innovation-Diffusion Theory or Source–Communication–User Model

This model assumes that the technology introduced to farmers is appropriate in its given form and that what determines the adoption decision is the effectiveness of communication to the targeted users (farmers). Communication to the targeted user is achieved through extension, media, opinion leaders, on-farm or on-station demonstration, farmers' fields, training, seminars, and workshops (Odera, *et al.*, 2000). This theory has been criticized for prescribing a top–bottom approach.

2.2.2 Resource Constraint Model

Resource constraint model is concerned with the level of resource endowment as it impacts on adoption behavior. The theory assumes that the technology being introduced to farmers is appropriate in its given form and that what mainly determines adoption decision is the farmer's level of resource endowment. Factors such as farm size and liquidity constraint affect decisions to adopt or not to adopt new technologies. The resource constraint model assumes only farmers' resource level is important in adoption decision and that farmer's knowledge about the technology and farmer's perception it is not important (Njane, 2007).

2.2.3 Adopter Perception Model

The perception model is the most recent one. This category deviates from the other two and instead, focuses on whether technology-specific attributes are satisfactory to the farmer and on the understanding of the degree to which the attributes encourage or discourage adoption decisions. The adopter perception model assumes that farmer's perception of a technology's attributes and the farmer's socioeconomic circumstances have an influence on adoption behavior (ibid).

Perception is the process through which one gains an understanding of what is happening and forms an opinion/attitude/judgment about it. The way farmers perceive attributes of a given technology influences their adoption behavior. However, the way potential adopters perceive the attributes of a technology may in fact be different from the actual or inherent attributes of a technology. It may also be different from the expert point of view. Therefore, technology specific attributes of agricultural technologies are important as far as they are perceived by farmers favorably. A review of past empirical studies on adoption reveals that, farmer's perception of technology-specific attributes is an important factor in explaining farmer's adoption behavior (Hailu, 2008).

(Sall et al, 2000) contends that by virtually ignoring technology-specific attributes and how farmers evaluate the appropriateness of the technologies, the literature on adoption has omitted major sets of critical factors determining farmer's adoption behavior. Therefore, current studies including this one employ adopter-perception model.

2.3 Empirical Literature Review on Determinants of Adoption

Review of empirical studies is important for two main reasons. First, it helps to assess the present state of knowledge of the adoption process. Second, it helps to enhance the interpretation of empirical models and their results and its implications as against the conceptual or theoretical models. The Subsequent section deals with empirical Studies on the adoption of agricultural technologies in general and the empirical studies on adoption of improved wheat varieties in Ethiopia in particular.

Though determinants of agricultural technologies are different for different technologies and geographical areas, different authors have emphasized on different factors as a significant determinant of adoption decision in agricultural technology. For the sake of simplicity those significant determinant factors in this study has been organized under the following categories of variables.

2.3.1 Economic-Resource Status of HHs

Concerning cultivated land size, different studies reported its effect differently. The study conduct by Legesse (1992) reported negative relationship between cultivated land size and adoption. Contrary to this, (Yishak, 2005) indicated positive relationship between cultivated land size and adoption. According to Degefu Kebede *et al*. (2017) farm size explained package of wheat technology adoption positively which could be related to possible gains from comparative advantage from intensification of production and productivity level per a given farm size.

Farmers that have more oxen have higher rate of adoption of agricultural technologies. Because availability of oxen during the main agricultural season (sowing and thrashing) help farmers to collect farm output on time (Degnet *et al*., 2001).Kidane (2001) indicated that adopters of new wheat varieties were better in size of livestock holding and plough oxen than the non-adopters.

Availability of household labor is the other important variable which in most cases has an effect on household's decision to adopt new technologies. Several studies reported the positive effect of household labor availability on adoption of improved agricultural technologies. The study conducted by, Kidane (2001) on factors influencing adoption of new wheat varieties in Tigray reported positive and significant relationship of household labor size with adoption. Contrary to this, Million and Belay (2004) reported that household labor size negatively affected adoption of physical soil conservation measures.

Livestock ownership is an important indicator of household's wealth position in rural context. Livestock are also an important income sources which enables farmers to invest on the adoption of improved agricultural technologies. No doubt that in most cases, livestock holding has positive contribution to household's adoption of agricultural technologies. This is evident from many of the past adoption studies which have reported positive effect of livestock holding on adoption. To mention some of them, Endrias (2003) have found that livestock holding has positive influence on adoption of improved agricultural technologies. Chilot*et al*. (2014) on their study "adoption and impact of rust-resistant wheat varieties on productivity and household food security in Ethiopia" found that livestock ownership positively and significantly impacted the probability of using rust-resistant wheat varieties.

Household's income position is one of the important factors determining adoption of improved technologies. In the context of rural households, annual farm income obtained from sale of crop and/or livestock, off-farm income is an important income sources. Regarding annual farm income, almost all empirical studies reviewed shows the effect of farm income on household's adoption decision is positive (Getahun, 2003).

2.3.2 Demographic and Farm Related Characteristics of HHs

With regard to age different studies report different results. Age of the household is usually considered with the assumption that older farmers will have more knowledge, skill and attitudes with farming which enables them to easily understand and be familiar with the benefits of the technology better than others. Also it is assumed that as farmer age increases the probability of adoption is expected to decrease because as the farmer's age increases, it is expected that the farmer becomes conservative (Techane et al., 2006). Mulugeta (1994), in his study on smallholder wheat technology adoption in South Eastern highlands of Ethiopia reported that age had a negative effect on the adoption of wheat technologies. Similarly, Kidane (2001), in his study factors influencing adoption of improved wheat varieties in Hawzien wereda of Tigray found that age is negatively related with farmers' adoption of improved wheat variety. Contrary to this Hailu (2008) reported positive relationship between age and adoption which enables easy adoption of new technologies.

Wheat farming experience is important household related variable that has relationship with adoption. Longer farming experience implies accumulated farming knowledge and skill which has contribution for adoption. Farmers with higher experience appear to have often full information and better knowledge and were able to evaluate the advantage of the technology. Many studies supported this argument. The study done by Legesse (1992) in Aris Negelle area on adoption of new wheat technologies found that the probability of adoption of improved varieties increases with an increase in farming experience. Findings of some studies such as Chilot *et.al* (1996) shows that there is no statistically significant mean difference among adoption categories with respect to wheat farming experience.

Farm Slope: (Gauchan et al, 2012) in their study, land type (dummy for low land) was included in the model, and results showed the positive and significant effect on new improved rice variety adoption at the plot level. The significance of the land type variable indicated that endowment of lowland fields is important in increasing new improved rice variety adoption. Kassie et al. (2008) on their part explained the essentiality of different soil conservation technologies on sloppier farm lands which is as a complementary input with the adoption of other agricultural technology like inorganic fertilizer.

According to Schultz (1980) the type of farm land in terms of fertility (fertile, less-fertile, and non-fertile land) can affect adoption and crop productivity. Devereux and Sussex (2000) on their part explained that farmers' practicing on a less-fertile and non-fertile farm land can be productive through the application of yield increasing technologies. They also indicated that the declining soil fertility due to intensive cultivation in Ethiopia makes crop production low, thus the limited application of yield-enhancing technologies exacerbate the food insecurity problem. They also suggested that improved agricultural inputs to increase yields even in the areas where productivity/fertility is low. According to (Kassie and Holden, 2006) the type of farm land in terms of fertility can affect adoption and household welfare. They also indicated that since the livelihood of rural households depends on agriculture, increasing the productivity of land through modern agricultural technologies and practicing soil conservation measures increase sustainable agricultural production that reduce poverty and food insecurity among rural farm families. Bezabih (2001) shows in his study that land quality play significant roles in the adoption decision. The result revealed that with increased land fertility, the probability of adoption of package of the technologies was low.

Types of Land Ownership: Possibly, owning an arable land could best be taken as a prerequisite to adopt and employ agricultural technologies since farmers could incur a cost. Being rational decision makers, while incurring cost for technologies, farmers want totally to employ technologies within their own land where the final crop yield couldn't be shared & sub-divided which is too common in share cropping system.

2.3.3 Institutional and Access Related Variables

Chilot *et al*. (1996) indicated that the adoption of improved wheat varieties in Wolmera and Addis Alem areas is positively and significantly influenced by farmers' contacts with extension agents. The study by Kidane (2001) on adoption of new wheat and maize varieties in Tigray region, Ethiopia investigated that adoption of crop varieties were influenced by frequency of contact between the farmers and extension. The study also indicated that the higher contact time positively influenced the adoption decision of the farmers for that farmers with higher experience appear to have often full information and better knowledge and were able to evaluate the advantage of the technology. Chilot *et al*. (2014) found that extension contact positively and significantly impacted the probability of adopting rust-resistant wheat varieties.

Findings of some studies such as Menale *et al.* (2012) in rural parts of Tanzania and Berihun Kassa Hailu *et al.* (2014) in Southern Tigray, Northern Ethiopia revealed that adoption of technologies and farm income decreases as plot distance increases. Some other studies discovered that Households Home-farm distance has positive correlation with the decision to adopt high yielding varieties. That is why as plot is far away from the homestead, farmers most probably to adopt High Yielding improved Varieties to compensate costs caused by remoteness of their farm

Access to road in general and distance from a nearest market and input suppliers in particular influence farmers' adoption of new technologies. Markets are communication centers both for producers, consumers and traders (Hailu, 2008).The study conducted by Degefu Kebede *et al*. (2017) also revealed that distance to market negatively and significantly influenced the adoption of wheat technology package in the study area.

The study done by Legesse (1992) in Aris Negelle area on adoption of new wheat technologies also indicated that participation in farm organization as a leader is one of the factors which significantly influence the probability of adoption of improved varieties and intensity of adoption. The study conducted by Degefu Kebede *et al*. (2017) also revealed that membership to cooperatives predicted positively and significantly the adoption of wheat technology package.

2.4 Impacts of Adoption of Improved Agricultural Technologies

Research results provide evidence for heterogeneous effects of adoption of improved agricultural technologies. Dixon et al (2006) posits that adoption of improved varieties can have impacts at different levels. First, improved wheat varieties can generate significant field-level impact on yield and stability. Second, intensification of food crops often leads to the release of land, water and labor resources for on-farm diversification. Third, higher and more stable wheat yields produce people-level impacts on household food security and household income. Fourth, the combination of intensification and diversification creates further household level impacts on wider dimensions of household livelihoods and poverty reduction, including the off-farm effects on the local economy and in more distant cities.

Setotaw et al (2003) found that adoption of improved varieties and agronomic practices have positively and significantly affected household's food security in Ethiopia. Solomon et al (2010) also examined the impacts adoption of chickpea varieties on food security in Ethiopia and found that it reduces food insecurity in adopter households/the same result.

A study by Adekambi et al, (2009) on the impact of agricultural technology adoption on poverty in Benin indicates the increase in productivity of rice farmers, improving expenditure/income of farmers and consequently to poverty reduction. Similarly, Kassie, et al (2010) found that improved ground nut technologies had a significant positive impact on crop income and poverty reduction in Uganda.

Studies conducted in Asia also reveal similar results. Using a propensity score matching method, Mendola (2007) examined the impacts of agricultural technology adoption on poverty reduction in rural Bangladesh. Findings show a robust and positive impact of agricultural technology adoption on farm households' well-being. Similarly, Wu et al (2010) conducted an impact study rural China and found that adoption of agricultural technologies had a positive impact on farmers' well-being thereby improving household income.

2.4.1 Impacts of improved wheat varieties on Productivity and income in Ethiopia

Research results provide evidence that agricultural technology adoption can contribute to improving productivity and raising income of farm households. The adoption of improved agricultural technologies is an important means to increase the productivity and farm income of smallholder agriculture. Study results show that improved agricultural inputs positively contributed for smallholders' crop productivity and farm income. (Awotide *et al*., 2012) and (Ibrahim *et al*., 2012) are among many others.

The study by Tesfaye *et al*. (2016) confirms that adoption of improved wheat varieties increased the wheat productivity of the adopters. Research results of Chilot *et al*. (2014) also suggested that adoption of rust-resistant wheat varieties has a significant and positive effect on wheat productivity. The use of rust-resistant varieties also has a positive impact on cash earnings of adopting households. This impact is reflected in an increase of the cash earnings from sales of wheat grain and seeds.

2.5 Conceptual Frame Work of the Study

(Interactions of covariates, dependent and outcome variables)

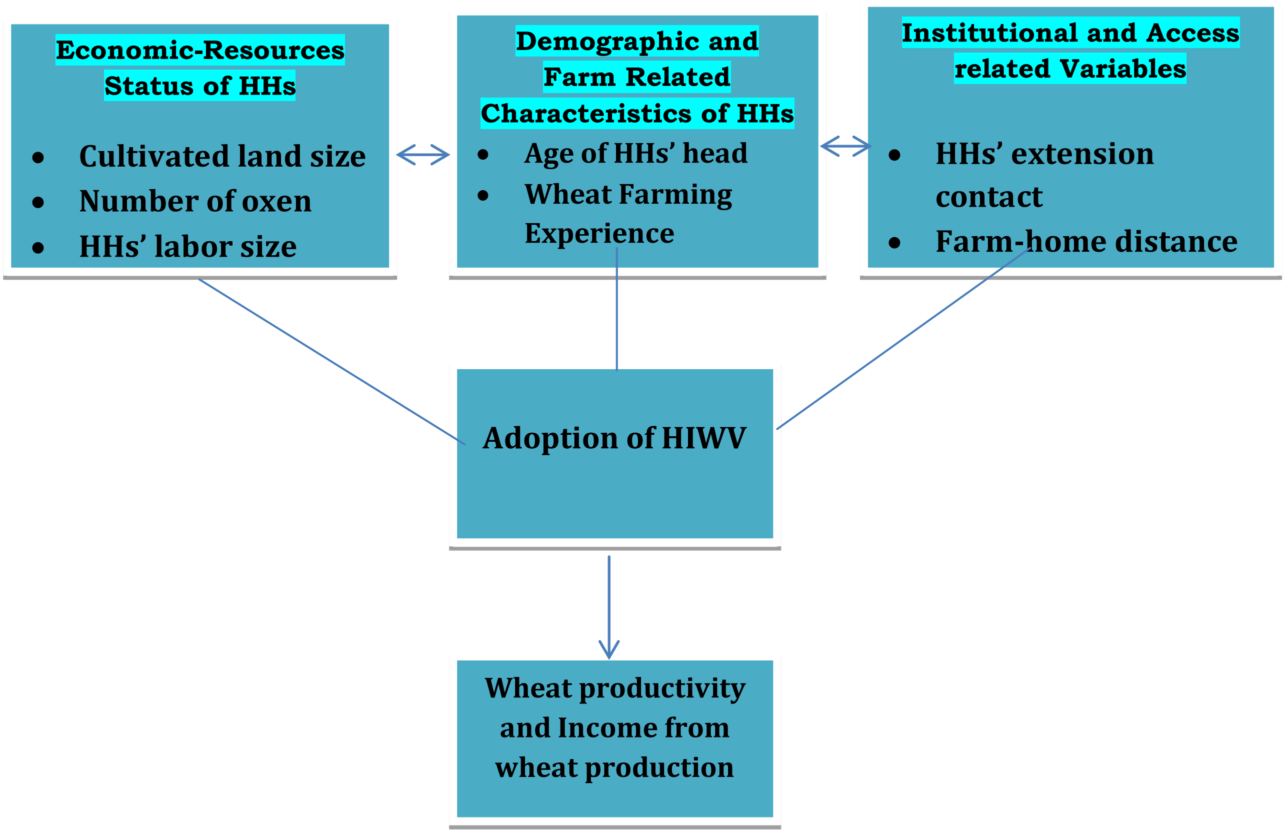

Figure 1 Conceptual Framework of the study

Initially a total of 19 explanatory variables were considered to influence the decision to adopt. When these variables tested individually only 12 of them were found to significantly influence adoption of Hidase improved wheat variety (Tables 3.1 and Table 3.2). As shown in the above diagram five of these variables together with other two variables (HHs labor size and Age of HHs head) fit to the models was used for running the probit model, for the estimation the probability of adoption and PSM, for estimation of impacts of the adoption. The remaining seven variables were excluded from the model only due to the instability they created in the models (regardless of their importance and their significant relationship). Five of the above variables (except home-farm distance and age of households' head) found to be significant at 1% and less than 5% level of significance in determining the probability of adoption.

The top three boxes of the conceptual framework show categories of the variables and the arrows between them explain interplay of the variables and how they determine the probability of the adoption in combined, not separately. The interplay of the variables through determining the probability/rate of the adoption, they also impacted wheat productivity and income gain from the production of wheat.

Chapter Three: Methodology

This chapter presents description of the study area. It also includes the research approach, techniques & sampling designs, the data sources & collection methods, methods of data analysis, definition of Variables and Working Hypotheses

3.1 Description of the study area

SiyadebrinaWayu is one of the woredas in the Amhara Region of Ethiopia, located in the North Shewa Zone. North Shewa is one of 10 Zones in the Ethiopian Amhara Region. North Shewa takes its name from the kingdom or former province of Shewa. The Zone is bordered on the south and the west by the Oromia Region, on the north by DebubWollo, on the northeast by the Oromia Zone, and on the east by the Afar Region. The highest point in the Zone is Mount Abuye Meda (4012 meters); other prominent peaks include Mount Megezez. Towns and cities in SemienShewa include Ankober, DebreBerhan, and Shewa Robit.

3.1.1 Location and Demographics of SiyadebrinaWayu

3.1.1.1 Location

The administrative subdivisions of this Zone have been renamed, divided, and their boundaries were redrawn numerous times between the 1994 and 2007 national censuses far more often than any other Zone in the Amhara Region. SiyadebrinaWayu was part of the former SiyadebrinaWayuEnsaroworeda. SiyadebrinaWayu is bordered on the south by the Oromia Region, on the west by Ensaro, on the north by Moretna Jiru, and on the east by BasonaWerana. Towns in this woreda include Deneba.

3.1.1.2 Demographics

Based on the 2007 national census conducted by the Central Statistical Agency of Ethiopia, this woreda has a total population of 61,046, of whom 31,322 are men and 29,724 women; 4,522 or 7.41% are urban inhabitants. The majority of the inhabitants practiced Ethiopian Orthodox Christianity, with 99.58% reporting that as their religion.

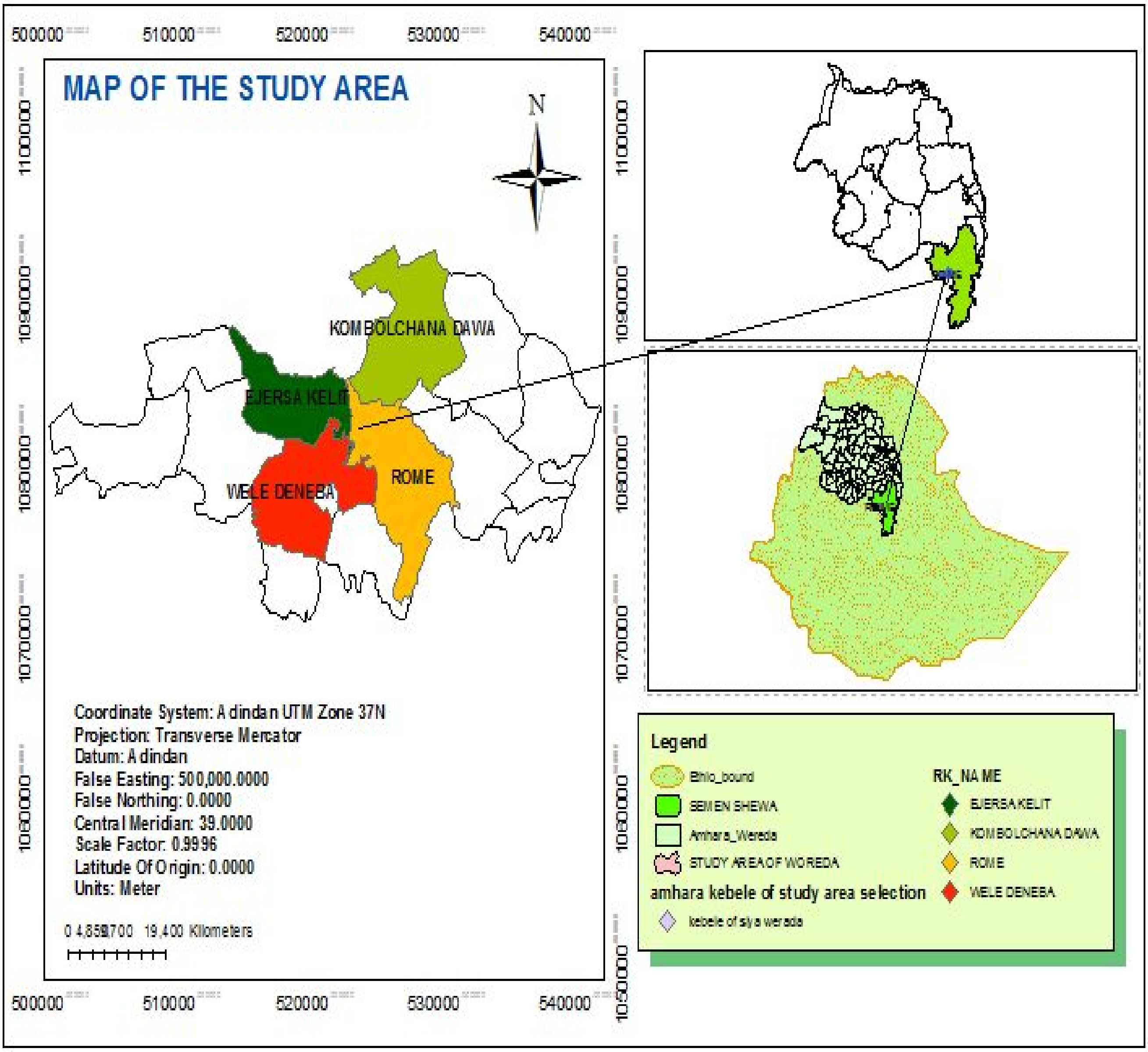

Figure 2 Location of the study area

3.2 Production Character of the Study Area

As it is common among highlanders of the country, mixed farming is also common activities of Siya DebirnaWayu woreda farmers. The major sources of cash income for sample households in the study area are sale from crop production, sale from livestock and livestock products. Wheat is produced for both home consumption and it is also major cash crop for sample households. In the study area wheat accounts 40% of the total value production of all crops. But the share of wheat income from total crop income is significantly higher for Hidase adopter Households than the non-adopters. Its share for total crop income of adopter and non-adopter households is 51% and 17% respectively (see Appendix Table 4.11-Table 4.13). The district farmers are also known for fattening and delivering of bulls, sheep and goat to the nearby towns and Addis Ababa.

3.3 Research Approach

According to Baker (2000), which is cited in (MUTUKU, 2014) there are three main types of impact evaluation designs namely, (i) experimental (randomized approach) associated with the control group, (ii) quasi-experimental (non-random) associated with comparison groups, and (iii) non-experimental associated with non-participants.

Non-experimental methods are used to undertake impact evaluation when it is not possible to construct treatment and comparison groups through experimental design. These techniques generate comparison groups that resemble the treatment group, at least in observed characteristics through econometric methodologies such as matching methods.

In the literature on impact assessment, two methods are commonly used to construct comparison groups. These are the 'before and after' method and the 'with and without' approach.

The "with and without" approach compares the behavior in a sample of program, project or policy beneficiaries, with that of non-beneficiaries (a comparison group). The approach approximates the counterfactual situation using experiences of the comparison group as a proxy for what would have happened in the absence of the program, project or policy (AIEI, 2010) cited in (MUTUKU, 2014).

This study used/applied the non-experimental research design and under this design "without replacement" approach has been carried out to compare beneficiaries from the adoption of HIWV with that of non-beneficiaries/a comparison group (non-adopters) and to measure the impact of participation on adopter households.

3.4 Techniques and Sampling Designs

First Siya DebrenaWayu woreda was selected purposively for this study for that it is one of potential areas of wheat production of the region and the country too. The woreda is also one of the areas where Hidase improved wheat is widely used since 2015/16. To reduce/eliminate sampling bias & ensure equal probability of sample selection multi stage sampling techniques were employed to identify the sample households.

In the production year 2017, there were 999 Hidase improved wheat variety adopter households in the woreda all they were in 5 kebeles. Of which the 956(96%) households were in four kebeles and the remaining one kebele only had 43 adopter households. This kebele was dropped out for that it has no representative size of adopter households, so that the four kebeles which consists of predominantly HIWV adopter households (956) have been purposively chosen with the help of CASCAPE's and woreda agricultural experts in the area. These sample kebeles are Dahoo Kombolcha, Ejeressa Kubati, Rommi and Walle.

These purposively chosen sample kebeles consists of 5040 total households then using Yemane (1996) at 0.08 margin error the size of sample households has been determined i.e 153 households. To find out non-adopter (control group) households, for impact assessment, roughly one third of the total sample size i.e 56 households made to be non-adopter households and the remaining 97 are adopter households. Then these total sample households i.e. 153 which have been divided in to 97 adopters and 56 non adopters have been attempted to distribute among the four kebeles in proportion to their respective sizes of adopter and non-adopter households.

Total number of female headed adopter households in the sample kebeles was only 66 i.e 7% of the total adopter households of the woreda. To see/check sex of household head's impact on the decision to adopt Hidase improved wheat variety, their percentage proportion increased purposively. Accordingly 14.3 % of the total sample households i.e 22 households in number, made to be female headed households. Out of the 22 female headed sample households, the 11 households (50%) are adopters which is 11.3% of the total 97 adopter sample households the remaining 11 female headed households (50%) made to be non-adopters which is about 20 % of the total 56 non-adopter sample households. They also have been distributed among the four kebeles in proportion to their respective sizes of male and female headed adopter and non-adopter households. ***Though, the result of examination of gender specific impact on determining adoption is still insignificant.*** Once proportions of male and female headed adopter and non-adopter households of each kebele determined, then random sampling for each kebele carried out from the existing data (See Appendix 7.2 & 7.3).

3.4.1 Sample Size

The sample size for this research will be determined using the formula, as indicated in Yemane (1996). This study uses the following formula to calculate sample size:

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

Where, N = total number of HHs of the four sample kebeles=5040 households

e = margin error i.e.0.08 and

n = sample size = 153 HHs

3.5 Data Type and Sources

This study used both primary and secondary data. The primary data were obtained from a household survey of 153 farmers (97 treated and 56 controlled) using a semi-structured questionnaire. Secondary data on reactions of the farmers, their perceptions of the technology and priority problem were obtained from the woreda agricultural offices.

3.6 Method of Data Collection

The primary data used for this study collected using semi-structured household survey. The qualitative method of data collection also has been employed to generate supplementary qualitative data. It include 4 ***FGDs***, one for each kebele (the FGD consists of adopter and non-adopter farmers of both sexes, agricultural experts of the woreda and the researcher), ***in-depth open-ended interviews*** (of those earlier adopter farmers), direct ***observations, reports*** from relevant organizations, published and unpublished documents, ***key informants*** (selected farmers, CASCAPE's focal person for the woreda, the researcher and officers of the woreda agricultural office) and ***individual interviews*** have been held to know reactions of the farmers, their perceptions of the technology and priority problem.

3.7 Data Analysis

3.7.1 Descriptive Statistics

Descriptive statistics were used to analyze and compare the socio economic characteristics and institutional variables, between adopters and non-adopters. These include Summary statistics, tabulations (mean & percentage), t-test and Chi Square tests.

3.7.2 Econometric Analysis

3.7.2.1 PSM (Propensity Score Matching)/Impact Model

One of the objectives of this study is to assess the impact of improved wheat technologies on households' wheat productivity and farm income. If the technologies were randomly assigned to farmers, It could be assessed the impact of their adoption on households' wheat productivity and farm income by comparing the average production and income of adopters and non-adopters. However, technologies are rarely randomly assigned. Instead, technology adoption usually occurs through self-selection of farmers or, sometimes, through program placement. In the presence of self-selection or program placement, estimation of the impacts of improved technologies could be biased since the treated groups (i.e. the adopters) are less likely to be statistically equivalent to the comparison group (i.e. the non-adopters) in a nonrandomized setting.

In such case, one of the commonly used techniques to analyze the changes of the project is the propensity score matching. In order to control for selection bias, the researcher propose the use of Propensity Score Matching (PSM), which is a quasi-experimental research design. It constructs a statistical comparison group that is based on a model of the probability of participating in the program, using observed characteristics. Then participants of the program are matched to the non-participant groups based on the probability of participating in the program.

Since matching participants to non-participants on each covariate will be practically difficult, based on observed characteristics of participants and nonparticipants propensity score will be predicted/calculated. Then, the average treatment effect of the program is calculated as the mean difference in outcomes between these two groups.

The importance of estimation of (PSM) is twofold: first, to estimate the average effect of Treatment on the Treated (ATT) and, second, to obtain matched treated and non-treated observations.

3.7.2.1.1 Model Specification of the PSM

Propensity score matching estimates the average impact of the program participation on participants by constructing a statistical comparison group on the basis of the probability of participating in the treatment T conditional on observed characteristics X, given by the propensity score (Rosenbaum and Rubin, 1983).

$$P(\chi i) = Pr(Ti = 1 \perp X) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where: Y1i = the outcome of unit i if i were exposed to the treatment Y0i =the outcome of unit i if i were not exposed to the treatment Ti ∈ {0, 1} = indicator of the treatment actually received by unit i Yi = Y0i + Ti (Y1i – Y0i) =the actually observed outcome of unit I and X-multidimensional vector of pre-determined characteristics or covariates (Rosenbaum and Rubin, 1985).

As a result, if the population of units denoted by *i* and the propensity score P (Xi) is identified, the average effect of Treatment on the Treated (ATT) can be estimated as follows:

$$T = E\{Yi^1 - Yi^0 \mid Ti = 1\} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2) = E\{E\{Yi^1 - Yi^0 \mid Ti = 1, p(Xi)\}$$

$$= E\{E\{Yi^1 | Ti = 1, p(Xi)\} - E\{Yi^0 | Ti = 0, p(Xi)\} | Ti = 1\}$$

Where the external expectation is over the distribution of (p (Xi) |Ti = 1), Y1i is potential outcome of the treated and Y0i is outcomes of the control.

Following Rosenbaum and Rubin (1983), the matching algorithms work with the following two strong assumptions:

The first one is conditional independence /un-confoundedness assumption: this presume that given a set of observable covariates X which are not affected by treatment, the potential outcomes are independent of treatment assignment: un-confoundedness, is that after controlling for covariates (X), mean outcomes of non-treated will be identical to outcomes of the treated if they had not received the program (Rosenbaum and Rubin, 1983).

$$Yi^1, Yi^0 \perp Ti, Xi \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

This implies that selection is only based on observable characteristics and that all variables that influence treatment assignment and potential outcomes simultaneously are observed by the researcher (Caliendo&Kopeinig, 2005). Caliendo&Kopeinig (2005) further noted suggested that if the balancing hypothesis of un-confoundedness is satisfied, observations with the same propensity score must have the same distribution of observable (and unobservable) characteristics independently of treatment status. In other words, for a given propensity score, exposure to treatment is random and therefore treated and control units should be, on average, observationally identical.

In this case, the treatment effects can be estimated by:

$$\begin{aligned}\beta &= E(Yi^1 \mid Xi, Ti = 1) - E(Yi^0 \mid Xi, Ti = 0) \\ &= E(Yi^1 - Yi^0 \mid Xi, Ti = 1) + E(Yi^0 \mid Xi, Ti = 1) - E(Yi^0 \mid Xi, Ti = 0) \\ &= Yi^1 - Yi^0 \mid Xi, Ti = 1) \\ &= E(Yi^1 - Yi^0 \mid Xi) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)\end{aligned}$$

Thus, because of conditional independence the selection effect=0, since

$E(Yi^0 \mid Xi, Ti) = E(Yi^0 \mid Xi)$

$ATE = ATET \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$

The second assumption is the common support assumption additional criterion besides independence is the satisfaction of overlap condition. It works with the trend of perfect predictability of D given X:

$(\text{Over lap})\ \ 0 < P(T = 1|\ X) < 1$…………………………………………….. (6)

It makes sure that individuals with the same *X* values have a positive probability of being both participants and non-participants (Heckman, LaLonde, and Smith, 1999). Treatment units will therefore have to be similar to non-treatment units in terms of observed characteristics unaffected by the treatment; thus, persons that fall outside the region of common support area would be dropped.

Estimation Strategy: if conditional independence assumption is satisfied and there is sufficient overlap between the two groups which is called ‘strong ignorability assumption’ by Rosenbaum and Rubin (1983), the PSM estimator for ATT can be written in general as follows:

$ATT = E\ p(x)|T = 1\{E[Y(1)|T = 1, P(X)] - \{E[Y(0)|T = 0, P(X)]\}$ ……………….……. (7)

Put simply, the propensity score matching estimator is simply the mean difference in outcomes more than the common support, properly weighted by the propensity score distribution of participants. After estimating the propensity score estimates using probit regression model, matching of observations from the treated and control groups will be carried out based on their propensity scores. The effect of adoption of improved wheat varieties on productivity and income of farm households have been estimated through the four different matching methods/algorithms.

3.7.3 Diagnostic Tests

3.7.3.1Testing for Multicollinearity

Prior of running the models all the hypothesized explanatory variables were checked for the existence of multi-collinearity problem. Multicollinearity may arise due to a linear relationship among explanatory variables and the problem is that, it might cause the estimated regression coefficients to have wrong signs, smaller t-ratios for many of the variables in the regression and high R^2 value. Besides, it causes large variance and standard error with a wide confidence interval. Hence, it is quite difficult to estimate accurately the effect of each variable (Gujarati, 2004; Woodridge, 2002). There are two measures that are often suggested to test the existence of multi-collinearity. These are:

Variance Inflation Factor (VIF) for association among the continuous explanatory variables and Mathematically, VIF for individual explanatory variable (Xi) can be computed as

$\boldsymbol{VIF=1/1-R^2}$ 4.1

Where R^2 is the coefficient of correlation among explanatory variables

The larger the value of VIF indicates the more collinearity among one or more model explanatory variables. As a rule of thumb, if the VIF of a variable exceeds 10, which will happen if a multiple R-square exceeds 0.90, that variable is said be highly collinear (Gujarati, 2004). The inverse of VIF (1/VIF) called Tolerance (TOL) is another measure of multicollinearity. The closer is TOL of one explanatory variable (Xi) to zero, the greater the degree of collinearity of that variable with the other regressors. On the other hand, the closer TOL of Xi is to 1, the greater the evidence that Xi is not collinear with the other regressors (Gujarati, 2004). The VIF values displayed in (Appendix table 7.14) have shown that all the continuous explanatory variables have no serious multi-collinearity problem

Contingency coefficients for discrete/dummy variable

Discrete/dummy variables are said to be collinear if the value of contingency coefficient (CC) is greater than 0.75 (Healy, 1984). Mathematically:

$\boldsymbol{CC= \surd X^2/n+X2}$ 4.2

Where n - is sample size and X^2 - is chi-square value

Similarly, contingency coefficient computed for the discrete variable HH extension contact. Accordingly its contingency coefficient value was 0.27 Based on these tests, both the hypothesized continuous and discrete variables which were included into the model have no serious multi-collinearity problem.

3.7.3.2 Testing for Heteroskedasticity

Heteroscedasticity refers to the variance of the error terms in a regression model in an independent variable. If heteroscedasticity is present in the data, the variance differs across the values of the explanatory variables and this will make the OLS estimator unreliable due to bias. It is therefore imperative to test for heteroscedasticity and apply corrective measures if it is present. Various tests help to detect heteroscedasticities such as Breusch Pagan test and White test. Breusch-Pagan test, which used in this study helps to check the null hypothesis versus the alternative hypothesis. A null hypothesis is that where the error variances are all equal (homoscedasticity), whereas the alternative hypothesis states that the error variances are a multiplicative function of one or more variables (heteroscedasticity). If the probability value of the chi-square statistic is less than 0.05. Therefore the null hypothesis of constant variance can be rejected at 5% level of significance. It implies the presence of heteroscedasticity in the residuals.

The chi-square statistic of the Breusch-Pagan test for probit model was 0.09 which is insignificant leads to the acceptance of the null hypothesis (Constant variance) mean that no heteroscedasticity problem (Appendix Table 7.15).

3.7.3.3 Testing For the Goodness-Of-Fit

The goodness-of-fit of a statistical model refers to how well the model fits a set of observations. In this study, the test for the goodness-of-fit of the probit model is carried out using the Hosmer-Lemeshow test, which is the standard statistical test for goodness-of-fit of logistic or probit models (Greene, 2003). The null hypothesis of Hosmer and Lemeshow’s goodness of fit is that the model is fit. If the p-value is less than 0.05, then the null hypothesis is rejected meaning that the model is not fit. Again the finding of p-value of this study is insignificant (0.3375) meaning that the model is best fit to deal the research issues (Appendix table 7.16)

3.8 Definitions of Variables and Expected Hypotheses

3.8.1 Dependent Variables for the Impact Analyses

3.8.1.1 Dependent Variable for Impact Analysis

Adoption of Hidase Wheat Variety. It is 0 or 1, 1 is for those HHs adopt HIWV and 0 otherwise

3.8.2 Outcome Variables for the Impact Analyses

Wheat productivity and income/value of wheat production have been used to estimate the impact of improved wheat varieties.

3.8.2.1 Wheat Productivity

Wheat productivity computed by dividing the total wheat yield/output produced by the total area of land cultivated for wheat during the season 2009/10 E.C (2017 G.C)

3.8.2.2 Income from Wheat Production

Income from wheat production is calculated by subtracting the input cost, which includes the costs of credit, fertilizer, seed, other chemicals, and hired labor, from the value of wheat production. The value of wheat production is the sum of the values, evaluated at the market prices.

3.8.3 Independent Variables

Independent variables are variables that explain adoption **(**decisions to adopt Hidase improved wheat variety). Definitions of their units, explanations of their effects and expected hypotheses /signs summarized in the below tables.

Table 3. 1 Summary of Discrete Independent Variables

variables	Explanation of Effects of Explanatory variables	Expected sign
Farm fertility	Bezabih (2001) shows in his study that land quality as one of a factor play significant role in the adoption decision. The result of his study revealed that with increased land fertility, the probability of adoption of package of the technologies was low. In this study too, soil fertility was hypothesized to be correlated inversely/negatively with the probability of adoption.	-
Slope of farm	According to (Gauchan et al, 2012) endowment of lowland/flatter fields is important in increasing new improved rice variety adoption. Unlike this because of the assumption that: Farmers' practicing on sloppier farm land can be productive through the application of yield increasing technologies, this study hypothesized that the more sloppier farm land the more adopter &VV	+
Land Ownership	According to some research results, owning an arable land could be taken as a prerequisite to adopt and employ agricultural technologies since farmers could incur a cost. Being a rational decision makers, while incurring a cost for technologies, farmers want to employ technologies within their own land where the final crop yield could not be shared and sub-divided which is common in some share cropping system. Contrary to this, in this study diversified land ownership status of farm households expected to influence adoption decision of HIWV positively. Those HHs who access land in different means of ownership needs to be productive and profitable and they are more likely to adopt than hhs using only their own land.	+
Membership to an Association	Membership to an association let farmers to access inputs easily with an affordable price that is pertinent to adopt HYV on time through an affordable price as well as through credit that will be returned back soon after harvesting.	+
Extension contact	Empirical results revealed that extension contact has a positive influence on farm households' adoption of new technology (Kidane (2001), Hailu, 2008).In this study also farmers' visited by extension agents are believed to be exposed for different, new, updated information used to adopt HYV	+

Table 3. 2 Summary of continuous independent variables

Independent variables	Explanation of Effects of Explanatory variables	Unit	expected signs
Farm size	Different studies reported effects of farm size on adoption differently. The study conduct by Legesse (1992) reported negative relationship between cultivated land size and adoption. Contrary to this, (Yishak, 2005) indicated positive relationship between cultivated land size and adoption. In this study also total farm size was hypothesized to have positive relation with adoption, for that those with large land size could use new technologies with lesser risk than those who have smaller land size.	**Ha**	**+**
Home to farm distance	Findings of Menale *et al.* (2012) in rural parts of Tanzania where input adoption and farm income decreases as plot distance increases. Unlike to that, this study was hypothesized Households Home-farm distance to be positively correlated with the decision to adopt HIWV. Because as plot is far away from the homestead, farmers most probably to adopt High Yielding improved Varieties to compensate costs caused by remoteness of their farm.	**Km**	**+**
HH's Wheat Farming Exp	Farmers who have longer years of experience may develop the confidence in handling the risk, skills in technology application and they are the more probable to adopt than less experienced. In most previous studies like Legesse (1992), (Chilot et al, 1996), Kidane (2001) and Endrias (2003) experience of wheat farming positively influence the probability of adoption. This study also hypothesized it to affect adoption positively	**Years**	**+**
Owners-hip of livestock	Studies by (Gorfe, 2004), (Geta, 2003) revealed that ownership of livestock increases adoption through increasing purchasing power of improved seed. This study as well It was hypothesized that livestock ownership increases adoption.	**TLU**	**+**
incomes of HHs	The income comparison excludes value/income of wheat for that income from wheat production is one of the outcome variables. Annual farm income obtained from sale of other crops and/or livestock, lead to an increase in the likelihood of wheat technology adoption. Because a household with sufficient annual income could not be financially constrained and prohibited from the timely use of the improved wheat technologies/varieties	**Birr**	**+**
Home-market distance	Access to road in general and distance from a near market and input suppliers in particular influence farmers' adoption of new technologies. Markets are communication centers both for producers, consumers and traders (Hailu, 2008). In this study too, it was hypothesized that the distance between the respondent's residence and the nearest market place to be negatively correlated with the decision to adopt newly introduced wheat variety.	**Km**	**-**
HHs number of Oxen	Animal power for plowing is important where the size of the cropped area is smaller and tractor mechanization is not possible. So that owning oxen by farm households can positively impact the probability of adopting improved high yielding wheat variety by farm households.	**count**	**+**

Chapter Four: Results and Discussion

Major findings of the study will be discussed in this chapter. Both descriptive statistics and econometric analyses used to analyze the primary data regarding with farm related characters, economic factors and institutional/access related variables of sample households. Econometric analyses used to identify the probability of adoption of Hidase improved wheat variety and impact of the adoption on wheat productivity and wheat income of households in the study area. The analyses have been done in the light of the objectives of the study. Section 4.1 is about the descriptive analysis of the model variables. Section 4.2 deals about the result of the econometric analyses.

4.1 Descriptive Statistics

In the following section mean, standard deviation, percentage, t-test and Chi-Square test will be employed to describe farm related characters, economic factors and institutional/access related variables of adopter and non-adopter sample households.

4.1.1 Descriptive Analysis of Categorical Variables

4.1.1.1 Households Extension Contact

The frequency of contact between the extension agent and the farmers is hypothesized to be the facilitator, which accelerates the effective dissemination of adequate agricultural information to the farmers, thereby enhancing farmers' decision to adopt HIWV. Empirical results revealed that extension contact has a positive influence on farm households' adoption of new technology (Kidane (2001) & Hailu (2008). In the same way in this study the result of chi-square analysis revealed that there is a significant association between extension contact and adoption of HIWV. The mean difference between adopters and non-adopters is significant at or below 1 percent probability level. As indicated in Table 4.1, in the first two highest categories of the frequencies i.e. twice a week and once a week 121 households have been visited by extension workers once up to twice a week. Of these 121 hhs 85 of them which is greater than 73% are adopters and the remaining 36 hhs which is about 27% are non-adopters. In the last and lowest category of the frequencies i.e. those visited only monthly or in longer time 32 households included of which the 20 (about 62.5%) are non-adopter and the remaining 12 (about 37.5%) are adopter households. Generally adopters of improved wheat variety are those more frequently visited by extension workers than the non-adopters.

4.1.1.2 Households Sources of Land (Land Ownership)

According to some research results, owning an arable land could be taken as a prerequisite to adopt and employ agricultural technologies since farmers could incur a cost. Being a rational decision makers, while incurring a cost for technologies, farmers want to employ technologies within their own land where the final crop yield could not be shared and sub-divided which is common in some share cropping system. Contrary to this, in this study diversified land ownership status of farm households expected to influence adoption decision of HIWV positively. Those HHs who's Source of land increased/diversified have higher probability of adopting HIWV unlike their counterparts, non-adopters. This clearly shown in the table below 87.5% of non-adopters rely only on their own farmland but about 45% of adopters accessed land through different means of ownership in addition to what they have. The probability and intensity of those who have better access to land is significantly higher than those non adopter households who have lesser access. The chi-square result of the analysis showed that there is a significant positive association between diversity of Source of land and adoption of HIWV. The mean difference between the two categories of adoption is significant at or below 1 percent probability level (Table 4.1)

4.1.1.3 Households Farm Fertility

Bezabih (2001) shows in his study that land quality as one of a factor play significant role in the adoption decision. The result of his study revealed that with increased land fertility, the probability of adoption of package of the technologies was low. This could be due to the decision behavior of the farmers in his study area. In this study too, soil fertility was hypothesized to be correlated inversely/negatively with the probability of adoption as found to be significant after the data analyzed and summarized in table 4.3.All the best and most fertile farms owned by only non-adopters. On the other hand, though it is small in size, all the least quality/infertile farms are owned by adopters. When adopters and non-adopter households compared with respect to moderately and less fertile farmlands, >98% of adopters' farmlands is moderately and less fertile farmlands but it is only 87.5% for non-adopters. The chi-square results of the analysis showed that there is a significant positive association between farm fertility and adoption of HIWV at or below 1 percent probability level (see Table 4.1)

4.1.1.4 Memberships in Associations

Membership and leadership in community organization assumes that farmers who have some position in peasant associations and other different social organization are more likely to be aware of new practices as they are easily exposed to information. This in turn determines the decision to adopt. In this study also Heads of Households membership in associations and adoption had positive relationship at less than 1% significant level. The percentage proportion in membership between adopters and non-adopters also shows how much membership in associations matter the decision to adopt. While greater than 82% of adopters are members in different associations and social organizations, but it is < 27% for non-adopters (Table 4.1)**.**

4.1.1.5 Households' Farm Slope

Like fertility Classifying the slope of land into flat, less-steep, and steep land type can affect the probability of adoption. According to (Gauchan et al, 2012) endowment of lowland/flatter fields is important in increasing new improved rice variety adoption. In this study it was expected that steepness of Households' farm slope to enhance the probability of adoption of HIWV.As hypothesized the analysis showed that a positive correlation which is statically significant less than at 1% significant level shown in table 4.1 below.

Table 4. 1 Summary of Descriptive analysis of categorical variables

	Variables	Non Adopter		Adopter		X^2	Total	
1	**HH extension contact**	**No**	**%**	**No**	**%**	**12.7803(0.002)*** **	**No**	**%**
	monthly-never	20	35.71	12	12.37		32	20.91
	weekly	28	50	73	75.25		101	66.01
	twice in a week	8	14.29	12	12.37		20	13.07
	Total	56	100	97	100		153	100
2	**Households Source of farmland**	**No**	**%**	**No**	**%**	**18.4253(0.000)*** **	**No**	**%**
	own only	49	87.50	52	53.61		101	66.01
	own+rent/share cropping	6	10.71	33	34.02		39	25.49
	own+rent+share cropping	1	1.79	12	12.37		13	8.5
	Total	56	100	97	100		153	100
3	**HHfarm_fertility**	**No**	**%**	**No**	**%**	**21.0606(0.000)*** **	**No**	**%**
	infertile	0	0	1	1.03		1	0.65
	less fertile	29	51.79	33	34.02		62	40.52
	moderately fertile	20	35.71	63	64.94		83	54.24
	Fertile	7	12.50	0	0.00		7	4.57
	Total	56	100	97	100		153	100
4	**membership_ass**	**No**	**%**	**No**	**%**	**46.7768(0.000)*** **	**No**	**%**
	not member	41	73.21	17	17.53		58	37.91
	Member	15	26.79	80	82.47		95	62.09
	Total	56	100	97	100		153	100
5	**HHfarm_Slope**	**No**	**%**	**No**	**%**	**7.2011(0.007)*** **	**No**	**%**
	plain/gentle slope	49	87.5	66	68.04		115	75.16
	steep	7	12.5	31	31.96		38	24.84
	Total	56	100	97	100		153	100

Source; own survey, 2017

Note: ** and * shows significance at 5% and 1% probability level respectively.**

4.1.2 Descriptive Analysis of Continuous Variables

4.1.2.1 Number of Oxen

Farmers that have more oxen have high rate of adoption of agricultural technologies. Because availability of oxen during the main agricultural season (sowing and thrashing) help farmers to collect farm output on time. It was hypothesized that ownership of oxen to influence adoption of HIWV positively. The average oxen ownership of adopters of improved wheat varieties was 2.39 and for non-adopters 1.8. As shown Table 4.2 the t-test revealed that, Oxen ownership positively influenced the probability of adoption of improved wheat variety at less than 1% significance level. This result suggests that, those farmers who owned more oxen have better chance to use improved seed technology in the study site. The results of this study agree with the result of (Degnet *et al*., 2001).

4.1.2.2 Farm size

Concerning cultivated land size, different studies reported its effect differently. The study conduct by Legesse (1992) reported negative relationship between cultivated land size and adoption. Contrary to this, (Yishak, 2005) indicated positive relationship between cultivated land size and adoption. In this study also total farm size was hypothesized to have positive relation with adoption and the data analyze that: The average total cultivated land size of the study area is about 2 ha, which is relatively good than many other parts of the country. The average total cultivated land size was 2.38 ha for adopters and 1.50 ha for non-adopters of improved wheat varieties. As shown in Table 4.2 the t-test indicated that, from sample farmers the mean differences for average cultivated land size and adoption of improved wheat verities were found to be at 1% significant level in the study area. This result is in line with (Yishak, 2005)

4.1.2.3 Ownership of Livestock (TLU)

It was hypothesized that livestock ownership increases adoption; because it increases purchasing power of improved seed. To help the standardization of the analysis, the livestock number was converted to tropical livestock unit (TLU). As shown in Table 4.2: The average cattle ownership of sampled households for the adopters was 7.25 TLU, while for the non-adopters was 6.10 TLU. The result showed that the Livestock holding owned mean difference between the two groups is significant at 5 % level. The implication is that adopters have more access to financial capital by selling their livestock to purchase improved seed from suppliers. The result of this study confirms with the study conduct by (Habtemariam, 2004) and Endrias (2003).

4.1.2.4 HH Income (other than Wheat income)

As many empirical studies confirmed, this study also hypothesized that the effect of income on household's adoption decision to be positive. As indicated in Table 4.2 that, the average annual farm income of the sample households was 56662.687ETB. The maximum annual farm income was 419824.2 Birr while the minimum was negative 2279.84. The negative sign may happen because of crop failure for different reasons or simply bankruptcy i.e outweigh of input costs than the value of wheat production. On average, adopters had higher annual farm income of 64984.04 ETB as compared, to non-adopters whose average was only 42248.88 ETB.

4.1.2.5 Households Home - Farm Distance

Households Home-farm distance was hypothesized to be positively correlated with the decision to adopt HIWV. The data analysis also proved that the probability of adopting improved wheat variety increases as plot distance from home increases. This finding is contrary to the findings of Menale *et al.* (2012) in rural parts of Tanzania and Berihun Kassa Hailu *et al.* (2014) in Southern Tigray, Northern Ethiopia, which revealed that adoption of technologies and farm income decreases as plot distance increases. The average distance between home-plot was about 1.47 km for adopter households but it is only 0.91km for non-adopter households which shorter in average by about 0.5km. The mean difference in farm-home distance between adopter and non-adopters is also significant at 1% significance level (Table 4.2).

4.1.2.6 Households' Market-Home Distance

Access to road in general, and distance from a near market and input suppliers in particular, influence farmers' adoption of new technologies. Markets are communication centers both for producers, consumers and traders (Hailu, 2008). In this study too, it was hypothesized that the distance between the respondent's residence and the nearest market place (measured in killo meters) to be negatively correlated with the decision to adopt newly introduced wheat variety. As Table 4.2 showed that the distance between the respondent's residence and the nearest market place mean difference between the two groups is significant at 5 % level.

4.1.2.7 Farming Experience

Households' wheat farming experience is one of important household related variables that have relationship with adoption. Well experienced households in wheat farming appear to have often full information and better knowledge and supposed to evaluate the advantage of the technology. Hence it was hypothesized to affect adoption positively. Result of the data analyses in this study also reveal that Experience of wheat farming positively influence the probability of adoption at 1% significant level which is in line with most previous studies like Legesse (1992), (Chilot et al, 1996), Kidane (2001) and Endrias (2003).

Table 4.2 Summary of Descriptive analysis of continuous variables

No	Variable	Non Adopter		Adopter		t-value	Total	
		No	Mean	No	Mean		No	Mean
1	**Number_Oxen**	56	1.803571	97	2.391753	4.4911(0.0000)***	153	2.176471
	SD		.7958904		.7713179			.8281054
2	**HHfarmsize**	56	1.503348	97	2.381799	-4.4739(0.0000)***	153	2.060275
	SD		.6079983		1.393259			1.24097
3	**HHTLU**	56	6.102875	97	7.255144	-2.4205(0.0167)**	153	6.833399
	SD		2.425642		3.046995			2.881458
4	**HHInc/wheat**	56	42248.88	97	64984.04	-2.7080(0.0075)***	153	56662.68
	SD		57441.61		45230.14			51055.91
5	**Home_farmdistance**	56	.9104911	97	1.470464	-2.8128(0.0056)***	153	1.265507
	SD		1.115114		1.225077			1.212875
6	**market_home-distance**	56	7.255536	97	5.310309	2.5912(0.0105)**	153	6.022288
	SD		4.547464		4.429899			4.556382
7	**Wheat Farming Exp**	56	11.55357	97	15.89691	-3.7208(0.0003)***	153	14.30719
	SD		6.002786		7.446314			7.243219

Source*; own survey, 2017*

Note ** and * shows significance at 5% and 1% probability level respectively.**

4.2 Results of Econometric Analyses

Initially a total of 19 explanatory variables were considered to influence the decision to adopt. When these variables tested individually only 12 of them were found to significantly influence adoption of Hidase improved wheat variety (Tables 3.1 and Table 3.2). Five of these variables together with other two variables (HHs labor size and Age of HHs head) fit to the models was used for running the probit model. The remaining seven variables (HHs Livestock ownership, HHs income positions, market-home distance, Source of land, membership in associations, farm fertility and farm-slope) were excluded from the model only due to the instability they created in the models (regardless of their importance and their significant relationship). List of the variables with their operationalization presented below. Table 4.4 presents determinants of adoption of Hidase improved wheat Variety and Summary of ATT of wheat productivity and Wheat income presented in the tables 4.8 and 4.9

4.2.1 Determinants of Adoption of HIWV

The probit analysis of factors affecting the adoption of improved wheat variety showed that Households' Number of Oxen, extension contact, farm size and Households' wheat farming experiences are positively and significantly influenced the probability of adoption. However Households' labor size is negatively, but significantly influenced the probability of adoption of improved wheat varieties in study area. Among the variables included in the analysis, indicated in the Table below showed that Number of Oxen, frequency of Extension contact and Households' wheat farming experiences are significant at 1% significance level. Farm size and Households' labor size are also significant at less than 5% significance level in influencing the probability of adoption improved wheat variety. While all other significant variables influenced the probability of adoption of improved wheat varieties positively, Households' labor size negatively influenced the adoption of improved wheat variety. This negative sign is unexpected and in different direction from which hypothesized before. This could happen because technologies have different labor characteristics; some save labor, while others significantly demand it.

4.2.1.1 Number of Oxen

As hypothesized before the number of oxen farmers owned positively and significantly affect adoption of HIWV at 1% significant level. This implies that farmers that have more oxen have higher rate of adoption. The result suggests that, those farmers who owned more oxen have better chance to use improved seed technology in the study site. The result of this study is in line with the result of (Degnet *et al.*, 2001).

4.2.1.2 Households Extension Contact

Frequency of extension service by extension agent to farmers as expected, positively related to adoption of improved wheat varieties and statistically significant at 1% probability level in the study area. The result of the study revealed that as frequency of Households extension contact increased, adoption of HIWV also increased. This is because the higher the linkage between farmers and development agents, the more the information flow and the technological (knowledge) transfer from the latter to the former. Those farmers with frequent contact with extension workers are likely to have up-to-date information on production technologies that would help them to better adaptation and usage of the new variety.

4.2.1.3 Farm size

Households' farm size was hypothesized to increase a farmer's adoption of improved wheat varieties. As the probit model indicates cultivated land size has positive and significant influence on the adoption of improved wheat varieties at less than 5% significant level. This result agrees with Tesfaye et al., (2001) and Mesfin, (2005). This shows that large cultivated land size have better access to adoption of improved wheat varieties and are more likely to adopt improved wheat varieties than small cultivated land size and also increase their wheat production. Small cultivated land size have not better access to on improved wheat varieties and are not more likely to adopt wheat varieties than large cultivated land size. This is may be because of fear of risk to allot the whole or portion of their small land to adopt new wheat variety.

4.2.1.4 HHs Wheat farming Experience

As anticipated, farming experience had a positive and significant relationship at ($p< 0.1$). This implies that farmers who have longer years of experience in farming have adopted improved bread wheat varieties than those who have the lower years of experience in farming. This may be due to relatively farmers who have longer years of experience may develop the confidence in handling the risk, skills in technology application. Different studies have agreed with this argument. For instance, Legesse (1992), Kidane (2001) and Melaku (2005) have described the positive relationship of farming experience with adoption.

4.2.1.5 Households' labor size

Households' labor size is important variable which in most cases has an effect on household's decision to adopt new technologies. In this study unexpectedly the HHs labor size and the probability of adoption of HIWV related negatively. This is in line with Million and Belay (2004) but contrary to Kidane (2001). The inversely/negatively proportionate of HHs labor size with probability of adoption display that those HHs with small size labor intended to raise their productivity through applying high yielding varieties. This in turn led them to hire the needed labor for the adoption of improved variety depends on the variety labor character, which is well proved in this study from YES answer of 131 interviewees out of 153.Out of which adopters account about 66% and non-adopters only the remaining 34%.So that being small size labor HH is not mean that being non-adopter rather it is being employer of labor for being adopter of a technology.

4.2.2 Impact of Adoption of HIWV on HHS Wheat Productivity and Income

4.2.2.1 The program effect

This study used the two sample t-test to check adoption of Hidase Improved variety program has a significant impact on wheat productivity and households' income. The mean value of wheat productivity (in Quintal/hectare) of the adopters equals to 58.9523 /ha and the non-adopter households is 38.11905/ha, the result shows that adopter households wheat productivity is higher by more than 20 quintal/ha compared with the non-adopter households. Similarly, the mean value of income of the adopters is 46026.08ETB while it is 4703.831 ETB for the control groups. The mean difference indicates that adopter households annual output is higher by 41322.25ETB than non-adopter households. The difference in both wheat productivity and income is significant at 1% critical level. This indicates that adopter households have better wheat productivity and income than non-adopters

Table 4. 3 Two sample T-test on Wheat Productivity and income before matching

Outcome Variables	Groups	Observations	Mean	Std.err.	Std.dev.	T-test
Wheat Productivity	Non-adopters	56	38.11905	1.41638	10.59922	-4.1369***
	adopters	97	58.9523	3.733201	36.76776	
	combined	153	51.32706	2.551226	31.55692	
	Difference		-20.83325	5.035936		
Income	Non-adopters	56	4703.831	6344.257	47476.07	-6.5065***
	adopters	97	46026.08	3147.727	31001.52	
	combined	153	30901.6	3450.325	42678.16	
	difference		-41322.25	6350.957		

Source; own survey, 2017

*** denotes significant at the 1% probability level

4.2.2.2 Estimating PSM

The pseudo – R^2 value of the binary probit model which was used to estimate PSM of adopter and non-adopter groups is 0.2893 (Table 4.4). This low R^2 value indicates/implies that the selected household doesn't have much different characteristics and easy to find a good much between adopter and non-adopter groups.

In this study, the participant households in adopting Hidase improved wheat variety is the treatment variable, it takes the value 1 otherwise 0 (for non- participants). The probit result of participation in adopting Hidase improved wheat variety is presented in table 4.4. The observable household characteristics used for estimating propensity score matching are Households' Number of Oxen, extension contact, farm size, Households' wheat farming experience, Households' labor size, HHs home to farm distance and ages of hhs head.

Table 4. 4 Probit Result Participation in Adopting Hidase Improved Wheat Variety

Covariates	Coef	Std.Err
Number of Oxen(count)	.5261365***	.1943475
Farm size(ha)	.4790269**	.1908601
Extension contact(frequency)	.6534107 ***	.2278483
Home to farm distance(km)	.2018627	.1081644
Households' labor size	-.2740122**	.1357782
Age of housholds' head	-.0060902	.0157194
HHs' wheat farming experience	.0671827***	.0216387
_cons	-4.178325	1.158865

Log likelihood = -71.417904

Number of obs = 153

LR chi2 (8) = 58.14

Prob =0.0000

Pseudo R2 = 0.2893

Source; own survey, 2017

******denotes significant at 1% level and **denotes significant at 5% level***

4.2.2.3 Region of Common Support

The binary probit model also define/determine region of common support and ATT for both adopter and non-adopter groups. Accordingly all the non-adopter/controlled households are included on support, while from the total treated observation 24 households or 24.7% are off support and the remaining 73 households (75.3%) are on support.

Table 4. 5 Common support region

	Wheat Productivity			**Income**		
	Off	On	Total	Off	On	Total
Untreated	0	56	56	0	56	56
treated	21	76	97	21	76	97
Total	21	132	153	21	132	153

Source: own survey, 2017

Each treated unit is matched only with the control unit whose propensity score falls into a pre-defined common support region of the propensity score matching. As we can see from the ATT result in table 4.6, on the common support region, wheat productivity, Hidase adopter household's average wheat production/ha is 63.65 % higher than the control group, significant at 1% level. Regarding income the adopter household's average income is much more than the non-adopter households, significant at 1% level. ***This is because of that Hidase improved variety is not only more productive than the comparing local variety, but also less costly for cost of productions and higher value/price of the production.***

Table 4. 6 ATT with a common support range income and output

Variable	Sample	treated	controls	difference	S.E	T-stat
Land Productivity	Unmatched	58.9523026	38.1190476	20.833255	5.03593559	4.14
	ATT	60.6384521	37.0526315	23.5858206	5.26191366	4.48
Income	Unmatched	46026.0781	4703.83056	41322.2475	6350.95666	6.51
	ATT	39504.3996	328.361063	39176.0385	18858.1651	2.08

Source; own survey, 2017

4.2.3 Specification Tests for the Propensity Score Matching

4.2.3.1 Covariate Balancing Test

The main purpose of the covariate balancing is to estimate the propensity scores in order to balance the distributions of the variables in both groups. The balancing power of the estimates is ascertained by considering the reduction in the median absolute standardized bias between the matched and unmatched models. Covariate balancing is achieved when the differences between the covariates have been eliminated or substantially reduced after matching. This covariate balancing test is used to test the null hypothesis that both groups (treated and untreated) have the same distribution in covariates *x* after matching (Gujarati, 1995). In this study as well, covariate balancing test done by using tests of differences in means. To know by how much the bias was eliminated the ATT result needs to be conformed using "pstest". Table 4.7 shows the comparison of density estimation of both treated and untreated groups before matching and after matching. As shown in the table, both the mean bias and median bias of the data for this study eliminated by 39.7% and 43.7% and reduced to 5.1% and 4.1% respectively, which indicates the matching was good.

4.2.3.2 Validity Test using Propensity Score Histogram

A propensity score histogram which is used to test the validity or performance of the propensity score matching estimation by verifying the common support or overlap condition. The assumption made is that the probability of participation in any intervention lies between 0 and 1 on condition that the characteristics are observed (Caliendo and Kopeining 2005). This is done by the visual inspection of the propensity scores distributions for the treated and untreated groups by observing the overlap condition to see if the matching is able to make the distributions look more similar (Bryson et al., 2002). Figure 3 presents the histogram of propensity scores to check up if there is enough overlap between treated and control groups. As shown in the graph, there is enough overlap or common support between the two groups

Table 4. 7 means bias reduction

Variable	Unmatched	Mean				T-test		
	Matched	Treated	Control	%bias	bias reduction%	t	p>t	V(T)/VC
Number of Oxen	Unmatched	2.3918	1.8036	75.1		4.49	0.000	0.94
	Matched	2.2105	2.2632	-6.7	91.1	-0.51	0.613	0.77
HHs farm size	Unmatched	2.3818	1.5033	81.7		4.47	0.000	5.25*
	Matched	1.9511	1.9951	-4.1	95	-0.39	0.695	1.86*
HHs laborsize	Unmatched	3.3856	3.3286	4.6		0.27	0.786	1.17
	Matched	3.3066	3.3145	-0.6	86.1	-0.04	0.966	1.68*
Extension contact	Unmatched	4	3.7857	35.9		2.23	0.027	0.54*
	Matched	3.9605	3.9605	0.0	100.0	0.00	1.000	0.51*
HHs wheat farming exp	Unmatched	15.897	11.554	64.2		3.72	0.000	1.54*
	Matched	14.724	14.539	2.7	95.8	0.17	0.869	0.98
HHAge	Unmatched	45.876	46.25	-4.0		-0.24	0.813	0.97
	Matched	45.645	44.658	10.5	-164.1	0.64	0.521	1.14
HHs Home to farm distance	Unmatched	1.4705	.91049	47.8		2.81	0.006	1.21
	Matched	1.3762	1.2429	11.4	76.2	0.65	0.514	0.64
* if variance ratio outside [0.67; 1.50] for U and [0.63; 1.59] for M								

Sample	Ps R2	LR chi2	p>chi2	Mean Bias	Med Bias	B	R	%Var
Unmatched	0.289	58.14	0.000	44.8	47.8	132.2*	1.59	43
Matched	0.007	1.43	0.985	5.1	4.1	19.3*	0.72	43

* If B>25%, R outside [0.5; 2]

Source; own survey, 2017

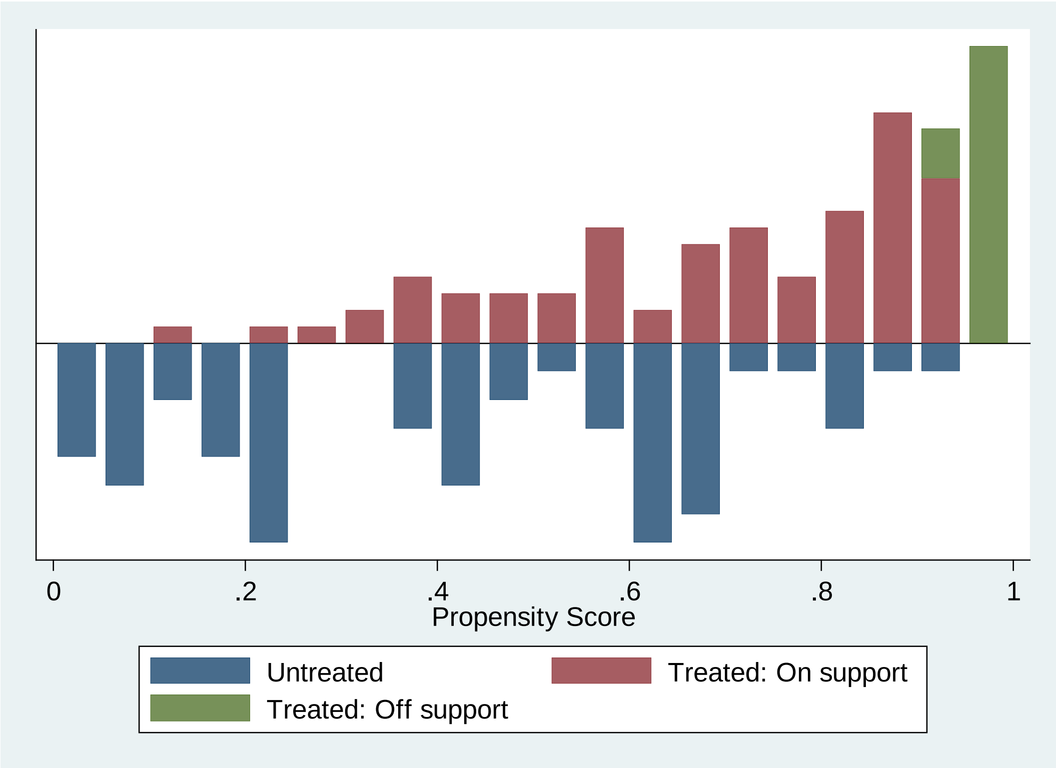

Figure 3 Psgraph

4.2.3.3 Testing the Matching Quality or Balance of Propensity Score and Covariant

Indicators of quality matching before and after matching test is conducted to ensure that the matching procedure (using PSM) balances the characteristics of the treated and the matched comparison groups. The critical values used in this test are the pseudo R2 and the likelihood ratio. The pseudo R2 is useful in evaluating multiple models which predict the same outcome on the same dataset while a likelihood ratio is a statistical test for making a decision between two hypotheses based on the value of this ratio (Ali and Abdulai, 2010). When the pseudo R2 are low and the likelihood ratio tests are insignificant after matching indicate that both groups have the same distribution in covariates X after matching.

The pseudo R2 and the likelihood ratio tests from the probit of treatment status on the regressors X were also generated. These two test indicators were compared before matching and after matching on the matched samples thus used as a diagnostic test to assess if the matching procedure using PSM was able to balance the characteristics of the treated and the matched comparison groups to ensure that the comparison group is a credible counterfactual. According to Sianesi (2004) the comparison of pseudo R2 (before and after matching the samples) should be lower after matching the samples to ensure that there are no systematic differences in the distribution of the covariates between the two groups.

4.2.4 Matching Participant and Non-Participant Households (Matching Algorithms)

Different matching estimator was used to match the treated and control group in the common support region. The final choice of a matching estimate was guided by different criteria such as the balancing test are equally mean, a low pseudo-R^2 and large sample size is preferred Dehejia and Wahba (2002) cited in (Alemayehu, 2018)

To estimate the average treatment effect of the intervention (adoption of Hidase improved wheat variety on the productivity and income) on the treatment group, different matching algorithms have been used. This includes Nearest-neighbor matching, Caliper or radius, stratification and Kernel matching. “attnd”, “attr”, “attk” and “atts” respectively (Khandker et al, 2010).

Out of 153 total observations, 28 matched observations in the nearest neighbor matching, 47 observations matched in Kernel matching and Caliper or radius matching (0.1) and 48 in Stratification matching (Table 4.8).

4.2.4.1 Estimation of ATT for Wheat Productivity Using the Four Matching Methods

Out of 153 observations, 23 matched observations in the nearest neighbor matching, 45 observations matched in Kernel matching, Caliper or radius matching (0.1) and Stratification matching (Table 4.8). The PS matching result tells us that participant’s households in adoption of HIWV show a significant positive impact on wheat production and income from the wheat.

As per NNM, RM, KM and SM the participant households wheat productivity is higher than the nonparticipant by 22.994 Q/ha, 21.921 Q/ha, 23.543 Q/ha and 23.150 Q/ha respectively at 1% significant level, as the t-value for Nearest-neighbor 4.587, Caliper or radius 5.187, under Kernel matching 5.689 and Stratification matching method 5.920. Therefore, the study chooses NNM, RM and KM method as per large matched sample size. On average the treatment effects on the treated group ranges of 23.543 Q/ha in kernel Matching method and 21.921 Q/ha in radius Matching method. Which means on average wheat productivity in Q/ha of participant households has been increased by 21.9921 Q/ha – 23.543Q/ha. This indicates that adoption of HIWV has brought a significant impact on an increase in the productivity of the participant households.

Table 4. 8 Estimation of ATT for wheat productivity using the four matching methods

Matching Method	Number of Treatment	Number of Control	ATT	Std. Err.	t-value
Nearest-neighbor matching	97	23	22.994	5.013	4.587***
Caliper /radius(0.1) matching	97	45	21.921	4.226	5.187***
Kernel Matching	97	45	23.543	4.138	5.689***
Stratification/Interval matching	97	45	23.150	3.911	5.920***

Source; own survey, 2017

4.2.4.2 Estimation of ATT for Income Using the Four Matching Methods

As per NNM, RM, KM and SM the participant households income higher by 40813.377, 40769.762, 37108.031and 38246.910 ETB than the non-participant respectively, the results are statistically significant at 1% level in all the three chosen algorithms, as the t-values are in Caliper or radius 4.027, Kernel matching 5.753 and Stratification matching 4.679 but in Nearest-neighbor it is only 1.608, which is less 1.96 i.e. insignificant (Table 4.9).

Therefore, the study chooses Caliper or radius (0.1), kernel and Stratification matching methods as per large matched sample size. On average treatment effects on the treated group have been ranged of 40769.762 ETB in Caliper/radius (0.1) matching method and 37108.031 ETB in Kernel matching method. This mean on average income from wheat production of participant households has been increased by 37108.031 - 40769.762 ETB. This indicates that, the adoption of HIWV has brought a significant impact on the participant households' income (Table 4.9) .

This study is consistent with the studies done by Ibrahim *et al*. (2012) which purport the direct effect of technology adoption on the farmer's income resulting from higher yields and prices and Besley and Case (1993) which also purports that, adoption of HYV has long been taken as a solution to heighten agricultural income and diversification.

Table 4. 9 Estimation of ATT for wheat income using the four matching algorithms

Matching Method	Number of Treatment	Number of Control	ATT	Std. Err.	t-value
Nearest-neighbor matching	97	23	40813.377	25373.746	1.608***
Caliper/radius(0.1) Matching	97	45	40769.762	10124.585	4.027***
Kernel Matching	97	45	37108.031	6450.444	5.753***
Stratification/Interval matching	97	45	38246.910	8174.728	4.679***

Source; own survey, 2017

Generally the result of this study reveals that there is a positive significant difference between adopter (Treated) and non- adopter (Control) households. This indicates that, the adoption of HIWV has a significant contribution to wheat productivity and income of the participants' households.

4.2.5 Checking Robustness of Average Treatment Effect

According to (Khandker et al, 2010) there are two major ways of checking robustness of average treatment effect. These are estimating propensity score equation and apply direct nearest-neighbor. If both methods give similar results, then the findings are assumed to be more reliable.

4.2.5.1 Estimating Propensity Score Equation

As the result of estimating propensity score equation summarized in the above table (4.8 and 4.9), ATT (Average Treatment Effect on the Treated) is significant in all the four algorithms which indicated Robustness of Average Treatment Effect

4.2.5.2 nnmatch

As shown in table 27 and 28, the nnmatch result are consistent with the result provided by ATT (Average Treatment Effect on the Treated) which is significant in all the four algorithms in land productivity and in three different algorithms except NNM in the case of income from wheat. The "Z'' value of both outcome variables are highly insignificant, having P- value<1 which also show robustness of the average treatment effect.

Table 4. 10 nnmatch result for wheat Income

HH wheat income	Coef.	Std. Err.	z	P>|z	[95% Conf. Interval]	
SATT	41553.33	9347.111	4.45	0.000	23233.33	59873.33

Source; own survey, 2017

Table 4. 11 nnmatch result for wheat productivity

Wheat productivity |	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
SATT	21.49869	6.32415	3.40	0.001	9. 103587	33.8938

Source; own survey, 2017

4.2.6 Sensitivity Analysis for the Hidden Bias

The hidden bias analysis shows the increase in uncertainty to an inference when a key assumption is relaxed (Caliendo and Kopeinig, 2005). The PSM assumes that the difference between any two comparison groups (e.g., project participants and non-participants) is due to differences in observable characteristics in the data set. This assumption is referred to as the conditional independence assumption (CIA) which ensures that the outcomes are valid and independent of the treatment effect. However, if the two groups do not differ in observable characteristics (or if they differ in unobservable characteristics), then the positive impact of participation on the outcome would be complicated. Therefore, a sensitivity analysis for the hidden bias examines whether the inferences about participation impacts may be changed by unobserved variables in the data set. According to Caliendo and Kopeinig (2005), the CIA is a set of covariates which are observable to the researcher such that after adjusting for the differences in these covariates, the potential outcomes are valid and independent of the treatment effect.

The specification test for the hidden bias ensures that the CIA is attained. Because the PSM is a non-experimental model, it cannot determine the magnitude of selection bias (Caliendo and Kopeinig, 2005). Rosenbaum bounds (or rbounds) test is formulated by use of the signed rank test statistic (non-parametric alternative to the paired t-test) which is calculated by taking the differences in the paired data (treated and untreated) and then the absolute value of these differences are ranked. Then the test statistic is the sum of the positive differences. The Rosenbaum bounds (rbounds) test is used in to test the null hypothesis (Ho: Change in the paired data = zero) that unobserved characteristics have no effect on the outcome of interest (Hujer et al., 2004). The gamma level is reported at the point where 10 percent significance level is exceeded and the gamma level is the odds ratio of differential treatment effect due to an unobserved covariate (Hujer et al., 2004).

According to (DiPrete and Gangl, 2004) in Maren Duvendack & Richard Palmer-Jones (2012): Rbounds uses the results from the nearest neighbor matching estimates to calculate the maximum and minimum p values from a Wilcoxon sign rank test between treatment and matched pairs, and the Hodges-Lehman point estimates of the impact of the treatment on the outcome variable and their confidence intervals (for a given level of confidence – for example 95%), for a unobserved confounding variables with different values of Γ. A value of Γ that produces a Hodges- Lehman confidence interval that encompasses zero is one that would make the estimated impact not statistically significant at the relevant level of confidence. If the lowest Γ at which this confidence interval encompasses zero is relatively small (say <2) then one may assert that the likelihood of such a characteristic being unobserved is relatively high and therefore that the estimated impact is rather sensitive to the existence of unobservables.

Maren Duvendack & Richard Palmer-Jones (2012) further argued that if a critical $\Gamma < 2$ (at $p<0.05$) surely suggests vulnerability to unobservables. According to (Rosenbaum, 2015) also If $\Gamma = 2$ in an observational study may be one subject triple as likely to receive the treatment because of unobserved pretreatment difference. The corresponding value of the different sensitivity parameter and each outcome variable is the upper bound p-value of Wilcoxon's signed rank test, if the bias of magnitude $\Gamma = 2$, it should that have the difference is significant 0.05 level. Differently Cerulli.G (2015) explained and argued that $\Gamma = 5$ means that the probability to be treated is five times higher for one unit than for another one, a situation that should be really rare in reality.

As per the result of wheat productivity and income gained the upper bound on the value $\Gamma = 2$, for the different sensitivity parameter is significant ($p<0.05$). Therefore, the sensitivity analysis results tell us after matching the treatment and control group as the same covariant may differ from their likelihoods of receiving the treatment by a sensitivity parameter up to $\Gamma = 3.4$ (appendix 7.17)

Chapter Five: Summary, Conclusions and Recommendation

5.1. Summary

This study was conducted in SiyadebrinaWayu Woreda, North Shewa Zone, Amhara Regional State of Ethiopia. This study was conducted with the objectives of identifying factors influencing of adoption of improved wheat variety by farmers in the study area. The study also investigated the status of adoption and productivity and income impacts of the adoption on adopter households. In the study area, wheat is an important crop, which serves as a source of food and cash. A total of 153 sample households (131 male and 22 female) selected from 4 *kebeles* of the Woreda were interviewed using structured interview schedule. Qualitative data were collected using group discussion with selected wheat crop growers and extension agents who were working in the respective *kebeles.* Mainly Chi-square test and t-test were used to test the variation of the sample group towards adoption of wheat varieties. The probit econometrics model was employed to estimate the effects of hypothesized independent variables on dependent variable i.e adoption of HIWV. The binary probit model also was used to estimate both the probability of participation in adoption of HIWV and Propensity Score Matching (PSM) of participant with non-participant households (Appendix Table 7.2 & 3).

The average age of the household heads 45.87629 years for adopters and 46.25 years for non-adopters of the improved wheat varieties. Man equivalent considered as economically active to the households were averaged to 2.76 for adopters and 2.87 for non-adopters, which shows that shortage of labor as it is proved from YES answer of 131 interviewees out of 153. Both adopters and non-adopters of improved wheat varieties in the study area are more of illiterate and educated informally only. The adopters had a larger cultivated land size and area of wheat production. Also, the adopters owned more livestock than the non-adopters of the improved wheat variety (Appendix Table 7.4-7.7).

The analysis is undertaken using both the descriptive and econometrics analysis. The descriptive analysis reveals that in the study area, households with better wheat farming experience, larger cultivated land size, own larger number of oxen and livestock, closer location to market, more frequent extension contact, more far from their farm plots, less fertile and more sloppier farmlands, more diversified sources of farmlands, more amount of income and more participations in associations are found to be better for adopters of Hidase.

To estimate the propensity score matching of participant with non-participant households the research design used for this study is Quasi-Experimental research design. Households' Number of Oxen, frequency of Extension contact and Households' wheat farming experiences are significant at 1% significance level. Farm size and Households' labor size are also significant at less than 5% significance level in influencing the probability of adoption improved wheat variety.

5.2 Conclusions and Recommendations

The study has identified key factors that influence adoption process in the study area. Those findings are useful to rethink about the determinants of adoption of new technologies like improved wheat varieties. Therefore, the result can be used by policy makers to promote technological change that is directly needed for the economic development of the country.

The explanatory variables: Households' Number of Oxen, extension contact, wheat farming experience and farm size were found to positively and significantly influence the probability of adoption of HIWV in the study area. On the other hand, the variable Households' labor size negatively and significantly influenced the adoption of Hidase improved wheat variety.

Under Quasi-Experimental research design, the researcher used propensity score matching model. The binary probit model used to estimate the propensity score matching of participant with non-participant households.

The study proved: adoption of Hidase Improved variety program has a significant impact on wheat productivity and income of adopter households in the study area, which was hypothesized before. The average treatment effect on the treated (ATT) result after matching also shows there is a statistically significant difference between treated and control group in-terms of wheat productivity and income.

On average wheat productivity in Q/ha of participant households has been increased by 21.9921 Q/ha – 23.543Q/ha. This indicates that adoption of HIWV has brought a significant impact on an increase in the productivity of the participant households. Similarly on average income from wheat production of participant households has been increased by 37108.031 - 40769.762ETB. This indicates that, the adoption of HIWV has brought a significant impact on the participant households' income.

From findings of this research it can be concluded that: Adoption of Hidase Improved variety program has a significant impact on wheat productivity and income of adopter households

The FGD also has identified and underlined major barriers of the development of adoption of improved wheat production technologies in the study area. These include: susceptibility of improved wheat variety to wheat rust disease; deterioration of the productivity of improved wheat varieties and high cost and the delay of fertilizer and improved wheat varieties. These barriers are not only impeding adoption, they are also causing many adopter farmers to abandon the varieties after some time. In order for the varieties to reach the final users/farmers properly and on time, an integrated activity among different stakeholders is also recommended by FGD participants.

Based on econometric analyses and research findings of the study, the following points are recommended to improve farmers' adoption of improved wheat varieties so as to enhance productivity and income from adoption.

Providing credit services to small holders to have oxen is so essential to encourage them to adopt and benefit from fruits of adoption. To increase and instigate the likelihood of adopting modern agricultural technologies by smallholder farmers, policy makers should put emphasis on overcoming credit market failures. The collected data also revealed the scarcity of credit service in the study area (Table 7.8).

Though, extension services are important in delivering timely agricultural information and extension communication, which are powerful and crucial to achieve better rate of adoption of improved agricultural innovations, experienced farmers are also sources of information and experiences for those who are youngster. Technology adoption can be more successful through such informal knowledge exchange as well. So that in arranging occasions for them is highly needed.

In a situation where farm plots are so small and fragmented extensive farming cannot be reasonable for those smallholder farmers. Hence, intensive farming using highly productive crops like bread wheat to maximize output per unit area should be advocated to farmers. To exploit the full potential of a given high yielding improved variety HHs may face lack of labor, but they shouldn't be discouraged rather looking for alternatives such as hiring labor will enable them to benefit properly.

Related areas of further research

1. ***Clustering /merging small plots together/ or land redistribution is a solution for long hh-farm distance?***
2. ***Does Specializations of crops using improved varieties outweigh benefits of mixed farming?***
3. ***Slope and fertility considerations of high yielding varieties: beyond environmental protection works***

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7. APPENDICES

Appendix 7. 1 Questionnaire

I. Household characteristics

1. Household members and labor availability in 2009 /2010 E.C

S. No	List of Family	Age Of HH head	Sex Of HH head 1=m 2=f	Educational Level Of HH head			*Relation ship	*Major job (occupation)	*participation in Wheat production Activities
				Illiterate 0	Informal 1	If formal, no of schooling years Grade1-4 = 2 Grade 5-8 = 3 Grade 9-10 = 4 > Grade 10 = 5			
1									
2									
3									
4									
5									
6									
7									
8									

* **Wheat production activities includes**: - 1) Land preparation 2) sowing 3)Weeding 4) Harvesting 5) Threshing 6) Transportation 7) Storage 8) Marketing 9) others (specify)

*__Major job (occupation)__ 1). Farming (2). Petty trading (3). Civil servant (4). Domestic house wife (5). Par time employee (6). Unemployed (7). Student (8) Others (specify)……………………..

* **Relationship**1) Head 2) Spouse 3) Child 4) relative 5) others (specify)……………

2. Family Labor size of the Household is ____________ in number
3. Do you have family labor shortage to carry out your wheat production practices? (1)…Yes (2)………No
4. If yes, by which method you are escaping from the problem?

   1) Hiring daily laborers 2) Giving part of the farm________ ha for Share cropping

   3) Working with neighbors and relatives in shift 4) 1&2 5) 1&3 6) 2& 3

5. Total expense for hired laborers by crop types in birr in 2009/10

Activities	**Wheat**		**Teff**		**Faba Bean**		**Lentil**		**Chick peas**		**Peas**	
	No of labor	**No of days**	**No of labor**	**No of days**	**No of labor**	**No of days**	**No of labor**	**No of days**	**No of labor**	**No of days**	**No of labor**	**No of days**
Land Preparation												
sowing												
Weeding												
Harvesting												
Threshing												
Transportation												
Storage												
Marketing												
Total expense for hired laborers	____________		____________		____________		____________		____________		____________	

6. Marital status of Head of the household:
(1) Single (2) Married (3) Divorced (4) Widowed (5) Others (specify)

7. Is the head female and married? (1)…Yes (2)………No

8. If female and married, her husband is 1) working outside/migrant 2)died 3)Divorced

9. Are there other members of the family who are working outside/migrant?
(1)…Yes (2)………No

10. Who make decisions on the type of practices to be adopted on this farm?
(1)……… Wife (2)……… Husband (3) Both/jointly (4) others (specify)

11. Wheat Farming experience of the household head in years------------

II. Agro Ecological Factors and Agronomical Practices of Wheat Production

12. Slope of your land: 1=plain 2=hilly 3=steep

13. The type of soil of your farm is:1=Black soil 2=red 3=Other specify

14. If the soil of your farm is black and water logging what do you did to alleviate the problem? 1) Applying BBM technology 2) Draining out water from the soil manually(in hand) 3) Other specify

15. How do you perceive the quality or fertility of your land? 1=fertile 2=medium fertile 3=less fertile 4=Infertile

16. The agro climate of your wheat farm is:
1) Sub tropical 2) Temperate 3) Other specify_____________

17. How was the availability of rain on your field in 2009/10 E.C?
1= moderate 2=too much 3=too little 4= other_____________

18. How was the temperature on your field in 2009/10 E.C?
1=medium 2=too hot 3=too cold 4= other_____________

19. When have you first heard of improved variety of wheat? _____________

20. Which improved varieties of wheat you have grown so far?

21. Have you adopted Hidase Improved wheat variety?1/ Yes ˇ 0/ No

No	Varieties	1st grown in ___Year	*Reason to choose	Being Used yes/No	Stopped? Yes/No	If Yes, When Stopped?	*Reasons for stopping
1	**Denda**						
2	**Tsehay**						
3	**Durum**						
4	**Hidase**						
5	**Et 13**						
6	**Other specify**						

* **Reason to stop**1) Availability of better variety 2) Unavailability of seeds 3) High seed purchase price 4) Low yield in my field 5) disease and pest problem 6) Others (Specify) ------

*__Reason to choose__1/good yield 2/the only available 3/disease resistance 4) 1&2 5) 1&3

6) 2&3 7)1, 2, &3

22. How do you cultivate different varieties of wheat together?
1) After one another on the same plot 2) at the same time on different plot?

23. How many times you are cultivating your farm in a year? _______times.

24. How many times you are producing wheat in a year? _________times.

25. Which type of production you are using?1) Sole/mono/ cropping 2) intercropping 3/ both

26. If you are intercropping, with which crop do you intercrop?1) Haricot bean _ 2) sorghum _ 3) chat _ 4) cabbage _ 5) other crop/specify.

27. Which method of sowing you used in cultivation? 1) Row planting _ 2) Broadcasting _ 3) Both _

28. If your answer is row planting, to which variety you used this method?1) Local _ 2) improved _ 3) Both

29. How many times do you cultivate your land before sowing Hidase improved wheat? ________times.

30. What about now (after sowing Hidase improved wheat)?_________________times

III.Economic variables

31. Which one of the following is dominant activity of the household?1) Crop production 2) Livestock rearing 3) Mixed farming

32. Do you have Income from bee-hive? 1/ Yes ˇ 0/ No

33. If yes, the average revenue in 2009/10 E.C was ____________________birr

34. For how long you are practicing beehive? ______________________years

Status of Land ownership

Plot No.	Size(ha)	Cultivated portion(ha)	*Uncultivated portion(ha)	Purpose of the plot	Source of land	Distance of the plot from home
Total=_____						

* **Purpose**1)Wheat 2)Teff 3)Faba bean 4) Lentil 5) Fruits and vegetables 6) Others(specify)______

* **Source**1) Own 2)Contracting/renting 3) Share cropping 4)Others(specify) 5)1&2 6)1&3 7)2&3 8)1,2 &3

***Reasons for left uncultivated** 1)labor shortage 2)fallowing 3)for grazing4) Others(specify)_______

35. Wheat production and annual income of the household in 2009 /2010 E.C

Types of Grown wheat varieties	Seeding Rate (Kg/Q of seed/ha)	Price of the seed in birr per (Kg/Q)	Yield (Kg/Q)	Amount Consumed (Kg/Q)	Unit(Quintal) Price in birr	*Purpo se sold	*To whom it sold
Denda							
Tsehay							
Durum							
Hidase							
Et 13							
Digellu							
Kubsa							
Other specify							

***Purpose sold**1) For purchasing farm inputs 2) For settling debts 3) For buying clothes for family 4) To buy food grains 5) Others (Specify) --

***To whom** 1) to whole seller 2) to retailer 3) to direct consumers 4)cooperative5/farmers6) Others (Specify) ---
----

36. Production of other crops and annual income by the household in 2009 /2010 E.C

Types of Crops Grown (varieties)	Seeding Rate (Kg/Q) of seed/ha	Price of the seed in birr per (Kg/Q)	Yield (Kg/Q)	Amount Consumed (Kg/Q)	Unit(Quintal) Price in birr	*Purpose sold	*To whom it sold
Teff							
Faba bean							
Lentil							
Chickpea							
Pea							
Others(specify)							

*Purpose sold1) For purchasing farm inputs 2) For settling debts 3) For buying clothes for family 4) To buy food grains 5) Others (Specify) --

*To whom 1) to whole seller 2) to retailer 3) to direct consumers 4)cooperative5/farmers6) Others (Specify) ----
----

37. Livestock ownership and Income from the sale 2009 /2010 E.C

Category	Total	No. sold	Unit price	Total Value	Purpose sold
Cows					
oxen					
heifers					
Calves					
Goats					
Sheep					
Poultry					
Donkey					
mule					
Horse					
Grand Total					

*Purpose sold1) For purchasing farm inputs 2) For settling debts 3) For buying clothes for family 4) To buy food grains 5) Others (Specify) ------------------------------

38. Income from sale of livestock products/2009 /2010 E.C

Product type	Amount collected (Lit,kg,No)	Consumed	Sold	Unit Price	Total Revenue	*Purpose sold
Milk						
Cheese						
Butter						
Egg						
Others						
***Purpose sold** 1) For purchasing farm inputs 2) For settling debts 3) For buying clothes for family 4) To buy food grains 5) Others (Specify) -------------------------------						

Income from participation in off-farm activities

39. Have you participated off-farm activities in 2009/10 E.C? 1/ Yes ˇ 0/ No

40. If yes, type of work:_______________________________

Types of off-farm activities	Income (in birr)	*Purpose used
Petty trade		
Daily laborer		
Remittance		
Others, Specify		
***Purpose used include** 1) To purchase household items ˇ2) to purchase farm inputs ˇ4) to settle debts ˇ 5) to buy food ˇ 6/other(specify)		

IV. Institutional Factors

41. Have you obtained credit for wheat production in the last three years?1) Yes 2) No

42. If yes,from where you get andhow much did you get?

Source ---Amount (in Birr) -----------------------------

43. For what purpose did you use the credit?

1) For purchasing fertilizer ˇ 2) For purchasing improved seeds ˇ 3) For purchasing Chemicals ˇ 4) other purpose (Specify) ------------------------

44. Have you obtained credit of improved wheat in kind?1) Yes ˇ 2) No ˇ

45. If yes,from where you get andhow much did you get?

Source ---Amount (in k/gram) -------------------------

46. Do you get advisory services from extension agents? 1) Yes ˇ 2) No ˇ

47. Averagely how frequently do the extension agents visit you? 0) never ˇ1) Once in a week ˇ 2) twice in a week ˇ3) monthly ˇ4) yearlyˇ other (specify)______

48. When does extension agent visit you? 1) during land preparation ˇ2) during Sowing 3) when disease/ pest occur ˇ 4) during harvesting ˇ 5) others (Specify)

49. Do you visit extension agent? 1) Yes ˇ 2) No ˇ

50. If yes, when do you visit? 1) During sowing for technical advice ˇ 2) During input Provision to obtain inputsˇ 3) It depends (any time when there is technical problem)

51. Please, indicate your last year participation in the following extension events related to wheat production

No	Extension events	*Frequency of Participation 1)zero 2)one 3) two 4) three 5) four 6) five 7) > five times	*Who arranged For You? 1) MoA 2) Research 3) NGO 4) Others (Specify)________
1	Field Day		
2	Training		
3	Demonstration		

52. Access to and frequency of use of mass media on agricultural extension programs related wheat production.

Mass media	Do you have?		How often you use them for attending agricultural programs/obtaining messages				
	yes (1)	No (0)	never	rarely	occasionally	often	Very often
Radio							
Television							
Mobile phone							
Others(specify)							

53. What are your other sources of information and how often you use/ have contact with them?

Sources of Information	How Often you contact them?					*Rank your sources information	*Means of information exchange
	Never	Yearly	Monthly	Weekly	Daily		
Researcher							
Contact farmer							
Fellow farmer							
PA leader							
NGO							
Cooperative							
Neighbors/ friends							
Input dealers							
Agricultural professionals							
***Means of information exchange**: 1) Demonstration 2) Field day/visit 3) Training 4) Written materials (leaflets, manuals, and so on) 5) Others (Specify) ---------------- ***Rank your sources of information** based on Accessibility, timeliness, reliability of their Information							

Membership of farmer's association

54. In which of the following organization are you member and leader? Please tick

Types of Association	Membership 1= yes, 0= No	Committee member(2) 1= yes, 0= No	Leader(3) 1 = yes, 0 = No
Seed multiplication group			
PA (Peasant Ass)			
Saving and credit ass			
Marketing cooperative			
Idir			
Youth association			
Other/specify			

V. Market related variables

55. Do you get market price information on wheat before you take it for sell?

1) Yes _ 2) No _

56. If yes, what are your sources of market information and how often do you get access to it?

No	Sources of Information	How often you get access to it?					
		Never(0)	Once in a year(1)	Monthly(2)	Weekly(3)	Daily(4)	Which source You prefer
1	DA						
2	Traders						
3	Neighbor farmers						
4	Cooperative society						
5	Middle men						
6	FTC						
7	0ther(specify)						

57. Have you changed to whom you sell the wheat product in the last 2 or 3 years? 1=yes ˇ 0=No

58. If yes, is there price change? 1=yes ˇ 0=No

59. What is the trend in price in the last 2 or 3 years?1) Decreasing _ 2) stable _ 3) increasing 4) volatile/unstable

60. In terms of prices, how does Hidase compare with alternative varieties that you can grow? 1) It is better __________ 2) It is less _________ 3) No difference _________

61. Do you expect low wheat price this/next year? 1/ yes 0/ No?

62. If yes, when/at what season you expect low prices? -------------------------------------

63. What do you do when you expect low prices? ------------------------------------

64. How much you are accessible to markets?

Name of nearest Markets	Market Distance from home (km)	Market Distance from farm (km)	*Mode of Transport	Transport cost	*Commodity sold in market
*Mode of transport; 1=feet 2= bus 3/Pack animals *Commodity; 1 = pulses 2= wheat 3=coffee 4 = fruits & vegetables					

VI. Access and utilization of farm inputs for wheat production (2009 /10 E.C)

65. Which type of agricultural inputs do you use for wheat production & what are the sources**?**

Categories of Inputs	Types of Inputs	Market	MoA	Research centers	NGO	Other source (Specify)	*Reason for not use/apply (If you don't use)
Fertilizers	DAP						
	Urea						
Chemicals	Fungicide						
	herbicides						
	Insecticide						
Seed/HYV	Seed/HYV						
Others(specify)							
*Reason for not use/apply 1/high price 2/ not timely available 3/effect on animals& human being 4/ lack of credit 5/lack of information 6/ Farm land is fertile 7/manual-traditional method is better & cost effective 8) 0ther (specify)							

66. fertilizers and chemicals used for the production of Wheat and other Crops

Types of Crops Grown (varieties)	DAP used (kg)	UREA Used (kg)	Fungicide used (Lit)	Herbicide used (Lit)	Insecticide used (Lit)	Total cost of fertilizers and chemicals by varieties of wheat and other crops
Denda						
Tsehay						
Durum						
Hidase						
Et 13						
Digellu						
Chickpea						
Lentil						
Barley						
Teff						
Faba bean						
Pea						
Unit(Quintal/Litter) Price in birr						

67. Productivity and farm Income for Different Varieties of Wheat and other Crops

Types of Crops Grown variety	Sizes of family labor and cultivated land		Total cost of production(7) (3+4+5+6)				Price of total yield(10)					
	Family Labor size(1)	Cultivated Land(ha)(2)	Costs of fertilizers and chemicals (3)	expense for hired laborer (4)	Price of the seed in birr per (Kg/Q) (5)	Credit used in birr or in /Q/kg (6)	Yield (Q) (8)	Unit (Q) Price in birr (9)	price of Total product (8)*(9)= (10)	Crop income(11)(10)- (7)	Land productivity(12) (8)/(2)	Labor Productivity(13) (12)/(1)
Denda												
Tsehay												
Durum												
Hidase												
Et 13												
Digellu												
Chick pea												
Lentil												
Barley												
Teff												
Faba bean												
Pea												
Unit (Q/L) Price in birr												

Appendix 7.2 Total Households of the Study Area

kebeles	Total No of Households			Total No of Adopter Households			Total No of Non-Adopter Households		
	Male headed	Female headed	Total	Male headed	Female headed	Total	Male headed	Female headed	Total
Walle	815	180	995	240	10	250	575	170	745
Ejeressa	733	109	842	209	33	242	524	76	600
Rommi	1214	440	1654	148	15	163	1066	425	1491
Dahoo	1364	185	1549	293	8	301	1071	177	1248
Total	4126	914	5040	890	66	956 (19%)	3236	848	4084 (81%)

Appendix 7.3 Total Sample Households of the Study Area

kebeles	Total No of Sample Households			Adopter (treated) Sample Households			Non-Adopter(controlled) Sample Households		
	Male headed	Female headed	Total	Male headed	Female headed	Total	Male headed	Female headed	Total
Walle	33	3	36	25	1	26	8	2	10
Ejeressa	27	6	33	20	5	25	7	1	8
Rommi	24	9	33	9	3	12	15	6	21
Dahoo	47	4	51	32	2	34	15	2	17
Total	131	22	153	86	11	97	45	11	56

Appendix 7.4 Conversion factor used to compute man equivalent (Labor Force)

Age groups(in years)	Male	Female
Less than 10	0.0	0.0
10-13	0.2	0.2
14-16	0.5	0.4
17-50	1	0.8
Greater than 50	0.7	0.5

Source: Stork, *et al.*, 1991.

Appendix 7.5 Conversion Factors Used to Estimate Tropical Livestock Unit

Animal Category	TLU	Animal Category	TLU
Calf	0.25	Donkey (young)	0.35
Weaned Calf	0.34	Heifer	0.75
Camel	1.25	Sheep & Goats (adult)	0.13
Cow and ox	1.00	Horse	1.10
Sheep & Goats (young)	0.06	Chicken	0.13
Donkey (adult)	0.70		

Source: Stork, *et al.*, 1991.

Appendix 7.6 Distribution of Sample Household Heads in their Age Category

Age category	Adoption category		Total
	Non Adopters	Adopters	
20-30	3	6	11
31-40	10	20	**35**
41-50	23	43	70
51-60	17	23	43
>60	3	5	9
Total	**56**	**97**	**153**
Mean	**46.25**	**45.87**	**46.01**

Appendix 7.7 Educational Level of Sample Household Heads

Status of adoption	Educational level of house hold											
	illiterate	%	informal	%	1-4	%	5-8	%	$9\text{-}10^{+}$	%	Total	%
Non-adopter	11	19.6	22	39.2	11	19.6	11	19.6	1	2	56	100
Adopter	22	22.68	27	27.83	26	26.8	15	15.46	7	7.21	97	100
Total	39	25.49	54	35.29	40	26.14	27	17.64	8	5.22	153	100

Appendix 7.8 Households' Access to Credit Service by Adoption Category

Status of adoption	Households with access to credit	Households without access to credit	Total
Non adopter	21	35	56
Adopter	51	46	97
Total	72	81	153

Appendix 7.9 Households' Off-Farm Activity Participation by Adoption Category

Status of adoption	Households Participating In off-farm activity	Households not Participating In off-farm activity	Total
Non adopter	3	53	56
Adopter	4	93	97
Total	7	146	153

Appendix 7.10 Households' Average Number of Plots and Their Average Participation in Field Day, Training and Demonstration by Adoption Category

Status of adoption	Average number of plots	Av participation in field day, training and demonstration
Non adopter	3.285714	2.6428
Adopter	3.28866	2.5597
Total	3.287582	2.5882

Appendix 7.11 households' Shares (Percentage Proportions) of Crop Income and Income from Livestock to the Total Farm Income by Adoption Category

Status of adoption	Crop income (%)	Income from livestock (%)	Total farm income
Non adopter	79.26	20.74	100
Adopter	82.89	17.11	100
Total	81.68	18.32	100

Appendix 7.12 Shares (Percentage Proportions) Of Wheat Income to the Total Crop Income by Adoption Category of Households

Status of adoption	Wheat income (%)	Income from other crops (%)	Total crop income
Non adopter	17.66	82.34	100
Adopter	51.82	48.18	100
Total	40.43	59.57	100

Appendix 7.13 shares (percentage proportions) of wheat income to the total farm income by adoption category of households

Status of adoption	Wheat income (%)	Income from other crops (%)	Income from livestock (%)	Total farm income
Non adopter	11.88	67.38	20.74	100
Adopter	43.26	39.63	17.11	100
Total	32.80	48.88	18.32	100

Appendix 7.14VIF (Variance of Inflators) and Inverse Of Variance

Variable	VIF	1/VIF
HHlaborsize	1.70	0.586831
HHAge	1.60	0.624840
HHfarmsize	1.59	0.630806
HHNumber_O~n	1.48	0.676413
Hhwheat farming Exp	1.22	0.822642
HHHome_far~e	1.07	0.932716
Mean VIF	1.44	

Appendix 7.15Breusch-Pagan / Cook-Weisberg Test for Heteroskedasticity for Probit Regression

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity	
Ho: Constant variance	
	Probit regression
Variables: fitted values of	Probability of adoption
chi2(1)	2.82
Prob > chi2	0.0932

Appendix 7.16 Hosmer-Lemeshow Goodness-Of-Fit Test for Probit Regressions

Pearson or Hosmer-Lemeshow Goodness-Of-Fit Test for Probit Regressions	
Probit model for HHHidaseI, goodness-of-fit test	
number of observations	153
number of covariate patterns	153
chi2(1)	152.60
Prob > chi2	0.3375

Appendix 7.17- Sensitivity Analysis

```
. rbounds delta, gamma(1 (0.05) 4)

Rosenbaum bounds for delta (N = 76 matched pairs)

Gamma           sig+      sig-    t-hat+    t-hat-       CI+       CI-
----------------------------------------------------------------------
    1        1.7e-08   1.7e-08   16.8619   16.8619        11   23.8333
 1.05        4.7e-08   5.7e-09   16.3167      17.5      10.5   24.6667
  1.1        1.2e-07   1.9e-09    15.803   18.0667        10   25.4167
 1.15        2.8e-07   6.6e-10   15.3642      18.7   9.66667   26.1667
  1.2        6.1e-07   2.2e-10        15   19.3452   9.16667        27
 1.25        1.2e-06   7.6e-11   14.6667   19.9697      8.75        28
  1.3        2.4e-06   2.6e-11   14.0667      20.3      8.25   28.6667
 1.35        4.4e-06   8.8e-12   13.6667   20.6667       7.8   29.4038
  1.4        7.8e-06   3.0e-12   13.0667        21       7.5   30.0738
 1.45        .000013   1.0e-12   12.6667      21.5       7.1        31
  1.5        .000022   3.5e-13     12.25        22   6.66667      31.5
 1.55        .000034   1.2e-13   11.9167      22.5   6.36422        32
  1.6        .000052   4.0e-14      11.5        23   6.06667   32.6667
 1.65        .000078   1.4e-14     11.25   23.4872       5.8   33.3333
  1.7        .000115   4.6e-15        11   23.8333       5.5   33.6667
 1.75        .000164   1.6e-15   10.7083     24.25      5.25   34.0667
  1.8        .000229   5.6e-16   10.4167   24.6667         5      34.5
 1.85        .000314   2.2e-16   10.1667   25.0833      4.75        35
  1.9        .000424   1.1e-16        10   25.6288       4.5      35.6
 1.95        .000563         0      9.75        26   4.33333   36.0739
    2        .000737         0       9.5   26.3333   4.03333      36.5
 2.05        .000952         0   9.33333   26.8788   3.83333        37
  2.1        .001214         0         9   27.4072       3.5   37.3333
 2.15        .001529         0   8.83333   27.8333   3.33333        38
  2.2        .001905         0       8.5     28.25   3.16667   38.4072
 2.25         .00235         0       8.4   28.6288         3   38.8333
  2.3        .002871         0         8   28.9697   2.66667        39
 2.35        .003475         0   7.83333   29.3333       2.5   39.4739
  2.4        .004171         0   7.66667   29.7954      2.25   39.8333
 2.45        .004968         0       7.5        30   2.03088     40.25
  2.5        .005872         0   7.33333   30.4697   1.91667      40.8
 2.55        .006892         0   7.16667   30.8288       1.7        41
  2.6        .008037         0         7   31.2954       1.5   41.6667
 2.65        .009313         0   6.78088      31.5       1.3        42
  2.7        .010728         0   6.58333   31.6667         1   42.3333
 2.75         .01229         0       6.5        32   .999999   42.8333
  2.8        .014005         0      6.25   32.3333   .690477   43.3333
 2.85         .01588         0   6.13333   32.5833   .633332   43.6667
  2.9         .01792         0         6      32.8        .5        44
 2.95        .020132         0   5.85714        33   .333333   44.3333
    3         .02252         0   5.66667   33.4167   .166667      44.5
 3.05         .02509         0   5.58333   33.6364  -3.5e-07   44.6667
  3.1        .027845         0       5.5   33.8205  -.166666   44.9697
 3.15        .030788         0   5.33333        34  -.333333   45.1667
  3.2        .033924         0   5.16667   34.0739       -.4      45.6
 3.25        .037254         0         5   34.3333  -.500001        46
  3.3         .04078         0         5      34.5  -.666666      46.5
 3.35        .044504         0   4.83333   34.6667       -.7        47
  3.4        .048427         0   4.70833        35  -.833333   47.4072
 3.45        .052548         0   4.66667     35.25  -.999999   47.9394
  3.5        .056869         0       4.5   35.5833        -1   48.1667
 3.55        .061387         0       4.5   35.8205  -1.25301      48.5
  3.6        .066102         0   4.33333        36  -1.33333        49
 3.65        .071013         0   4.33333   36.1667      -1.5   49.1667
  3.7        .076117         0   4.16667   36.4072  -1.58634   49.4167
 3.75        .081411         0         4   36.6061  -1.66667   49.6667
  3.8        .086894         0         4    36.747  -1.75301   50.1538
 3.85        .092561         0   3.83333        37  -1.83333   50.3333
  3.9        .098408         0   3.66667        37        -2   50.5238
 3.95        .104433         0   3.66667   37.3333        -2   51.6667
    4        .110631         0       3.5      37.5     -2.25   52.3333

* gamma  - log odds of differential assignment due to unobserved factors
  sig+   - upper bound significance level
  sig-   - lower bound significance level
  t-hat+ - upper bound Hodges-Lehmann point estimate
  t-hat- - lower bound Hodges-Lehmann point estimate
  CI+    - upper bound confidence interval (a=  .95)
  CI-    - lower bound confidence interval (a=  .95)

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