Adoption and Impact of Row Planting of Wheat Crop on Household Livelihood: - A Case Study of Duna Woreda in Hadiya Zone, Ethiopia.

A Thesis Submitted To The School Of Graduate Studies Of Jimma University In Partial Fulfillment Of The Requirements For The Award Of The Degree Of Master Of Science in Economics (MSc)

(Economic Policy Analysis)

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JIMMA UNIVERSITY

COLLEGE OF BUSINESS AND ECONOMICS

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Adoption and Impact of Row Planting of Wheat Crop on Household Livelihood: - A Case Study of Duna Woreda in Hadiya Zone, Ethiopia.

By:

NEGESE TAMIRAT MULATU

Under the Guidance of

Jemal Abafita (PhD)

And

Mr. Endag.T.

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DECLARATION

I hereby declare that this thesis entitled "Adoption and Impact of Row Planting of Wheat Crop on Household Livelihood: - A Case Study of Duna Woreda in Hadiya Zone, Ethiopia", has been Carried out by me under the guidance and supervision of Jemal Abafita (PhD) and Mr. Endag.T.

The thesis is original and has not been submitted for the award of the degree of diploma any university or instructions.

Researcher's Name	Date	Signature
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CERTIFICATE

This is to certify that the thesis entities "Adoption and Impact of Row Planting of Wheat Crop on Household Livelihood: - A Case Study of Duna Woreda in Hadiya Zone, Ethiopia", Submitted to Jimma University for the award of the Degree of Master of Science in Economic Policy Analysis (MSc) and is a record of Valuable research work carried out by Mr. Negese Tamirat, under our guidance and supervision.

Therefore we hereby declare that no part of this thesis has been submitted to any other university or institutions for the award of any degree of a diploma.

Main Adviser's Name	*Date*	*signature*
____________________	_________________________	_____________
Co-Advisor's Name	*Date*	*Signature*
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ACRONYMS OR ABBREVIATIONS

ADLI	Agricultural Development Led Industrialization
ATA	Agricultural Transformation Agency
ATT	Average Treatment Effect on Treated
DWADS	Duna Woreda Agricultural and Development Sector
DWFEDS	Duna Woreda Finance and Economics Development Sector
GTP	Growth and Transformation Plan
KM	Kernel Matching
MOA	Ministry of Agriculture
MOFED	Ministry of Finance and Economic Development
NNM	Nearest Neighbor Matching
PADETES	Participatory Demonstration and Training Extension System
PSM	Propensity Score Matching
RM	Radius Matching
SSA	Sub-Saharan Africa
TLU	Tropical Livestock Unit

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Abstract

Wheat is the most widely consumed grain in Ethiopia for thousands of years. Even though it is popularly consumed cereal, productivity is reported to be low. Consequently, Ethiopia's Ministry of Agriculture together with its partners introduced provision of extension service of row planting with the application of recommended agricultural inputs in recent years to improve wheat productivity, agricultural imput expenditure, food consumption expenditure and small-scale farmers' income. This study was conducted to assess the adoption and impact of row planting of wheat on household income in Duna Woreda using cross-sectional data obtained from 187 wheat farmers selected from four kebeles to represent major wheat producers. The study used a binary logistic regression model to identify factors affecting adoption of row planting of wheat and propensity score matching to assess the impact of row planting on wheat crop yield, household food consumption expenditure, household agricultural imput expenditure and household income. The results indicated that age of household head, the level of education, family size of a household head, size of cultivated land, livestock possession, utilization of credit and extension services significantly improved adoption of row planting of the wheat crop. The propensity score matching showed adoption of row planting of wheat has a robust and positive effect on farmers' wheat crop yield, food consumption expenditure, agricultural input expenditure and income per year. The average treatment effect on the treated (ATT) was 6079.56 Ethiopian Birr net income, 5244.75 Ethiopian Birr net food consumption expenditure, 4486.52 Ethiopian Birr net agricultural input expenditure and about 4.93 quintals yield-per-hectare increase for adopters as compared to non-adopters which indicate that efforts to disseminate existing row planting of wheat will highly contribute to increasing income among farm households.

Keywords: Row planting of wheat, propensity score matching, binary logit model, adoption and impact.

CHAPTER ONE

INTRODUCTION

1.1. Background of the Study

In Less Developed Countries (LDCs) in general and Sub-Saharan Africa (SSA) in particular, economic policy highly depended on agriculture. Poverty reduction and income growth can mainly be achieved by agricultural growth. It creates spillover effects to the remaining sectors (World Bank, 2014). However, production and productivity of the agricultural sector in SSA is low due to low technological adoption and techniques among others, Abraham et al., 2014; Berihune et al., 2014; Gashaw et al., 2014; Tsegaye and Bekele, 2012; Lulit et al., 2012; and MoFED, 2012.

Agriculture is Ethiopia's most important sector, basis for the country's food security and the livelihoods of nearly 85% of its people. It holds about 50% of the Gross Domestic Product (GDP), 90% of the total export revenue, 85% employment of the country's labor force and it also accounts 70% of raw materials requirement of the country's industries (MEDAC, 1999), but also the engine for the country's Agriculture Development Led Industrialization (ADLI) strategy.

The agricultural sector is the most important sector to Ethiopia's economic growth and to the country overall economic development. Despite the dominance of traditional smallholder farmers in the sector, a new type of dynamism has begun to emerge. Over the past decade, productivity and production have consistently grown at near double-digit rates. Increased engagement with mid and large-scale private sector partners has also brought new technologies and improved market linkages (ATA, 2014).

Improved agricultural productivity and income, that are part of this agricultural sector development can also provide employment opportunities for Ethiopia's farmers especially youth as well as drive industrialization and provide export growth (ATA, 2013). The main cereal cool-weather crops grown in Ethiopia are Teff, wheat and barley, and corn, sorghum and millet which are warm weather cereal crops. Ethiopia is the second-largest wheat producer in SSA next to South Africa (FAO, 2014). In production land area coverage fourth largest crop behind Teff, Maize and Sorghum and third in total yields (CSA, 2007). The report of (CSA, 2013) showed that Ethiopian farmers have got improved yields of 3.43 million tons from 1.63 million hectares.

According to (CSA, 2013), report showed that wheat covered about 17% of the total cereal crop production land area with a mean national product of 21.10 q/ha. This national yield is the lowest yield compared to the world mean yield of 40 q/ha (FAO, 2009). The average product levels are low because characterized by high rain-fed, subsistence oriented, low production system and broadcast farming practices. In adition to these: decreased soil fertility, unreliable climatic conditions, poor infrastructure, environmental degradation and land scarcity are also related to poor agricultural performance. Due to above factors agricultural sector is resulted in low cereal crop yields, food consumption expenditure, agricultural input expenditure and income variability, are on the one hand and high population growth rate on the other. Acording to MOADS agricultural yield decreases to keep increasing population growth rate in the last three decades. Due to this, quite a large amout of the population lives in poverty (MOADS, 2011). The study of (Rashid, 2010) showed that the country with low production meet the high demand implies that the country remains net importer despite its good potential for wheat production.

Improved agricultural Technologies such as row planting and transplanting, where the seed rate is reduced and more space between seedlings is given, have been shown to achieve important production increments over traditional broadcasting sowing. Because improved agricultural technologies allow for better weeding, decrease competition between seedlings, and allow for better branching out and nutrient uptake of the plants (Astatke et al., 2002; Chauhan et al., 2014). The potential of reduced seed rate agricultural technologies to enhance wheat productivity is the outcome of on-station agronomic research. Adoption row planting of wheat crop technology influence household‘s food security in Ethiopia (Setotaw et al., 2003).

According to (Gashaw et al., 2014; Sarah, 2014), studies showed that row planting of wheat technology (Sowing wheat crops in rows at low rate instead of scattering seeds by hand) in our country in order to increase wheat crop yields, household food consumption expenditure, household agricultural input expenditure and income, introduced about 400,000 farm households in four regions: Amhara, Oromia, SNNPR, and Tigray in 200 kebeles. Row planting of wheat technology increases wheat crop yields, household food consumption expenditure, household agricultural input expenditure and income. The farm households were convenced on recommended 50kg of wheat per hectare. Small-farm households who sow with the recommended amount of seed have got impressive yield (a deviation of 75% to 80% per hectare) (Sarah, 2014).

Row planting of wheat technology was promoted to farmers that included: planting crops in a row which reduce seed rate. Use of improved seed and the application of recommended levels of chemical fertilizer diammonium phosphate(DAP) and urea which increase wheat crop yields, household food consumption expenditure, household agricultural imput expenditure and income. Adoption of row planting technology that increases the productivity of any agricultural output is very decisive. Row planting of wheat technology is high productivity, which needs to conduct the study on the yield bottlenecks (Ibid).

This study, therefore, aims to gain a deeper understanding of how the adoption of improved agricultural technologies like row planting can possibly improve land productivity in these settings. The study was planned to assess the impact of row planting of wheat on the farmers’ food consumption expenditure, agricultural input expenditure and income specifically in the study area.

1.2. Statement of the Problem

Most of developing economies are characterized by heavy dependence on agricultural sector. The agricultural sector also highly characterized by: traditional type of farm practices, higher labor to capital ratio, low adoption rate of row planting technology, inadequate production incentive to farm households, weakness in support service to the farm households, depends on seasonal rain-fall, weather, poor infrastructure facilities including (roads, transport, marketing), etc, and low farm wheat crop yields, household food consumption expenditure, household agricultural input expenditure and household income. As a result food insecurity and poverty are prevalent in such countries (Alemitu, 2011; Susan, 2011; and Berhane, 2009).

The situation in Ethiopia is not any different. Problem such as low technology adoption, low use of recommended farm inputs, broadcast farming and rain-fall are the prime bottlenecks behind the poor performance of the sector (Lulit et al., 2012). The traditional broadcasting method decrease production, because plant competition with weeds decreases wheat growth and tillering. One of the crops commonly cultivated using the traditional broadcast planting is wheat. Such a planting technique causes wheat yield reduction (Astatke et al., 2002; Chauhan et al., 2014). By using new agricultural technology innovation such as row planting of wheat crop with sufficient and equal space gives large production than broadcasting and improve food consumption expenditure, agricultural input expenditure and income of the households.

However, Farmers typically broadcast wheat seeds that mean scattering seeds by hand, at high-speed rates. This slows down wheat products because the uneven distribution of the seeds makes weeding difficult and increased competition with weeds and other wheat plants lowers nutrient uptake by the individual wheat plant. Row planting and transplanting, where the seed rate reduced and more space between seedlings is given, have been shown to achieve important production increments over traditional broadcasting sowing. Row planting allows for better weeding, decrease competition between seedling, and allow for better branching out and nutrient uptake of the plants (Astatke et al., 2002; Chauhan et al., 2014).

However; in general, row planting of wheat crop technology are often adopted slowly and several aspects of adoption row planting of wheat technology remain poorly understood despite being seen as an important route out of poverty in most of the developing countries (Bandiera and Rasul, 2010; Simtowe, 2011).

In our country a few years ago provision of extension service of row planting with the application of recommended agriculture inputs have been introduced by Ministry of

Agriculture (MoA) and its partners to improve wheat productivity, food consumption expenditure, agricultural input expenditure and small-scale farmers' income. The Ethiopian Agricultural Transformation Agency (ATA) investigated that crop planting with space starts with growing seedlings in a garden center and planting these in the field with sufficient and equal spacing between each seedling and its partners to improve productivity, food consumption expenditure, agricultural input expenditure and small-scale farmers' income and started since 2011 to 2012 (MoA, 2012).

There are some previous related studies on adoption and impact of crop row planting on yield (Tsegaye and Bekele, 2012; Bola et al., 2012; Tolesa et al., 2014; Ibrahim, 2013; and Mamudu et al., 2012). Their studies includes adoption and impact of crop row planting on Yield of small household farmers, and socio-economic and institutional factor limiting adoption of crop row planting. According to their studies specifically tried to show that adoption and impact of crop row planting are significant on yield alone. The current study extends this line of research by including broader sets of outcomes at household level, specifically, focusing on measures household wellbeing such as per capita household income, consumption expenditure and agricultural input expenditure. In particular, the study focuses on assessing the impact of such a technology on household food consumption expenditure which is a key indicator of household food security.

Therefore, this study was designed to assess an adoption and impacts of row planting of wheat on household food consumption expenditure, agricultural input expenditure and household income, and identify factors that affect row planting of wheat with a specific focus on the role of socio-economic, socio-capital, demographic characteristics and institution variables in the study area.

1.3. Research Questions

What are the factors that affect adoption of row planting of the wheat crop?

What is the impact of adoption of row planting technology on wheat yield?

What is the impact of adoption of row planting technology on household income?

1.4. Objectives of Study

1.4.1. General Objective of the Study

The general objective of this study was to identify factors that affect adoption of row planting technology in wheat cropping and evaluates its impact on wheat yield and income of households in the study area.

1.4.2. Specific Objectives of the Study

To identify factors that affect adoption of row planting of the wheat crop.

To evaluates the impact of row planting on yield of wheat.

To evaluates the impact of row planting on household income.

1.5. Significance of the Study

This study was designed to fill the information gap on the impact of row planting of wheat crop on households' food consumption expenditure, agricultural input expenditure and income. It will provide information on row planting effectiveness to our farmers who live study area as well as useful insight for those who design various planning and policies that are addressing the ways to improve productivity, food consumption expenditure, agricultural input expenditure and income through targeting adoption of row planting wheat. In addition, the result from this study with other previous studies can be used as an input for future empirical studies which will target the areas of impacts of adoption and row planting of wheat on wheat productivity and others crop production.

1.6. Scope and Limitation of the Study

Since it is not possible to cover the whole part of Hadiya Zone with the available time and resources, the research was limited in terms of study size and the scope of the problem to a manageable size. Hence, the study focused on the representative sites in Duna Woreda. The study considered farmers who are participating in row planting of wheat crop and who are not participating. Significant qualitative and quantitative information was gathered on agricultural production, the different aspects of the row planting technologies adopted, problems related with the technology involvement and potential solutions, and reason not to adopt by non-users of the technology. Due to shortage of time, financial constraints and other resources primary data collection for the study was limited to four selected rural kebeles in the woreda and 187 sample household were interviewed. Some of the respondents have no interested in answering the questions at the time of interview. There are many factors which affect the adoption of row planting technology wheat cropping. But this study was limited to only 10 variables.

1.7. Organization of the Thesis

This research thesis contained five parts: Part one which introduced and discussed background of the study, statement of the problem, general and specific objectives of the study, significance of the study, and scope and limitation of the study. Part two elaborated and covered the relevant related literature reviews. Part three included a description of the study area, sampling techniques, sources of data and collection methods, data analysis and specification of the model. Result and discussion were reported in chapter four and finally in chapter five presented conclusion and recommendations of the study.

CHAPTER TWO

REVIEW OF THE LITERATURE AND CONCEPTUAL FRAMEWORK

2.1. Theoretical Literature Review

2.1.1. Origin and Definition of Wheat

South-Eastern Turkey is the considered the site of origin of wheat (Heun et al., 1997). The remains of the wheat crop have been found in Syria, Jordan, and Turkey. Wheat was domesticated in South-Eastern Turkey 10,000 years ago, as parts of Neolithic revolution, through a transitional period when human being changed from hunting and gathering to settled agriculture (Shewry, 2009). It is most important cereal crop in the world and harvested annually amounting to more than 651 million metric tons (FAO, 2010). Wheat is preferred in the production of bread, pasta, noodles, biscuits and many other confectionary products (Kumar et al., 2011). In modern agriculture, the cultivated species of wheat are bread wheat or common wheat (T. festival), durum wheat (T. durum), and spelt-wheat (T. spelt). Bread wheat is highly grown all over the world and accounts for 95% of the total wheat, while the remaining 5% consists of durum and spelt-wheat (Shewry, 2009). Currently, a total of around 4000 bread wheat varieties is cultivated in the world with a spring or winter growth habit (Posner, 2000). Bread wheat is used mainly for bread and productions are generally higher than that of durum wheat. Durum wheat is used mainly for pasta and yields are generally lower than that of bread wheat (Bushuk, 1997). Spelt-wheat is grown on a small scale inorganic cultivation (Vasil and Vasil, 1999).

According to economic use wheat is the world‘s mostly cultivated crop, planted large area than any other cereal crop and its world trade is larger than for all other cereal crop combined. It is easily stored and transported (Slafer and Satorre, 1999). Wheat further classified as winter or spring, hard or soft, red or white, and by protein content (Briggle and Curtis, 2002). It has the highest content of protein of all the stable food and contains essentials, vitamins, and lipids. It is the primary source of protein in developing countries with 1.2 billion of people depends on wheat for survival (CIMMYT, 2011). The majority of wheat produced is used for human consumption. Wheat is also used on a limited basis for animal feed processing wheat produces by-products which have proven especially useful in poultry rations (Briggle and Curtis, 2002). The nutritional value of wheat is of key importance since it is the world's largest food crop in terms of the amount after rice and maize; thereby it contributes more calories and nutrients to the human diet than any other cereal crop (Abdel et al., 1998). Wheat grain is easy to transport and store and it is an important source of protein, dietary fiber and vitamins (Shewry, 2007; Simmonds, 1989). For caloric intake, wheat is the second most important food in the country next to Maize (FAO, 2014a). It is considered to have one of Ethiopian's main stable crop in terms of both production and consumption, production is low. The average production of wheat crop is 2.1 t/ha, which is smaller than recommended production 5 t/ha (Hailu, 1991; MoA, 2010; 2011 and 2012).

The study conducted by (Yonas, 2013; ATA, 2012) planting wheat crop on plot of land by using row planting of wheat technology with appropriate level of space and recommended agricultural inputs mostly important to grow their roots and shoots fully than using the broadcasting method and it improve wheat crop yield, household food consumption expenditure, household agricultural input expenditure and income than broadcast method of sowing.

2.1.2. Definition of Adoption new Technology

The participation is the change that takes place within farm household's with regard to innovation from the initial that farm household's becomes aware of innovation to the final decision to use new technology or not (Ray, 2001).

However, as emphasized by (Ray, 2001), decision to participation is a processes of innovation is not normally a single act, it involves a process, farm households goes through a number of mental stages or staps before making a final decision, farm households goas from initial knowledge of an innovation to forming an attitude towards an innovation to a decision to participat new technology or reject, to implementation of new idea and to conformation of the decision. Participation does not necessarily follow the suggested stage or steps from first innovation to participation of new technology; trial may not always be happend by farm households to participat new technology, because of other factors influenace the decision-making process of participation of new technology, participation may not occur. Participation is not a permanent behavior. Individual may not use of an innovation for a personal, institutional or social reasons one of which could be the availability of a practices that are crucial in satisfying his or her needs. The adoption process is mental process through which an individual passes from first knowledge of an innovation to the decision to accept or reject and to confirmation of this decision (Van de Ban and Hawkins, 1998).

Adoption classified as a farm-level adoption and aggregate adoption (new technology within a region) Feder et al., 1985. Adoption at the individual farmers' level is defined as the degree of use of new technology in long run equilibrium when the farmer has full information about the new technology and it's potential.

As indicated by (Dasgupta, 1989) adoption is not permanent behavior. Farmers often reject an innovation instead of adopting it, non-adoption of an innovation does not necessary mean rejection, and farmers are sometimes unable to adopt an innovation, even though they have mentally accepted it, because of economic and situational constraints. Participation or adoption process is defined as the mental process through which household passes from initial knowledge about a technology to final participation or adoption. This indicates that adoption is not a sudden event but a process. Farmers do not accept innovations immediately; they need time to think over things before reaching a decision. In adition of Dasgupta, Nkonya et al., 1997 who gives the similar deffinition of adoption.

The importance of adoption study is to quantify the number of technology users over time and to assess impacts 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).

2.1.3. Definition of Row Planting Technology

Planting wheat crop on plot of land by using new agricultural technology like row planting of wheat technology with appropriate level of space is mostly important to grow their roots and shoots fully than using the broadcasting method and it is important to plants to get aeration, moisture, sunlight, and nutrient. Row planting or planting with space allow for better weeding, decrease competition between rows planted wheat seedlings, and allow for proper branching out, and nutrient uptake of the plants (Astatke et al., 2002; Chauhan et al., 2014). In which seed rate is reduced through row planting which improve yield, household food consumption expenditure, agricultural input expenditure and household income. According to ATA (2012) planting wheat crop on plot of land by using row planting of wheat technology with sufficient and equal level of space mostly important to grow their roots and shoots fully than using the broadcasting method. In Ethiopia, row planting technology applied on a crops like: sorghum, wheat, maize, and Teff.

2.1.4. Technological Change and Agricultural Development

Despite various attempts to shift agriculture by the developing countries, the sector until in its traditional state. The main reason behind the low level of agricultural development is introverted policies followed by the governments of these countries over the years. Development activity of the 1950s and early 1960s gave priority to keep the industrial sector for which agriculture was neglected. The large population growth, on the one hand, and the large gap between the demand for and the supply of food yield, on the other, has brought an impetus for agriculture to receive induced attention in the late 1960s (Yonas, 2013).

Therefore, in order to reap the importances that agriculture can highly creates to the mass of the rural poor in particular and to the national development at large, it is necessary to shift (transform) the traditional agriculture into a modern agricultural sector (Shultz, 1964) or what (Mosher, 1966) termed as agricultural transformation or moving. The appropriate public policy intervention (Yotopoulos, 1967; Halcraw, 1984) so as to provide the surplus yield. Further, the creation of agricultural policy, in turn, needs a consideration of various important factors that include, among others, an organization of agriculture, natural factors, institutional arrangements, product characteristics, factor and product markets (Halcraw, 1984).

One of the main determinants in the transformation of agriculture is technological shift. Hailu (2008), emphasized that treated, on a regular basis, among others, improve a dynamic growth process that provide the agricultural sector to produce food cheaply, and it is used to release labor to the non-agricultural sector. Agricultural technology, hence, refers to treatment of new ideas, methods, practices or technology of yield that emphasized the means of gaining sustained improve in farm productivity (Abate, 1989). According to the study of (Anderson et al., 2013) pointed out that treatment not previously employed in the yield procedure indicate technological shift, treatment is explained as the act of incorporating something into the yield procedure. It is used to note that the creation of new technology is not sufficed by itself but the degree of its diffusion does so. In this regard, Anderson stated that the treatment must be preceded by technology diffusion where the latter term indicates the act of providing technology available to potential treated and is then a connection between R and D and treatment. (Moser and Barrett, 2006) emphasized that treatment and diffusion alone is not enough to found agriculture shifting and thus shifts in the institutional, infrastructural, and cultural costriants must found in the procedure of transformation. Similarly, Nerlove (1993) emphasized that innovation, it seems that plays a basis in agricultural transformation, but the procedure cannot be understood solely in terms of innovation. The interactions of innovation with a amount of social and economic constriants have to be taken into account.

The need for treatment, in addition enhancing constriants' efficiency, is to cope with natural hazards faced by the sector. Experiences of many countries showed that sizable amount of agricultural technology is commodity specific, that are suited only for limited and usually most favorable ecological environments (Anderson et al., 2013). The areas with poor environments may not have a chance of treatment due to their poor response to the innovation in question. Agricultural innovation includes not only biological and chemical types but also mechanical and management technology. It is within this given framework that agricultural innovation should have to be perceived. These technologies innovation can help enhancing efficiency in a number of ways.

According to (Anderson et al., 2013) described that agricultural technology such as row planting technology enhances wheat crop yield, household food consumption expenditure, household agricultural input expenditure and household income. The reduce in agricultural technology such as row planting technology decreases sustainable growth of wheat crop yield, household food consumption expenditure, household agricultural input expenditure and household income. Agriculture based research and extension services are main important procedure to enhance technological change.

2.1.5. Wheat Production and the Promotion of Row Planting

Wheat production during 2012-13 meher seasons was 3.4 million metric tons accounting for 15% of the total grain output in the country (CSA, 2012 and 2013). According to the (CSA, 2012 and 2013), wheat production in 2012-13 was 18% higher than in the previous year.

During the 2013 row planting method as an indicator of technology for it is a recent practice in Ethiopian agricultural sector, it conducted in Ethiopian agriculture implies that production is very responsive to this improved practice. The studies conducted by comparing the row planting technique with conventional broadcasting method, for example, by using educational level, age of household head, access to pesticides, household size, access to improved seed, access to credit, livestock holding size and off-farm income; on average 14.6% more wheat yield from row planting technique than that of conventional broadcasting type of farming in Arsi Zone of Ethiopia, and the studies also by using like: practice of crop rotation, livestock holding size, land holding size and access to improved seed, row planting technology improve wheat yields. According to the studies of (Tolesa et al., 2014) average production of row planting method was 13.9% larger than broadcasting method and row planting technique encourages the country‘s extension system to increase promotion of this agronomic practices.

A major agronomic constraint to enhance wheat crop yield is the traditional technology of sowing wheat. Farmers typically use broadcasting that is scattering wheat seeds by hand, at a high seed rate. Broadcasting impedes wheat productivity because the uneven distribution of the seeds makes weeding difficult and enhanced competition with weeds and other wheat crop lowers nutrient uptake by the individual wheat crops. New technologies such as row planting and transplanting, where the seed rate is reduced and equal space between seedlings is given, have been shown to achieve important product enhancements over traditional broadcasting sowing. Because row planting or transplanting technologies allow for better weeding, decrease competition between seedlings, and allow for proper branching out and nutrient uptake of the plants (Astatke et al., 2002; Chauhan et al., 2014). The Ethiopian agricultural transformation agency (MoA, 2012) investigated that crop planting in the field with sufficient and equal spacing (distance) between each seedling enhances wheat crop production.

According to (Gashaw et al., 2014; Sarah, 2014) studies discussed row planting of wheat technology were introduced about 400,000 farmers in 200 kebeles in the main wheat producer or belt region of Ethiopia: Amhara, Oromia, SNNPR and Tigray. Decreased seed rate to recommended amount by using row planting of wheat technology is a major piece of the packages which increase productivity 75% to 80% per hectare (Sarah, 2014). According to MoA, on their reports discussed row planting of wheat technology were initiated about 400,000 farm households, initiation was introduced in 41 woredas for about row planting technology, the goals of the initiation is to increasing wheat crop yield, household food consumption expenditure, household agricultural input expenditure and household income by row planting technology.

2.1.6. Response of wheat to Sowing Method

As the study of (Hunt, 1999) broadcast planting method are resulted by less expensive, high competition between plants at certain area, take time, no competition all in other areas takes place in the field, less tillering. This type of method resulted low wheat crop yield, household food consumption expenditure, household agricultural input expenditure and household income (Fufa et al., 2011).

In order to enhance wheat crop yield, household food consumption expenditure, household agricultural input expenditure and household income, the row planting of wheat technology is preferred, time taking and use educated or skilled person (Hunt, 1999). Row planting technology will crucial in controlling weeds, especially mechanical control by inter-cultivation, and management of the crop, and maintain sufficient density of seedlings. Row planting technology introduced on the small scale because of its costs and difficulty in obtaining implements (Chatterjjee and Maiti, 1985). The study of Baloch et al. (2002) showed that row planting technology important for plants in order to take more nutrients and more solar radiation, which is impotant to increase wheat crop yields. According to Sarah (2014), adopting row planting technology increases wheat crop yield, household food consumption expenditure, household agricultural input expenditure and household income by reducing seeding rate from 75 Kg/ha to 50Kg/ha and reducing competition of plant for water, sunlight, and soil nutrients. Therefore, row planting of wheat technology increases wheat crop yield, household food consumption expenditure, household agricultural input expenditure and income than the other sowing method.

2.1.6.1. Household Income

Agriculture is the most important sector for majority households´ livelihood, and primary source of income in developing countries. It has been a crucial activity for most rural households in Sab-Saharan Africa (SSA), which offers a strong option for promoting growth, reducing poverty, and enhancing food security (World Bank, 2008). Household income from agricultural sector is most important determinants of household livelihood in developing countries. However, the agricultural farming sector is the primary source of household income, has become fail to guarantee sufficient household livelihood for most agricultural farming households in Sub-Sahara African countries. Because agricultural farming sector in Sub-Sahara African countries mostly characterized by reducing farm sizes, low productive incentive, low adoption of row planting technology, low-level output per farm, and a high degree of subsistence farming (Jirstrom et al., 2011).

Like other Sub-Saharan African countries, agriculture is the main source of their livelihood in Ethiopia, since 2010 (CSA, 2013). It is a most crucial sector for economic growth, and for the increment of wheat crop yield, household food consumption expenditure, household agricultural input expenditure and household income in Ethiopia (Pender and Gebremedhin, 2007; Kassie et al., 2009). But the agricultural sectors in Ethiopia farming are subsistence farming and their wheat crop yield, household food consumption expenditure, household agricultural input expenditure and household income are low from agricultural sectors.

Agricultural sector serves as the primary source of income for rural household livelihoods (MoA, 2010). The sector is dominated by small farmers, producing mostly basic stable for the subsistence of their households; because of backward technology, small fragmented land size, and irregular rainfall, which leads low wheat crop yield, household food consumption expenditure, household agricultural input expenditure and household income, (i.e low household livelihoods) (Arega et al., 2013).

Household income is the most important determinants of household livelihood, it is more preferred measure than any other determinants, and personal income for analysis of household livelihood, while income is usually received by individuals shared by other household members. According to (ILO, 2004) household income is all receipts whether monetary or in-kind (goods and services) that are received by the household or individual members of the household, are available current consumption, and do not decrease the net worth of the household and cover income from employment, property, production of household service for own consumption and current transfer received.

Enhancing agricultural productivity through row planting will raise the living standards and livelihood wealth of rural households because high income improves people's ability to purchase goods and services, enjoy leisure, improve housing and education, contribute to social and environmental programs. By considering of its uses, measuring agriculture productivity will clearly show the level of incomes of the rural household those who are engaged in agricultural activity. Row planting on wheat increases their wheat crop yield, household food consumption expenditure, household agricultural input expenditure and household income. And also increase the livelihood of rural household by increasing agricultural income (Gashaw et al., 2014; Bola et al., 2012).

2.2. Empirical Literature Review

The empirical studies help in interpreting the significance of the theoretical explanations. That is, the empirical works can confirm or reject the theoretical assumptions and also suggest the importance and new aspects of the conceptual framework (Feder et al., 1985). Numerous studies have related household and institutional characteristics to adoption behavior and impact with different findings. The following are some of the results of previous studies. In order to increase adoption of suitable row planting, it is important to know the factors that influence the choice of row planting and adoption.

Using PSM model and does adoption of wheat row planting technology increases small household farmers' crops income? The following are some of the previous studies of an empirical literature review on different crops, shows that adoption of crop row planting technology increases small household farmers´ crops income. The study conducted by (Debelo, 2015) on Tef crops, Does Adoption of Concho Tef Increases Farmers' Crops Income?; by using kernel matching method result revealed that the crops net income of the farmers who were an adopter of Concho tef was much greater with 11,790.59 Ethiopian Birr than non-adopters. So it is concluded that the agricultural technology adoption has positive income effect.

Tsegaye and Bekele (2012) in their study on impacts of adoption of improved wheat technologies on households food consumption in south eastern Ethiopia found that age, education, farm experience, off-farm activities, access to credit, extension contact, wheat seed varieties with recommended planting space and livestock holding are significant on wheat row planting and household's food consumption expenditure and income by using propensity score matching model. According to ATT that calories per day increment came on the adopters of row planting method wheat thereby increasing household's food consumption expenditure and income.

A study conducted by Tolesa et al. (2014) in Arsi Zone of Ethiopia showed that the Impact of Wheat Row Planting on Yield of Small farm household by applying the logit and propensity score matching. Row planting of wheat significantly influenced by educational level, access to pesticides, household size, access to improved seed. The most important variables influences row planting wheat technology in both districts significantly. A study conducted by (Gashaw et al., 2014) in Ethiopia, showed that the selected wheat seed, a lower seeding density, row planting, fertilizer recommendations, and marketing assistance as full-package obtain higher wheat yields as compared to non-users. The study emphasized by (Mamudu et al., 2012) participation of row planting technology by farm households in Ghana" by applying logit model plot size, expected returns from row planting technology participation, access to credit, and extension services are significant on row planting technology participation of small farm households in the west district Ghana.

An empirical study carried out by (Yonas, 2013), showed that the significant impact of row planting teff crop on households' income by using two models like the propensity Score Matching (PSM) and Heckman two-stage selection model. The variables like level of education, cultivated land size, tropical livestock unit, access to extension services, availability of family labor and nearness to farmers training center are significant on row planting tef crop and on household income. According to the results of a propensity score matching, adoption of row planting had enhanced the teff crop income. As the study nearest neighbor matching (NNM), radius matching (RM), kernel matching (KM) and SM which is statistically significant on average compared to the non-adopters.

An empirical study carried out by (Ejegayehu and Berhe, 2016) showed that Effect of wheat row planting technology adoption on small farms yields in Ofla Woreda, Ethiopia by using propensity score matching method. According to their study Variables like sex, age, field visit days, and age square are significant on wheat row planting technology adoption on small farmers. The result of their study showed that the marginal farm land adopter was gotten higher production than non-adopter of the wheat producer in a single production year. Those results are consistent to the researches that had been done before (Tsegaye and Bekele, 2012; Bola et al., 2012; and Mamudu et al., 2012).

Tolesa (2014) conducted a study on Socio-economic and Institutional Factors Limiting Adoption of Wheat Row Planting in Ethiopia, by applying logit model. The study found that improved seed, agricultural extension services, education, and livestock size are significant on wheat row planting. The study showed that row planting of wheat crop better in midland and highland agroecology than lowland. A study by Debela (2011) in Beressa and Umbrello Watersheds showed that Impact of agricultural technology on farm production. According to Debela adoption of row planting technology were important to agricultural sector growth. According to the study Ibrahim (2013), with low educational level and small land holdings are less likely to adopt improved seed and fertilizer technologies, by panel data using probit model in Uganda.

An empirical study carried out by Bekalu and Tenaw (2015) in their study showed that Effect of Method of Sowing on Yield and Yield Components of Tef. According to thier studies tef row planting technology had acceptable MRR (627.7%); and 6775.6 Birr/ha more Tef crop yield and income than the broadcast planting method. Thus, it is possible to conclude and recommend that, row planting of tef crop is important to increase crop yield and income in the trail area. However, it is advisable to undertake further research and extension services across soil type, years and locations to draw sound recommendation on a wider scale.

According to (Tolesa et al., 2014) the studies conducted on row planting technology. Logit and PSM is important used model in their studies. The study showed that practices of row planting of wheat technology significant impact on productivity and household income. Row planting technology significant on rice productivity in Nigeria. The model used are a local average treatment effect, studied by (Bola et al., 2012).

The above studies of the empirical literature showed that socio-capital, demographic characteristics and institutional variables like education level of household, access to credit, livestock holding, access to extension contact, income from other crop production, nearness to farmers training center, access to improve seeds and availability of farm labor are enhance row planting of wheat crops. Some studies of empirical literature use age of household are significant and positive (i.e. the age of household increases and approach to old, increase adoption level of row planting of wheat crops) (Tsegaye and Bekele, 2012). The most of the studies conducted that adoption of row planting technology; there is a significant effect on wheat crop yield, household food consumption expenditure, household agricultural input expenditure and household income.

The current study was conducted on adoption and impacts of the row planting wheat crop on household livelihood. According to the study variable like education level of household, sex of household, family size, access to credit, livestock holding, access to extension contact, cultivated land size, recommended agricultural inputs, access to improve seeds and availability of family farm labor are increase row planting of wheat crops and enhances small farm household wheat crops income (Getahun et al., 2000; Million et al., 2004; and Belay, 2003). The current study has used the age of household headed on row planting are inversely related: when the age of household increase and approach to old, adoption level of row planting technology will decrease (Techane et al., 2006).

2.3. Conceptual Framework of the Study

The conceptual framework of the study is developed in the existing literature. That is the education level, the age of household, sizes of land holding, family labor, livestock holding, extension contact and net income of the households influences adoption of row planting of wheat. Demographic characteristics like sex, age and education, Economic variables like family size, livestock ownership, and family labor, Institutional variables like extension service, use of credit and use of fertilizer, and Social capital variables like social capital and membership in cooperatives are influences adoption of row planting technology. Adoption of row planting of wheat crop enhances farmers' wheat crop yield, household food consumption expenditure, household agricultural input expenditure and household income. In addition, the crops income of adopters is greater than non-adopters which show the positive impact of the adoption of row planting technology of wheat crop on farmers' crop income. The conceptual framework presented in Fig .1 shows most important variables expected to affect the intensity of adoption of the row planting wheat crop in the study area.

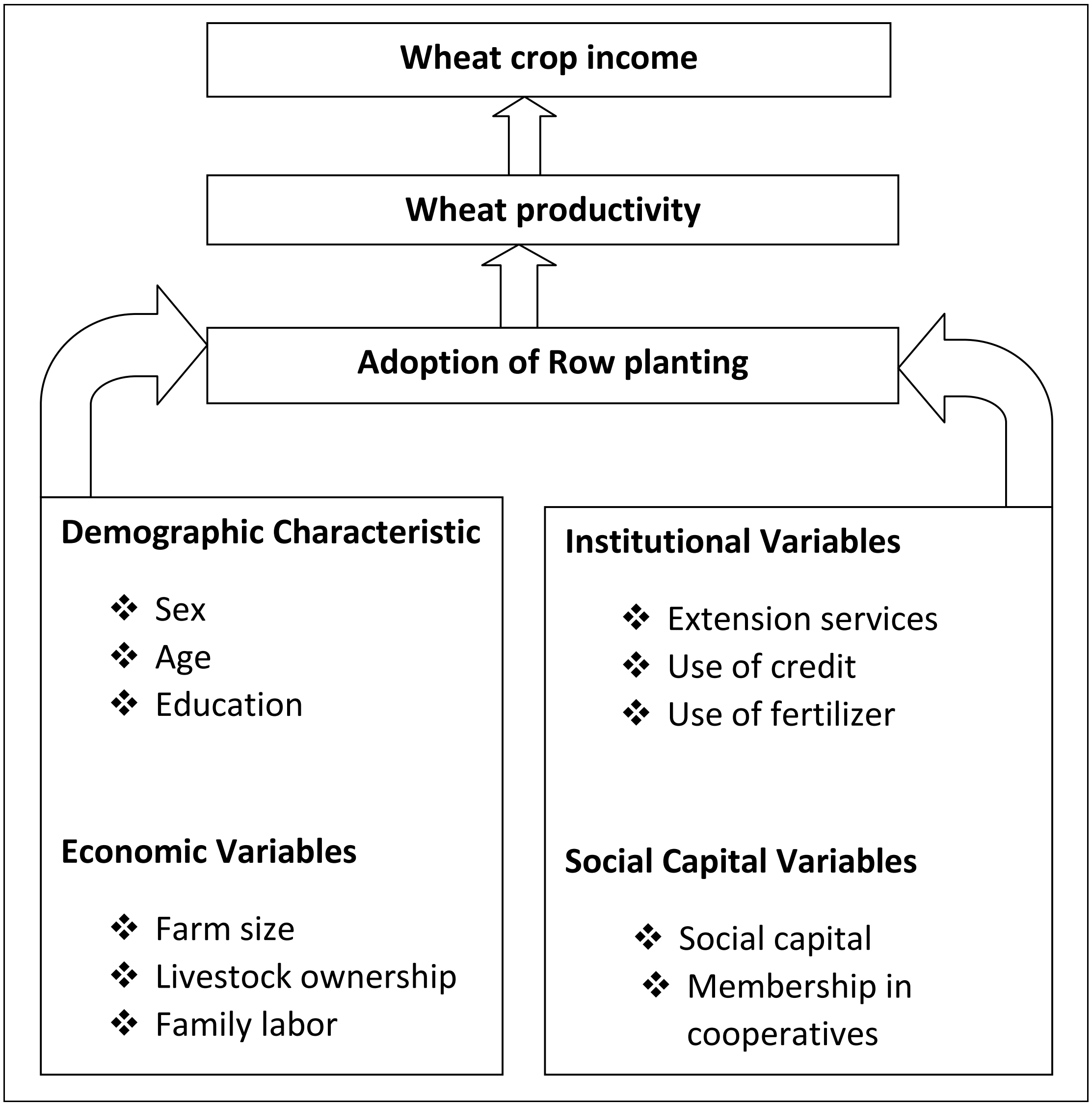

Figure 1: Conceptual framework of the study
Sources: Modified from (Yonas, 2013; Debelo, 2015)

CHAPTER THREE

RESEARCH METHODOLOGY

3.1. Description of the Study Area

The study was conducted in Duna Woreda, Hadiya Zone, Southern Nations, Nationalities and Peoples Regional state (SNNPRS), Ethiopia. Duna woreda is located in South Nations, Nationalities, People's Region (SNNPR), in the South West central part of Ethiopia about a distance of 270 km south of Addis Ababa, 211 km from regional city, Hawassa, in the South West and 42 km from the Zonal Town, south away from Hossana, the capital of Hadiya Zone and it is one of the 11 Woredas of Hadiya Zone and geographically located between 7^{0} 37′19´´ N latitude and 37^{0} 37′ 14´´E longitudes (figure 2). It was established in 2002 and Ansho became the center of the woreda. Duna woreda is bordered with Soro woreda (Hadiya Zone) in the North, Doyogena woreda (Kembata Zone) in the South, Omosheleko woreda (Kembata Zone) in the West, and Soro woreda (Hadiya Zone) in the East. Duna woreda there are 32 kebeles found; out of these 30 are rural Kebeles and 2 are urban Kebeles. The administrative center of this Woreda is Ansho; another town in woreda includes cafimera.

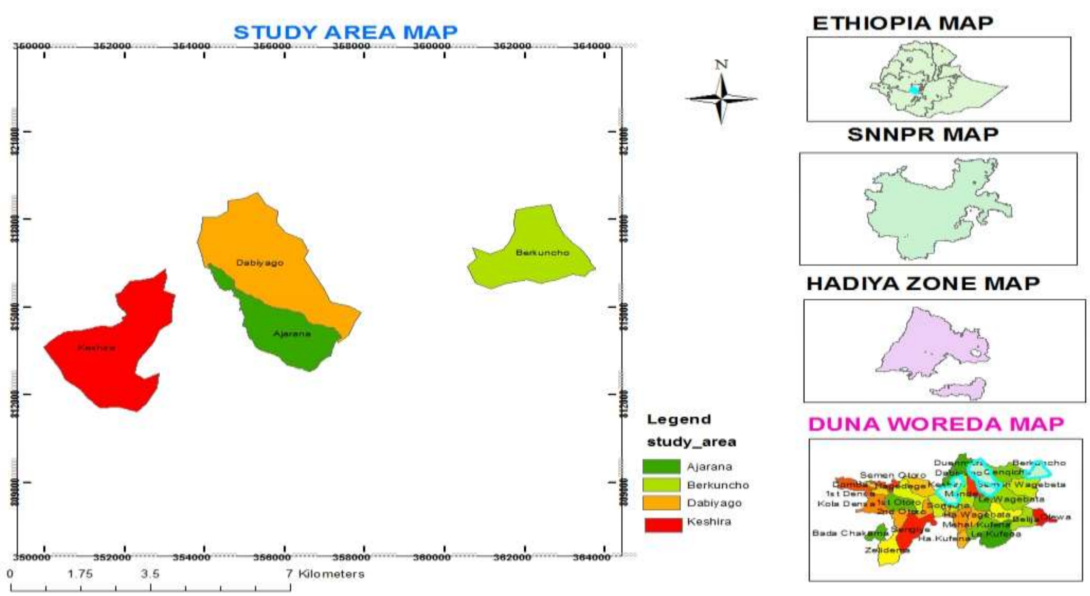

Figure 2: Map of the study area

According to the recent Woreda population reports (2013), the total number of household in Duna woreda is 18,752. Out of these, 18,109 (95.57%) are men headed households and 643 (3.43) are women headed households. A total number of households in 30 rural kebeles is 17,580 (93.75%). Out of these, 17,080 (97.15%) are men headed households and 500 (2.85%) are women headed households and a total number of households in 2 town kebeles is 1172 (6.25%). Out of these, 722 (61.60%) are men headed households and 450 (38.4) are women headed households. The total population of the Duna Woreda is 148,566, out of these, 75,383 (50.74%) is male and 73,183 (49.26%) is female.

The Woreda has an agriculturally suitable land in terms of topography. Agro ecologically, the Duna Woreda is classified in to three categories like as Dega 85%, Weina Dega 10% and kola 5%. The annual rainfall varies from 1500mm to 1896 mm, the mean annual total rainfall is about 1896mm, and has an average temperature of woreda is $19C^{O}$ (Behailu, 2009).

The large part of Duna woreda topographically falls within the southeastern highlands of Ethiopia, data obtained from (HZPEDs, 2001). According to (HZPEDs, 2001) the elevation within the woreda ranges from 2,970m mean sea level Sengiye which is the highest mountain in Hadiya Zone and 1000m mean sea level at the wagabata above which is the lowest place in the woreda. The average elevation of the woreda is taken as to be 1985m from the mean sea level.

The Duna woreda receives a bimodal rainfall where the low rains are between March and April while the high rains are from July to September, 75% of the total amount rain falls during July to September and the main rainfall occurs in July and August. During the main rains, all crops grown in the area are planted, including maize, teff, wheat, haricot bean, sorghum, and millet. Rainfall during the main rains is unpredictable that most of the time crops fail due to uneven distribution of rainfall over the growing period. That is why the Woreda faces crop failures sometimes in years.

According to (DWFEDs, 2012) the total area of the Duna woreda is 43,104 ha (222.57 s/ km) and the population density is 619.58 per s/km. This shows that the population pressure on land was high in the study area. The potentially cultivated land is 30,172.8 ha

(70%), the remaining part of the land is used as uncultivated, grazing land, forest occupied land and it may be fertile land and others.

For the majority of the farm households in the woreda, agriculture is the crucial source of income for their livelihood. More than 95% of the population depends on the agricultural sector for their livelihood with the traditional farming system. Agriculture is dominated by subsistence farming were limited usage of improved agricultural technologies such as row planting technologies and recommended agricultural inputs, which significantly limits wheat crop yield, household food consumption expenditure, household agricultural input expenditure and household income. According to (DWFEDs, 2013 and 2015), statistical evidence shows that high proportion (number) of the young age of the population in the rural area with high demand for farm land. Regardless of a small proportion of the cultivable land in Duna woreda, the population, particularly, young population that demands the farm land is proportionally high. Like most of the highland of Ethiopia, Duna woreda was also facing the problem of land degradation.

The residents of Duna woreda has been Protestant, Catholic, and Ethiopian Orthodox Christianity religious followers. They account 84.92% are Protestant, 8.32% are Catholic and 6.76% are Ethiopian Orthodox Christianity followers.

3.2. Sampling Techniques

A multi-stage sampling technique was applied, so as to reach the selection of a sample of smallholder farm households in the study. The study was applied both non-probability and probability sampling techniques to select the sample from a given population. In the first stage: Out of the total of 11 woredas of Hadiya Zone, Duna woreda were purposively selected, because of its high potential for wheat production, and introduction and application of row planting level of wheat production. In Duna woreda, there are 30 rural kebeles with households of 17,580 (93.75%) and 2 urban kebeles with households of 1172 (6.25%). All the 30 rural kebeles of Duna woreda are wheat producers and 2 separate town kebeles would not be included in this research sampling because they are not wheat producers. Out of 30 rural wheat producer kebeles, 23 kebeles with a total household of 13,478 (76.65%) are adopters of row planting of wheat and the remaining 7 kebeles with a total household of 4,105 (23.35%) are non-adopters of row planting of wheat. The wheat producer kebeles in Duna Woreda were stratified based on the adoption of row planting of wheat.

In the second stage: Take into account the resource available, from 23 adopters of wheat row planting rural kebeles of Duna woreda four kebeles (Ajarena, Kashira, Dabiyago, and Barkuncho) were selected based on their agro-ecological zone compared to the remaining kebeles of the Duna woreda. Out of selected four kebeles agro-ecologically Ajerana, Kashira and Barkuncho are Dega and Dabiyago is Weina Dega. In the third stage: A total sample size 187 smallholder farmers was selected from each stratum using proportionate selecting procedures. From ntotal selected 187 sample size, 107 were a non-row planter of wheat and 80 were row planter of wheat. The sample respondents from four kebales would be selected randomly by employing or using random sampling method.

A Simplified Formula for Proportions

The sample size was determined based on the formula given by (Yamane, 1967). Yamane provides a simplified formula to calculate sample sizes (Yamane, 1967). This formula was used to calculate the sample sizes from given population at 95% confidence level, 5% degree of variability and 7% acceptable error margin (e). Accoring to the above information, sample size was estimated as follows:

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

Where n = the sample size, N = the population size, and e = the level of precision. N= the total number of households in the selected kebeles (2344 HHS), and e= acceptable error margin 7%. It could be calculated by using above formula:

$$n = \frac{234\ 4}{1+0.07*0.07*(234\ 4)}$$

$$n = \frac{234\ 4}{12.4\ 856}$$

$$n=187$$

After determining the total sample size of selected kebeles, then determining the stratified sample size of each selected kebeles proportionally as follow:

$$n_i = \frac{N_i}{N}(n)$$

Where n_i = the total number of selected sample from each i^{th} selected kebele.

N_i = the total number of household in the i^{th} kebeles.

N = the total number of households in the selected kebeles.

n = the total sample size.

$$\text{Ajarena } (n_1) = \frac{N_1}{N}(n) = \frac{533}{2344}(187) = 43$$

$$\text{Kashira } (n_2) = \frac{N_2}{N}(n) = \frac{592}{2344}(187) = 47$$

$$\text{Dabiyago } (n_3) = \frac{N_3}{N}(n) = \frac{663}{2344}(187) = 53$$

$$\text{Barkuncho } (n_4) = \frac{N_4}{N}(n) = \frac{556}{2344}(187) = 44$$

Therefore, the total number of farm household sample size of selected kebele is the sum of farm household sample size of each selected kebeles, in this study total numbers of farm household sample size is 187.

$$n=43 + 47+ 53 + 44 = 187$$

The total number of respondents from each selected kebeles are: total number of respondantes from Ajerana kebele is 43, total number of respondants from Kashira kebele is 47, total number of respondants from Dadiyago kebele is 53 and total number of respondants from Barkuncho kebele is 44 and the sum is the total sample respondants (187).

How it would be selected in proportionally farm household sample size from each stratum group stated in the (Table 1) as follows:

Table 1: stratified and proportionately selected sample

Kebele	Farmers' type	Total number of HH	Sample household (ni)
Ajarena	Non-adopters	310	25
	Adopters	223	18
	Total	533	43
Kashira	Non-adopters	340	27
	Adopters	252	20
	Total	592	47
Dabiyago	Non-adopters	375	30
	Adopters	288	23
	Total	663	53
Barkuncho	Non-adopters	316	25
	Adopters	240	19
	Total	556	44
Total		2344	187

Source: kebeles' administrative offices (2017).

Where n_i= number stratified or small group population.

3.3. Data Collection

The data for the study was collected from both primary and secondary sources. Cross-sectional data was employed from the survey of randomly selected sample farmers. For the primary data collection, questionnaires was designed and pre-tested based on the objective of the study in the study area. The questionnaires schedule was tested at 16 randomly selected farm households in the study area. In the light of pre-testing, essential amendments was made on the wording and statements. Furthermore, the pre-test shows to know whether farm households have clearly understood the interview schedule. The primary data collection was included households' demographic and socioeconomic characteristics.

The secondary data like population number, agricultural inputs, and outputs, farm land use pattern, rainfall amounts (annual mean and cropping season), temperature and agroecology was collected from different sources. Secondary information was used to supplement the primary data was collected from published and unpublished documents obtained from, Duna woreda office of agriculture and rural development, Hadiya zone office of agriculture and rural development, research center, other research studies, Ethiopian seed enterprises, relevant literature, websites and others relevant organizations. After, this both quantitative and qualitative information was collected to respond to raised questions around studying area as well as others wheat producers. The qualitative information like extension services and use of credit was collected to enhance adoption of row planting and impacts of row planting wheat crop on wheat crop yield, household food consumption expenditure, household agricultural input expenditure and income.

3.4. Methods of Data Analysis

The study was employed or used both descriptive and econometric data analysis methods. The descriptive analysis was applied to discuss the behavior of row planting of wheat technology in the study area and performed using frequencies, means, and maximum and minimum values. While the econometric analysis was applied to identify variables that influence row planting of the wheat crop and to evaluates the effect of row planting of wheat on wheat crop yield, household food consumption expenditure, household agricultural input expenditure and household income.

3.4.1. Binary Logistic Regression Model

The Binary logistic regression function was invented in the 19th century for the description of the growth of populations and the course of autocatalytic chemical, or chain reactions (Cramer et al., 2003). Logistic regression was incorporated to analyze relationships between a dichotomous dependent variable and explanatory variables. Our focus here was on binary logistic regression for two groups. Logistic regression combines the explanatory variables to estimate the probability that a particular event will occur that is a subject will be a member of one of the groups explained by the dichotomous dependent variable.

The Probit and Logit models are commonly used, models. The Probit probability model is associated with normal probability function and the logit model with logistic probability distribution respectively. The advantage of these models over the linear probability model is that the probabilities are found between zero and one. Both Logit and Probit models may give the same result. The logistic function is used because it represents a close approximation to the cumulative normal distribution, mathematically easily used model and is easier to work with. Therefore, the Logit model is accepted or selected for this study.

The model is fitted employing method of row planting of wheat technology as dependent variable, socioeconomic variables as explanatory or independent variables which are influence practice of wheat row planting and the outcome variable, wheat productivity and it would be important to shows the factors that influence the farmers' participation status. The dependent variable is binary, taking values of 1 (one) if the farmer participants and zero otherwise. However, the explanatory or independent variables are both continuous and discrete.

The justification for using logit is its simplicity of calculation and that its probability lies between zero and one. Moreover, its probability approaches zero at a slower rate as the value of independent variable gets smaller and smaller, and the probability approaches one at a slower and slower rate as the value of the independent variable gets larger and larger (Gujarati, 2003).

The function form of model or logit model is specified as follows:

$$P=E(Y=1/Xi)=\frac{1}{1+e^{-(\beta o+\beta iXi)}} \quad (1)$$

This will be writing as follows, z_i is equal to $\beta_0 + \beta_i X_i$

$$P_i = \frac{1}{1+e^{-zi}} \quad (2)$$

$$1 - P_i = \frac{1}{1+e^{zi}} \quad (3)$$

The probability that a given household is row planter of wheat is expressed in equation two, while the probability for a non-row planter of wheat is expressed in equation three.

Therefore, we can write as

$$\frac{P_i}{1-P_i} = \frac{1/1+e^{-zi}}{1/1+e^{zi}} = \frac{1+e^{zi}}{1+e^{-zi}} = e^{zi} \quad (4)$$

The ratio of the probability that household is row planter to the probability of that it is a non-row planter of wheat.

$$L_i = \ln \frac{P_i}{(1-P_i)} = z_i = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots\ldots + \beta_n X_n \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

Where L is the log of the odds ratio and it is called the logit.

The above equation with disturbance term can be written as:

$$z_i = \beta_0 + \sum_{i=1}^{n} (\beta_i X_i) + U_i$$

Where z_i= function of explanatory variables (X).

β_0 = an intercept,

$\beta_1, \beta_2, \beta_3 \ldots\ldots \beta_n$ are the slope of the equation in the model

L_i = log of the odds ratio = z_i

X_i= vector of a relevant characteristic or independent variables.

U_i = disturbance term

3.4.2. Propensity Score Matching (PSM)

In this study, PSM was employed or used in order to capture the impact of row planting of wheat on wheat crop yield, household food consumption expenditure, household agricultural input expenditure and household income. The PSM is mainly used in impact determination absence of baseline data. According to Ravallion (2005), impacts estimated with parametric models are more biased and less robust to miss specification of regression functions than those based on matched samples. To determine the effect of adoption of wheat row planting on the productivity and efficiency of the smallholder household's PSM is used. Treated in wheat row planting of wheat technology absence random, matching randomization when compared to parametric models PSM allows the determination of average effects absence of arbitrary assumptions about logistic functional forms, and error distributions. Furthermore, despite that binary logistic models employed or used enough sample, PSM is confined to match one. Propensity score methods allow the researcher to directly address the question of what can be earned from the data and what cannot (David, 2011).

The PSM technique has been applied in a very wide variety of fields in the program evaluation literature: Heckman et al., 1998; (Lechner, 1999), Dehejia and Wahba (2002), and Smith and amp; Todd (2005) use PSM techniques to estimate the impact of labor market and training programs on income; Jalan and Ravallion (2003) use PSM techniques to evaluate antipoverty workfare programs; Almus and Czarnitzki (2003) employ PSM techniques to evaluate the impact of research and development subsidies and patent laws on innovation; (Lavy, 2002) estimates the effect of teachers' performance incentives on pupil achievement; and Persson, Tabellini and Tre bbi (2003) use PSM techniques to analyze the impact of electoral reform on corruption, to evaluate the effects of public program and policies Jalan and Ravallion (2003). The technique enables us to extract from the sample of treated farmers a set of matching farmers that look like the adopting households in all relevant pre- intervention characteristics. The objective of PSM is to find the closest comparison parties (group) from a sample of non-user farmers to the sample of program user farmers. "Closest" is measured in terms of observable characteristics. Small farm household with the same or similar propensity scores are paired and the average treatment effect is then estimated by the differences in outcomes (Greene, 2012).

In this study, the main pillar of Propensity score matching (PSM) is wheat productive household farmers, users 'household in a wheat row and space planting with equal distance and potential outcome were wheat crop yield, household food consumption expenditure, household agricultural input expenditure and household income. The idea was to match those wheat productive farmers that adopt wheat row planting with that of non-users of row and space planting group, sharing full observable characteristics. Then mean effect of wheat row planting is measured as the average difference in wheat crop yield, household food consumption expenditure, household agricultural input expenditure and household income between a user in wheat row planting and non-user in wheat row planting small household groups i.e. the impact is the change in wheat crop yield, household food consumption expenditure, household agricultural input expenditure and household income as an outcome indicator. The importance of PSM model is to answer the question “what would be wheat crop yield, household food consumption expenditure, household agricultural input expenditure and household income per hectare for a household who planted wheat in a row had these household not adopted planting wheat in a row? ”, treated and control groups in wheat row planting technology is related or connected with household variable features. These variables are important to determine comparison households with different matching algorithm; like as nearest neighborhoods matching (NNM), radius matching (RM), caliper matching, and kernel matching (KM).

According to Rosenbaum and Rubin (1983), PSM can be explained as the conditional probability of taking a treatment given pretreatment characteristics of the small farm households. Therefore, Y_i^T and Y_i^C are the outcome or dependent variable treated and control grops respectively. The difference in outcome between treated and control groups can be calculated from the following mathematical equation:

$\Delta Y_i = Y_i^T - Y_i^C$……………………………...……………………………..……… (6)

Y_i^T: Outcome of treat, wheat yield in quintal per hectare, and food consumption expenditure, agricultural input expenditure and income in Birr of the i^{th} household, when he/she is treated, Y_i^C: outcome of control, that is wheat yield in quintal per hectare and food consumption expenditure, agricultural input expenditure and income in Birr of the i^{th} household, when he/she is controled, ΔI change in the outcome as a result of teated for the i^{th} household. Let the above equation can be determined in causal effect notational form, by assigning or conveying D_i=1 as treatment variables taking the value 1(one) if the respondents treated and 0 (zero) otherwise. Then the formula for Average treatment effect on treated (ATT) can be seen as follow:

ATT = E ($Yi^T - Yi^C/D_i$= 1) = E (Yi^T/D_i = 1) - E (Yi^C/D_i= 0)………………………. (7)

E (Y_i^T/D_i=1): mean outcomes for household, with treated, if he/she would treated (D_i=1).
E (Y_i^C/D_i=0): mean outcome for household, with untreated, when he/she would controled

(D_i=0). ATT=The Average Effect of Treatment on the Treated for the sample. The Average Effect of Treatment on the Treated (ATT) for the treated and controled sample respondants or households as is given by:

ATT=E (Y_i^T-Y_i^C/D_i=1) = E (Y_i^T/D_i=1)-E (Y_i^C/D_i=1)……………….…………………(8)

The main evaluation problem in determination of effect is that it is difficult to observe a person's outcome for absence and presence treatment of treated at the same time. The post-intervention outcome E (Y_i^T/D_i=1) is can be to observe, however, the counterfactual outcome of the i^{th} household when she/he does not a treated the treatment is not observable in the data.

According to Rosenbaum and Rubin (1983), there are two basic assumptions to determine importantance of outcome variable: wheat crop yield, household food consumption expenditure, household agricultural input expenditure and household income effect by using PSM model, such as:

Assumption 1: Conditional Independence Assumption (CIA)

Assumption implies that treatment assignment (D_i), which is conditional on attributes, X is explanatory variable of the post program outcome (Y_i^T Y_i^C) . Assumption mathematically can be expressed as:

$(Y_i^T - Y_i^C) \perp (D/X_i)$…………………….……………………………..……….. (9)

This assumption creates a restriction that selecting to treat is purely random for the similar households. As a consequence, this assumption excludes or not includes the familiar dependence between dependent variables and treated groups that lead to a self-selection problem (Heckman et al., 1998). The conditional mean effect of ATT has a problem, if the number of the set of conditioning variables (X's) is very high, and the degree of complexity for assessing similar households both from treated and control becomes imposible. To dimminish the dimensionality problem in determinig the conditional expectation, Rosenbaum and Rubin (1983), their studies indicated that instead of matching on the base of X's one can equal match treated and control measurement on the basis of the PSM explianed as the conditional probability of taking the treatment given the values of X's, mathematically can be calculated as P (X_i) = $P_r(D_i{=}1/X_i)$.

Where P_r = the probability of the binary logistic cumulative distribution, D_i = 1 if the subject was treated, X_i is a vector of pre- treatment features. In evaluating the PSM, all variables that influence treatment and productivity of outcome variables were can entered in the model. Thus, the ATT conditional on propensity scores P(X).

ATT = E ($Y_i^T/P(X)$, D_i =1) = E ($Y_i^C/P(X)$, D_i =1)

Assumption 2: Assumption of Common Support:

0 <P(X) <1………...…………………………………………………..…………….… (10)

The assumption is indicated that P(x) lies between 0 (zero) and 1 (one). This restriction indicated that the test of the balancing property is performed only on the observations whose PSM fall to the common support region of the PSM of treated and control groups (Becker and Ichino, 2002). A household who falls off-support regions were can not be treated in the treatment impact determination. This is a useful condition to guarantee to induce the matching employed or used to evaluate the ATT. The common support condition checks that a person with the similar X values or explatory variables have a positive probability of being both treated and controled (Heckman et al., 1999). This indicates that a match may not be hapend for every household. According to the study of Rosenbaum and Rubin (1983) emphasized on their studies that the assumption 1 (one) and 2 (two) both together as high ignore ability assumption. According to the studies conducted by Caliendo and Kopeinig (2008) emphasize that; there are important stages or steps in estimating PSM. The most common are: evaluation of the PSM, sellecting a matching algorithm, estimating the common support condition, and testing the matching quality.

Choosing a Matching Algorithm

There are four the most commonly used matching algorithms, which are the nearest neighbor matching (NNM), radius matching (RM), caliper matching and kernel (KM) matching, was employed or used to evaluates the impact of row planting a wheat crop on wheat crop yield, household food consumption expenditure, household agricultural input expenditure and household income. The NNM method matches each farm household from the participant group with the farm households from the non-participant group having the closest propensity score. The matching can be done present or absent replacement of observations. NNM algorithm faces the risk of a bad match due to neighbors far away, in order to minimize this risk RM can be used with high tolerance. The users or participants of wheat row planting technology units may not be matched if the dimension of the neighborhood, which means the radius, is too lower to obtain non-users or non-participants of wheat row planting technology units. According to the KM method, the method uses a weighted mean of all farm households in the users or participants of wheat row planting technology or innovation group to build a counterfactual. The most important uses of the KM method is that it provides ATT estimates with smaller variance since it uses the larger information; its limitation or weakness is that some of the observations used may be poor matches.

3.4.3. Dependent Variable

Impact analysis refers to the analysis of the distributional change of adoption of new technology on the well-being or welfare or income of the beneficiary (World Bank, 2008). Adoption of new technology aims at impacts or changes that are intermediate to livelihood outcomes and that relate more to the income of the user to the policies and structure in the sustainable livelihood framework (Asres, 2003).

The dependent variable for the logit model is adopting row planting of wheat. Dependent variable is a dummy variable (given a value of 1 (one) if the household treated and 0 (zero) otherwise). The outcome variables are wheat crop yield, household food consumption expenditure, household agricultural input expenditure and income, for the PSM model household wheat crops income is continuous variable, calculated by dividing total amount of household income to total household family size (i.e per capita household income), measured by birr (ETB). Food consumption expenditure is continuous variable, calculated by dividing the total amount of food consumption expenditure of household to total household family sizes (i.e per capita household food consumption expenditure), measured by birr (ETB). Household agricultural input expenditure is also continuous variable, it is calculated as, total amout of expenditure for agricultural input at the household level, can be measured by birr (ETB) and wheat crop yield is continuous variable and it is calculated as total production of wheat crop at the household level, measured by quntals. Farmers produces 92% wheat yield from total crop production, above 88% of household income, 85% household food consumption expenditure and 80% household agricultural input expenditure are from wheat crop yields in the study area and wheat crop yield is main source of income, food consumption expenditure and agricultural input expenditure for household than other farm and non farm economic activities in the woreda. The non farm contribution to income, household food consumption and agricultural input expenditure is very low in the study area. In the area farmers income, food consumption expenditure, agricultural input expenditure was mainly based on wheat crop yields and income from other crops and non farm activities are very poor. We need wheat yields in order to whether the similar effect with food consumption expenditure, agricultural input expenditure and income is there or not.

3.4.4. Independent Variables

The explanatory variables of importance in this study are those variables, which are a consideration to have an influence on adoption of row planting of wheat on wheat crop yield, household food consumption expenditure, household agricultural input expenditure and household income. This included household personal and demographic variables, socioeconomic variables, household socio-capital variables and institution variables. These explanatory variables are listed as follows:

1. Age of households head (AGEH): it is measured in terms of year and in the most rural area of Ethiopia household head is a responsible member of a household to contribute labor for farm production. In this study age of the household, the head was used as an indicator of experience of the household head who started farming. It is continuous variable and expected to be affecting negatively because when the age of farmers approach to old, able to adopt new technology such as row planting technology will be weak.

2. Sex of households head (SEXH): sex of household is hypothesized that male are in a better position to pull labor force than the female. Women farmers may need a more adjustment period to increase their wheat crop yield, household food consumption expenditure, household agricultural input expenditure and household income sources fully and to improve participation in row planting wheat technology (Christiaensen et al., 2011). According to their studies, male households are larger crop yields than female households. Sex of households head in the model as a dummy variable (takes a value of 1 (one) if the household is male and 0 (zero) otherwise) and expected to have a positive impacts on the adoption of row planting of wheat crop yield, household food consumption expenditure, household agricultural input expenditure and household wheat crops' income.

3. Family size of the household head (FSIZE): family size implies that the number of family members in a household which is measured in number. The existence of a large family size positive impacts on household row planting of wheat crop. It is a continuous variable measured in the number of adult equivalent.

4. The level of education of households (EDU): it is a categoral dummy variable which helps the household to increase wheat crop yields, through promoting awareness on the possible advantages of modernizing agriculture and improve way and adoption technological inputs. Educatioin in the model, categoral dummy. Education level of households head in the model as a categoral dummy variable; take a value of 1 for illiterates (0) grade, a value of 2 for primary (1-5) grade, a value of 3 for secondary (6-8) grade and a value of 4 for tericiary (above grade 9). Education level expected to have a positive effect on the adoption of row planting of wheat; wheat crop yields, household food consumption expenditure, household agricultural input expenditure and income.

5. The size of cultivated land (CLSIZE): this variable is continuous that stands for the total amount of cultivated a land area of the wheat crop which is measured in a hectare. The size of cultivated land has a positive relationship with household row planting of wheat crop yields, household food consumption expenditure, household agricultural input expenditure and household income. Farmers who have larger cultivated land size increases row planting of wheat crop than those who have smaller area and large cultivated land size is important in reducing the risk of row planting technology. So that it is hypothesized that positive relationship is expected between land and adopting wheat row planting.

6. Livestock ownership (TLU): This variable implies that the total amount of animals of the household estimated in tropical livestock unit (TLU). Livestock is used as another capital, which is liquid and it is very important a security against crop failure. Moreover, livestock used for plowing, threshing, transporting. It ehance farm wheat crop yields, household food consumption expenditure, household agricultural input expenditure and household income. Therefore, this variable would be hypothesized positive relationship with adoption of row planting of the wheat crop, wheat crop yield, household food consumption expenditure, household agricultural input expenditure and household income.

7. Use of credit services (USECRIDS): use of credits is dummy variable it takes a value 1(one) if the household uses to credit service and 0 (zero) otherwise. This variables is hypothesized as positive impacts on wheat crop yield, household food consumption expenditure, household agricultural input expenditure and household income. Because of row planting technology needs more labor power, so that to hire labors they need more money.

8. Recommended agricultural input (RAI): it refers utilizing agricultural inputs which are fertilizer, improved seed, and pesticides which are matched with a given land size and sowing time. Household who are reported as users of all as recommended or most of these packages of technology were considered as a user. This variables is hypothesized positive effect on the row planting of the wheat crop. So the 1 if the household is user and 0 otherwise.

9. Availability of farm labor (AFL): it is hypothesized that Availability of farm labor and row planting technology of wheat have a positive relationship. The availability of farm labor would be entered the model as a dummy variable (it takes a value 1 if the household has farm labor and 0 otherwise). The number of availability of farm labor increases, the adoption of row planting technology is also increases.

10. Extension services (EXTEN): it is a dummy variable for extension contact: 1 if the household is contacted by an extension worker in the last years; 0 otherwise. Farmers having extension contact knows the source and possible benefit of wheat crop production and hence expected to be better adopters of row planting technology of wheat crop. Therefore, it will be hypothesized to affect adoption of row planting technology of the wheat crop, wheat crop yields, household food consumption expenditure, household agricultural input expenditure and household income positively.

3.4.5. Variable Definition and Measurement

To determine the probability of adoption socio-economic, demographic and inistitutional variables were used to affect adoption level of row planting technology. Adoption of row planting technology enhances wheat crop yield, household food consumption expenditure, household agricultural input expenditure and household income. According to the Duna Woreda Agricultural and Development Sector (DWADS, 2015 and 2016) reports and research own computation based on data 2017, farmers produces 92% wheat yield from total crop production in the study area. Wheat yield is main source of income, food consumption expenditure and household agricultural input expenditure for household than other farm and non farm economic activities in the woreda. The dependent variable for the model is adoption of row planting technology of wheat, variables is dummy take values 1 if they are adopter and 0 otherwise. The outcome variables for the model are wheat crop yield, household income, household food consumption expenditure and household agricultural input expenditure. The first outcome variable is wheat crop yield, it is the total amount of production of wheat crop at the household level and it is continuous variable, measured by quntals. The second outcome variables is household income, calculated by dividing total amount of household income to total household family size (i.e per capita household income) and this variables is continuous variables, measured by birr (ETB). The third outcome variables is household food consumption expenditure, this variables is calculated by dividing the total amount of food consumption expenditure of household to total household family sizes (i.e per capita household food consumption expenditure) and this variables is continuou variable, measured by birr (ETB). The fourth and the last outcome variables for the current study is household agricultural input expenditure, this variable is also continuous variable, it is calculated as, total amout of expenditure for agricultural input at the household level, measured by birr (ETB).

Table 2: Variables definition

Code	**Definition**	**Scale measurement**	**Type**	**Expected sign**
EDU	Education level	In year school	Categoral dummy	+
AGEH	Age of household head	In year	Continuous	-
FSIZE	Family size	In number	Continuous	+
CLSIZE	Size of cultivated land	In hectare	Continuous	+
TLU	Livestock owned	TLU	Continuous	+
EXTEN	Participation of extension	No=0, Yes=1	Dummy	+/-
AFL	Availability of farm labor	No=0, Yes=1	Dummy	+/-
USECRIDS	Use of credit service	No=0, Yes=1	Dummy	+/-
SEXHH	Sex of household	Male=1, female=0	Dummy	+/-
RAI	All recommended agriculture inputs	No=0, Yes=1	Dummy	+/-

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1. Descriptive Statistics

In this study, both primary and secondary data were collected. Primary data was from 187 sampled household farmers who have been lived in study area four kebeles on demographic characteristics, sex, age, education, access to extension services, access to credit, family size, the livestock holding, cultivated land size, availability of family labor, recommended farm inputs utilization and household expenditure, agricultural income and non-agricultural income. Secondary data was collected from published and unpublished documents obtained from, Duna woreda office of agriculture and rural development, Hadiya zone office of agriculture and rural development, economics, and finnance development office and another important office. The descriptive and econometric analysis was undertaken by this research using STATA software version 13.

Table 3: The descriptive statics for continuous variable

Variables	Obs	Mean	Std. Dev.	Min	Max.	Pearson chi2	Pr.
Ageh	187	56.80	13.46	28	81	32.1582	0.807
Fsize	187	5.42	1.36	3	9	46.6972	0.000
CLsize	187	2.39	0.38	1.25	3	33.5024	0.000
TLU	187	10.66	3.16	2.9	17.2	49.1990	0.000

Source: Own computation based on data (2017)

Table 4 : The descriptive statics for dummy variable

Variables	Obs	Mean	Std. Dev.	0	1	Pearson chi2	Pr.
Sexh	187	0.70	0.46	29.95%	70.05%	0.3989	0.528
Exten	187	0.63	0.48	36.90%	63.10%	22.5960	0.000
Usecrids	187	0.50	0.50	49.73%	50.27%	12.1389	0.000
AFL	187	0.70	0.46	30.00%	70.00%	1.6307	0.202
RAI	187	0.53	0.50	46.52%	53.48%	0.4325	0.511

0 represents :non-adopters, females and 1 represents:adopters, male

Source: Own computation based on data (2017)

Table 5: The descriptive statics for categoral dummy variable

Variables (Education)	0	1	Obs	Pearson chi2	Pr.
1	13.09%	5.00%	187	32.1582	0.000
2	47.66%	34.76%			
3	37.38%	61.23%			
4	1.87%	16.25%			
Total	100.00%	100.00%			

Source: Own computation based on data (2017)

According to this study participants are those farm households that sow the wheat crop in a row and non-participants are those who plants wheat by using the broadcasting method. Adopter of a row planting technology refers to farmers who used row planting of wheat by allocating a proportion of their land. The number of sample farmers who practiced planting wheat in a row was 42.78% while those who used the conventional planting method comprise 57.22% of sample farmers from the total randomly selected 187 sample farmers. The study examined the adoption of row planting of wheat technology in the study area as well as to assess the importance of each hypothesized independent variables on the dependent variables (adoption of row planting of wheat crop technology).

4.1.1. Age of the household head

The average age of the sample household head was found to be 56.80 years where the minimum is 28 and the maximum is 81 (Table 6). The average household age of adopters of row planting is 52.98 and the corresponding figure for non-adopters of row planting is 59.64. From the statistical analysis performed, it is found out that the mean age difference between adopters and non-adopters of row planting is 6.66. The study results showed that age of households' head who started farming and affect row planting technology negatively. The age of the household head affect row planting of wheat technology negatively because when the age of farmers increases, adoption of new agricultural technology such as row planting of wheat technology decreases. That means the age of household heads and row planting technology inversely related and statistically significant at 1% probability level.

Table 6: Age of sample household head

Description	Total sample size	Adopters	Non-adopters
Mean	56.80	52.98	59.64
Minimum	28	28	29
Maximum	81	80	81
Total	187	80	107

Pearson chi2 (40) = 32.1582   Pr = 0.807
Source: Own computation based on data (2017)

4.1.2. Sex of the household head

The socio-economic/demographic characteristics of the small farm households by adoption status of row planting of were presented in (Table 7). According to data, the result showed that majorities 70.05% of the respondents were males and 29.95% were females. When we see the comparison by participation in row planting, out of the 100% participant‘s households 72.50% is headed by male participants and the corresponding figure for non-participants is about 68.22%. Comparison by participation in row planting, out of the 100% participant‘s households 27.5% is headed by female participants and the corresponding figure for non-participants is about 31.78%. Adopters' respondents said that row planting method is important to enhance agricultural productivity, improve environmental sustainability is an instrument for achieving economic growth, poverty alleviation in the study area. Non-adopters' respondents said that broadcast sowing method is easy to apply, low labor cost and suitable for their land whereas, row planting method was it requires more labors, and it takes time and is not suitable for their land. Thus mentioned problems as their expressions affect them not to participate in row planting a wheat crop. Statistical analysis showed that sex of households was statistically insignificant.

Table 7: Sex of sample household head

Category	Non-adopters	%	Adopters	%	Total Sample Size	%
Female	34	31.78	22	27.50	56	29.95
Male	73	68.22	58	72.50	131	70.05
Total	107	100	80	100	187	100

Pearson chi2 (1) =   0.3989   Pr = 0.528
Source: Own computation based on data (2017)

4.1.3. Level of education of the household head

As tabulated (Table 8), this variables is categorical dummy variable. It can be categorized into four categories: 1 for illiterates (0) grade, 2 for primary (1-5) grade, 3 for secondary (6-8) grade and 4 for tertiary (above grade 9). According to data, the result showed that education and application of row planting of wheat technology are positively related. As result of (Table 8), from total sample households, 9.62% of the sample respondents were illiterates (0) grade, 34.76% of the sample respondents were attained primary education level (1-5) grade, 47.59% of the sample respondents were attained secondary education level (6-8) grade and 8.03% of the sample respondents were attained tertiary education level (above grade 9). According to the result of the sample data majority of sample household heads on average attained secondary education level (47.59%), that means between grades (6-8) grade. About 90.37% of sample household heads have attained education greater or equal to grade 1. That means 90.37% of sample household heads are literate while 9.63% of sample household heads are illiterates. When we compare adopters 5% with non-adopters 13.09% were illiterates (0) grade, 17.50% of adopters and 47.66% of non-adopters were attained primary education level (1-5) grade, 61.25% of adopters and 37.38% of non-adopters were attained secondary education level (6-8) grade, and 16.25% of adopters and 1.87% of non-adopters were attained tertiary education level (above grade 9). According to the result of the sample data majority of adopters sample household heads on average attained secondary education level (61.25%), that means between grades (6-8) grade and majority of non-adopters sample household heads on average attained primary education level (47.66%), that means between grades (1-5) grade. Education helps households to enhance wheat crop yields, household food consumption expenditure, household agricultural input expenditure and household income through promoting awareness on possible advantages of modernizing agriculture especially on row planting technolgy. Modernize agriculture through adopting technological agriculture inputs and row planting methods. Thus, it was hypothesized that household which is heads by relatively more education ones are in a better position in terms of adopting of row planting of wheat than those heads are less educated. And also the statistical result showed that there was a significant difference between adopters and non-adopters' households in terms of education and the level of education of household head statistically significant at 5% probability level.

Table 8: Education level of sample households head

category	Non-adopters	%	Adopters	%	Total Sample Size	%
1	14	13.09	4	5.00	18	9.62
2	51	47.66	14	17.50	65	34.76
3	40	37.38	49	61.25	89	47.59
4	2	1.87	13	16.25	15	8.03
Total	107	100.00	80	100.00	187	100.00

Pearson chi2 (3) = 32.3703   Pr = 0.000

Source: Own computation based on data (2017)

4.1.4. Family size of household

Table 9, it was indicated that in the study area the average family size is 5.42 person per household, when the minimum is 3 and maximum is 9. When we compare the average household size between adopters in row planting and non-adopters, the study revealed that households that participate in row planting have more household size than non-participant households. Average household size of adopters of row planting is 6.00 and non-adopter is 5.00 and there is the difference. The data results showed that average household size difference between adopters and non-adopters of row planting of wheat technology is 1.00 and the variable is statistically significant at 5% probability level. In the agricultural sector, wheat row planting technology require more labor in the production, to increase wheat crop yields, household food consumption expenditure, household agricultural input expenditure and household income. As household who have large family size were able to provide a large number of labor from their family members. The number of family members high, the possible application of row planting technology also increases. As a result of this among the high- adopters of the row planting of wheat technology, most of them had large family size. According to the data results, household family size and level of participation of row planting wheat technology are positively related.

Table 9: Family size of sample household head

Description	Total Sample Size	Adopters	Non-adopters
Mean	5.42	6.00	5.00
Minimum	3	3	3
Maximum	9	9	8
Total	187	80	107

Pearson chi2 (6) = 46.6972 Pr = 0.000

Source: Own computation based on data (2017)

4.1.5. Size of cultivated land

In as (Table 10) stated, the land holding of the sample household varies from 1.25 hectare to 3 hectares. The average land holding is 2.39 hectare. The mean land holding for adopters is 2.54 and the corresponding figure for non-adopters is 2.27 hectare.

It is quite true that in normal circumstances land size and land productivity are directly and positively related. That means the cultivated land size of the household heads was the required resource for the adoption of row planting technology. The cultivated land size of the farm influences farmer adoption of row planting technology of wheat crop. This implies that most of the farm size of the cultivated land is small so the application of row planting was low. The respondent responds that soil type and size of cultivated land has its own influence on row planting of wheat crop production in case of this study. Cultivated land size is statically significant at 10% probability level.

Table 10: Cultivated land size sample household head

Description	Non adopters (N = 107)	Adopters (N = 80)	Total Sample (N = 187)
Mean	2.27	2.54	2.39
Minimum	1.25	1.25	1.25
Maximum	3	3	3

Pearson chi2 (7) = 33.5024 Pr = 0.000

Source: Own computation based on data (2017)

4.1.6. Livestock holding

Table 11, indicated the mean livestock (cattle, horse, donkey, mule, sheep and goat, and chicken) holding in Tropical Livestock Unit for the sample households is 10.66, where the minimum is 2.9 and the maximum is 17.2 in TLU. Adopters households have a better livestock holding than non-adopters households. The mean livestock holding for adopters' households is 11.87 TLU and 9.77 TLU for non-adopters. The average comparison for the two groups implies that the difference between the groups with regard to livestock holding is significant at 10% probability level. In the communities where agriculture are the main source of economic activity, TLU has a significant influence on their agricultural wheat crop yields, household food consumption expenditure, household agricultural input expenditure and on the total amount of income received. As respondents respond if they have a number of oxen, they will use to tillage and get income from selling at least about 6,500 Ethiopian Birr per ox which helps them for agriculture input utilization cost. They said that livestock's, especially oxen are used for multidimensional purpose.

Table 11: Livestock holding sample household heads

Description	Non adopters (N = 107)	Adopters (N = 80)	Total Sample (N = 187)
Mean	9.77	11.87	10.66
Minimum	2.9	2.9	2.9
Maximum	15.5	17.2	17.2

Pearson chi2 (14) = 49.1990   Pr = 0.000
Source: Own computation based on data (2017)

4.1.7. Access to extension service

Extension services are very important and effective to enhance the productivity of wheat crop in the study area. As result of (Table 12), from total sample households about 63.10% of the sample households get extension service, 36.90% sample households do not get extension service and this variable is statistically significant at 1% probability level. When we compare the adopters with non-adopters 48.60% majority of the adopters 82.50% households get support from extension agents. The household heads who have involved in extension services were more likely participate in row planting technology and which enhances wheat crop yield, household food consumption expenditure, household agricultural input expenditure and household income. Extension service here refers to advice, demonstration, and distribution of input. From the respondent, about 17.50% of the adopters and 51.40% non-adopters reply they do not get extension service.

Table 12: Extension services user sample household heads

Description	Non-adopters	%	Adopters	%	Total Sample Size	%
Yes	52	48.60	66	82.50	118	63.10
No	55	51.40	14	17.50	69	36.90
Total	107	100	80	100	187	100

Pearson chi2 (1) = 22.5960
Pr = 0.000 Source: Own computation based on data (2017)

4.1.8. Use of credit service

The main source of credit in the study area is Duna Woreda "OMO" microfinance and richer individuals. Table 13, showed that from the sample households 50.27% have to get credit while 49.73% did not want to take credit due to various reasons which are food consumptions rather than farm inputs consumption and unexpected expenditure, existing of high-interest rate and by having enough money to buy agricultural inputs. When we compare adopters 65.00% and non-adopters 39.25% households' majority of the adopter households have taken credit. From adopters about 35.00% of the sample respondents and from the non-adopters 60.75% households not use credit services. There is match more difference between adopters and non-adopters in terms using credit access. The study result showed that use of credit increases participation of row planting of wheat technology in the study area. The data results showed that the use of credit positively influence row planting wheat technology through which enhances wheat crop yields, household food consumption expenditure, household agricultural input expenditure and household income. That means the use of credit service in this study statistically significant at 5% probability level.

Table 13: Credit user of sample household heads

Description	Non-adopters	%	Adopters	%	Total Sample Size	%
Yes	42	39.25	52	65.00	94	50.27
No	65	60.75	28	35.00	93	49.73
Total	107	100	80	100	187	100

Pearson chi2 (1) = 12.1389   Pr = 0.000
Source: Own computation based on data (2017)

4.1.9. Availability of farm labor in farm activity

In (Table 14), we consider active labor as who can participate in an agricultural activity in the household. The Large working labor force in a family means the household may not need to hire more additional labor and the money saved due to the use of own labor force could be used for purchasing other crop production inputs. This will increase adoption of row planting technology. The data result showed that from the sample households 70.00% have farm labor while 30.00% do not have farm labor. According to the data result, about 75.00% of adopters and 66.36% of non-adopters have farm labor. About 25.00% of adopters and 33.64% of non-adopters farmer's express they do not have availability of farm labor. The reasons that are having their own work, prefers work and by the lack of demand to work farm activity. This variable is statistically insignificant.

Table 14: Availability of farm labor of sample household head

Description	Non-adopters	%	Adopters	%	Total Sample Size	%
Yes	71	66.36	60	75.00	131	70.00
No	36	33.64	20	25.00	56	30.00
Total	107	100	80	100	187	100

Pearson chi2 (1) = 1.6307 Pr = 0.202
Source: Own computation based on data (2017)

4.1.10. Recommended agriculture input user sample household head

According to (Table 15), about 53.48% of the sample households used as recommended agricultural inputs utilization, 46.52% of sample households' non-user of as recommended. When we compare to adopters with non-adopters' households there is no match more difference recommended agricultural inputs utilization to improve wheat crop products. According to, the survey about 56.25% of adopters and 51.40% non-adopters used as recommended agricultural technology inputs. Agricultural improved technologies are recommended fertilizer, variety wheat seed, pesticide and others which are used to improve wheat products. About 43.75% treated group and 48.60% control groups used without recommendation which means they use as their own desires and this variable statistical insignificant.

Table 15: Recommended input user household head

Description	Non-adopters	%	Adopters	%	Total Sample Size	%
User	55	51.40	45	56.25	100	53.48
Non users	52	48.60	35	43.75	87	46.52
Total	107	100	80	100	187	100

Pearson chi2 (1) = 0.4325 Pr = 0.511

Source: Own computation based on data (2017)

4.1.11. Type of wheat seeds

According to (Table 16), about 46.00% of the sample households used improved wheat seed, 24.00% of sample households used local wheat seed and 30.00% of sample households used both. When we compare adopters 56.25% and non-adopters 38.30% households' majority of the adopter households use a more improved variety of wheat seeds. According to the survey, about 18.75% adopters and 28.00% non-adopters used local seed, and 25.00% adopters and 30.70% non-adopters used both.

Table 16: Used wheat seeds by sample household head

Description	Non-adopters	%	Adopters	%	Total Sample Size	%
Improved	41	38.30	45	56.25	86	46.00
Local	30	28.00	15	18.75	45	24.00
Both	36	33.70	20	25.00	56	30.00
Total	107	100	80	100	187	100

Source: Own computation based on data (2017)

According to row planting technology adoption, in order to enhance wheat yield, household food consumption expenditure, household agricultural input expenditure and household income, adopter households were participating in the row planting technology of wheat crop because of the awareness creation activities carried out by the Woreda. As adopters respond row planting of wheat helped them to increase wheat crop yields, household food consumption expenditure, household agricultural input expenditure and income, and decrease amount seed rate. The non-adopter households were forward different reasons for not participating in the row planting of wheat technology. The reasons for 24% non-adopter respondents were lack of personal interest to participate in row planting technology, 31% non-adopter respondents said our cultivated land is not suitable for row planting of wheat technology due to logging water, hence we don‘t have the confidence to sow the available land we have in row and 45% non-adopter respondents said we don't have enough labor force, not suitable sowing and takes time. In finally they said that as much as possible government should support farmers by distributing row planting of the wheat machine to substitute labor force and to decrease time expense.

4.2. Econometrics Results

4.2.1. Binary logistic regression model result

A binary logistic regression model was used to estimate and identify determinant factors of row planting of the wheat crop and propensity score matching model was used to analyze the impact of row planting on wheat crop yields, household food consumption expenditure, household agricultural input expenditure and income. Before fitting both models, it is essential to check whether there is or not a high degree of association among and between both discrete and continuous explanatory variables. In logistic regression contained a binary outcome and discreet or continuous explanatory variables. For each explanatory variable in the model, there would be an associated parameter. The Wald test by (Angrist et al., 1995) is used to test whether the parameter associated with an explanatory variable is zero or not. If the parameter of the explanatory variable significantly differs from zero then associated variable should be included in the model. Therefore, all explanatory coefficients were greater than zero.

The goodness fit of a model for the binary logistic regression model, an intuitively appealing way to summarize the result of the fitted logistic model is via a classification table. This cross-classification is the result of cross-classification of the outcome variable 'y" with a dichotomous variable whose values are derived from the estimated logistic probabilities. With regard to the predictive efficiency of the models out of 187 sample household include in the model, 150 (80%) were correctly predicted. The sensitivity and specificity indicate that 73.75% of adopter of row planting of wheat and 84.11% of non-adopters of row planting of wheat households were correctly predicted in their categories respectively. With regard to the error rates committed in the classification table, the false positive rate (number error where the household is predicted to be adopter but is, in fact, non-adopter) is 22.37% while the false negative rate (the number of error where the false household is predicted to be non-adopter, but is, in fact,adopter) is 18.92%. This result is thought to provide evidence that the model fits.

4.2.1.1. Main factors that affecting adoption of row planting of wheat crop

In this subsection, we treat results concerning adoption at the household level as well as the socio-economic, demographic and other factors that affect the adoption of row planting behavior of households. This study employed or used logistic regression model to estimate and to figure out factors having a certain sort of relationship to the row planting technology. The output of the logistic regression model showed that seven variables determine the probability of participating in row planting technology. These are the age of households head, the level of education of the household head, family size of the household head, cultivated land size of a household head, Tropical Livestock Unit (TLU), use of credit service and access to extension services.

Age of the sample households: this variable is a negative relationship with row planting technology and significant at 1% probability level. The odds ratio is .95 (Table 17). It implies that; odds ratio in favor of adopting row planting of wheat technology decreases by a factor of .95, as the age of the small farm household heads increases by one year. This implies that as age of the farmer increase by one year, the probability of adoption of row planting of wheat technology decreases by 1%. The result of the sample data shows that younger household heads are more likely to participate in row planting of wheat technology as compared to older household heads. Accordingly, Debelo, 2015; Alemitu, 2011; Hattam, 2006; and Legesse et al., 2001 findings result showed that the younger farm households are more users than the older farmers.

The education level of household heads: this variable is a positive relationship with row planting technology and significant at 5% probability level. The odds ratio is 2.00 (Table 17). The odds ratio implies that as the year of schooling of household heads increased by one grade, household heads who educated is about two times more likely to participate in row planting technology as compared to household heads who are illiterate. A possible explanation is an education helps the household to increase wheat crop yields, household consumption expenditure, household agricultural input expenditure and household income through promoting awareness on the possible advantage of modernizing agriculture and on working efficiency, diversify income, adopting new technology which is used to improve wheat crop productivity and information from development agents. Similarly, studies conducted by (Hattam, 2006; Bwire, 2008) the more the household farmers educated level, the more adoption of row planting of wheat technology. Therefore, educated is better to participate in row planting of wheat than an illiterate one.

Family size of household: this variable is positive relationship with row planting technology and significant at 5% probability level. Marginal effect is 0.076 (Table 17), that implies the being other things constant, as the family size of household head increased by one, the probability of household being row planter increase by 7.6%. This positive relationship tells us that a large number of family size of household heads more likely to participate in row planting technology as compared to household heads who have small family size. As household heads who have large family size were able to provide a large number of labor from their family members. Wheat row planting technology require more labor in the production, to increase wheat crop yields, household food consumption expenditure, household agricultural input expenditure and household income. This suggests that large family is the major variable in influencing decisions of households to participate in row planting technology.

Cultivated land size: this variable is positively related with row planting technology and significant at 10% probability level. As stated (Table 17), marginal effect is 0.23. The positive relationship implies that farmers, who have more farm size, are most likely to participate in row planting technology, keeping the effects of other variables constant. That means households' farm size increases, the probability of participating in row planting technology increases, ceteris paribus. As the cultivated land size increases, the household becomes able to increase row cropped area on the cultivated land; this may, in turn, imply increase wheat crop yields, household food consumption expenditure, household agricultural input expenditure and household income. The possible explanation is that household' cultivated land size increases, the probability of participating in row planting of wheat crop increases. The study by Yonas, 2013 suggests that land is an important factor in influencing farmer‘s decision to produce.

Tropical Livestock unit (TLU): this variable is significant at 10% level of significance in odd ratio, robust and marginal effect' result. It has positive relationship with row planting of wheat technology. As stated (Table 17), marginal effect is 0.033, for tropical livestock unit implies that, other things kept constant, as the number of livestocks increase by one TLU, the probability of household being row planter increase by 3.3%. That means especially having many oxen make him or her possible to participate in row planting technology of the wheat crop. TLU also implies that adopters having much Tropical livestock units have more access to financial source than non-adopters. That means adopters have a large amount of livestock, they sell off livestock which could be used to purchase farm inputs, like seed and fertilizer. Holding a large amount of livestock is important to minimizing risk. The main reasons are the household head that has many TLU will have high wheat crop yields, high household consumption expenditure, high household agricultural input expenditure and household income, and he/she will use his/her oxen for plowing so it is easy for them to participate in row planting technology. Accordingly, Mesfin, 2005; Solomon et al., 2011 and Alemitu, 2011, findings the household heads who have a large number of livestock holding interims of tropical livestock unit, more participating in row planting technology.

Use of credit service: this variable is positively related with row planting technology and significant at 5% probability level. Its odds ratio is 2.51 (Table 17), The implication is that the result is expected since use of credit service is major source of income for agricultural input expenditure in the rural area, hence a household heads who got credit is about two times more likely participate in row planting technology as compared to household heads who did not get credit. Small farm household heads who have the opportunity of getting credit for agricultural inputs, more participate than those who have no access. The possible explanation is that household heads who got credit; they would use row planting technology more easily to enhance households' wheat crop yields, household food consumption expenditure, household agricultural input expenditure and income.

Access to extension services: it is positively related with row planting wheat technology. This variable is significant at 1% probability level. The odds ratio is 2.85 (Table 17), this is that household heads who are involved in extension services are about three times more likely to participate in row planting wheat crop as compared to household heads who are not involved in extension services. The extension services are very important and effective variables by advice, demonstration and distribution of recommended agricultural inputs through row planting technology, which increases wheat crop yields, household food consumption expenditure, household agricultural input expenditure and household income. The data results showed that adopter households have more contact with extension agents than non-adopter households in the study area. The main reasons for possible factor in farmers‘ decision to participate in row planting technology and their level of production since farmers receive a number of services from extension services, including technical services on its production. The possible explanation is that adopter household heads with more extension services, easily participating in row planting technology than non-adopter households.

Table 17: Estimation result of the binary logit Table model

Variable	Coef.	Robust std. Err.	Odds Ratio	Z	P >|Z|	dy/dx
AGEHH	-.0467232***	.0156098	.9543515	-2.90	0.003	-.0111192
SEHH	.116301	.4559993	1.123334	0.26	0.799	.027526
FSIZE	.319241**	.1512633	1.376083	2.11	0.035	.0759728
EDU	.693629**	.2711641	2.000964	2.56	0.011	.1650696
CLSIZE	.9678345*	.5360575	2.632238	1.81	0.071	.2303249
TLU	.1399694*	.0716798	1.150239	1.95	0.051	.0333099
CRUHH	.9171961**	.405024	2.502264	2.26	0.024	.2149421
RAI	.5425498	.3887685	1.720388	1.40	0.163	.1279105
AFL	.1734129	.454173	1.189357	0.38	0.703	.0409221
EXTEN	1.046396***	.384173	2.847372	2.72	0.006	.236481
_cons	-6.696468	1.859443	.0012353	-3.60	0.000	-

***, ** and * shows the significance level at 1%, 5% and 10% respectively
Source: Own computation based on data (2017)

4.2.2. Impact analysis of propensity score matching

The use of estimation of the propensity score is twofold: first, use to estimate the ATT and, second, use to obtain matched adopter and non-adopter observations. Thus, Propensity score methods allow the researcher to directly address the question of what can be earned from adopters and the loss of being non-adopters. According to (Grilli and Rampichini, 2011) the necessary steps when implementing propensity score matching are: Propensity Score estimation, Choose matching algorithm, Check overlap/common support. To estimate the effect of treatment on farmers' income, PSM with different matching algorithms: nearest neighbor matching (NNM), radius matching (RM), caliper matching, and kernel matching (KM) were most importantly used.

Matching of the treated and control households were mostly carried out to estimate the common support region. The main criterion for estimating the common support region is to delete all respondants or observations whose PSM is lower than the minimum PSM of treated or adopters and higher than the maximum in the control group or non-adopters (Caliendo and Kopeining, 2008). That is, deleting all respondants or observations out of the overlapping region. The summary statistics of propensity scores of farmers (Table 18), the predicted propensity scores for adopters of row planting and non-adopters of row planting of wheat farmer range from .0345565 to .9590279 with mean value of .649575 and standard deviation .2501255 for the adopter farmers, while it ranges from .027161 to .957612 with mean value of .2598412 and standard deviation .2298615 for those non-adopter farmers. The common support region indicates that the propensity score for the overlap region ranges from .0345565 to .957612. This is the region between the minimum propensity score of the adopter and the maximum propensity score of non-adopter farmers in wheat row planting (Table 18). The table shows a summary of the propensity score for adopters, non- adopters, common support region and off-support regions from the two categories of small household farmers. Therefore, the production impact analysis considered both farmers involved in adopters and non-adopters of row planting methods with propensity score of the overlap region i.e. propensity score ranging from .0345565 to .957612. Accordingly, the common support region was satisfied in the range of .0345565 to .957612 by deleting 1 observation (1 observation from those adopters).

Table 18: Predict propensity score common support region

Observations	Mean	Std. Dev.	Min.	Max.
Non adopter	.2598412	.2298615	.027161	.957612
Adopter	.649575	.2501255	.0345565	.9590279
Total	.4265722	.3066998	.027161	.9590279

Source: Own computation based on data (2017)

Before to computing or to calculating the ATT, the same of the subsample of control cases that are directly compared with the treated cases should be tested by employing or using the test is "pstest". Pstest highly helps to balance data for PSM and for each covariate before and after matching. The standardized bias difference between treated and control sample households was important as a convenient way to evaluate the bias deffirence between the treated and non-treated sample households. It is result of the data that shows sample household differences in the raw data significantly larger those data in the sample household of matched cases. The procedure of matching provides a large degree of covariate balance difference between the treated and control sample household that are very useful in the evaluation procces. According to the Table 19, the regretion data result indicated that the values of Pseudo R-square(low), LR chi-square (insignificant), that means the p - value is high and the sample size is large before and after matching which can be useful as increases for the fulfillment of the balancing criteria. Sianesi, 2004 suggests re-estimating the propensity score on the matched sample that means only on participants and matched non-participants and comparing the pseudo-R-square before and after matching. The pseudo-R-square indicates that how the regressors X define the adoption probability. After matching there should be absence systematic differences in the distribution of covariates between both treated and controled groups and therefore the pseudo-R-square should be fairly low or small. To determine the best matching estimator among nearest neighbor matching, caliper matching, radius matching and kernel matching methods, performance criteria such as balancing test of covariates, low pseudo R^2 value, and a large number of matched sample size by discarding or deleting only 1 unmatched farmers from a total of 187 sample farmers.

Then, a smaller value of pseudo-R-square and the insignificant LR Chi-square showed in row one and columns two that both user and non-user groups have the same distribution of covariates after matching. The data results showed that the matching procces is able to equalize or balance the features of the treated and the control groups. The data results evaluates the impact of participation of row planting of wheat technology between treated and control groups of respondants or observations having the same observed features or characterstics.

Table 19: pstest balance score matching

Matching Algorithm		Before matching			After matching		
		Ps R^2	LR chi- square	P – value	Ps R^2	LR chi- square	P – value
Neighbor	1	0.334	85.28	0.000	0.036	7.94	0.957
	2	0.334	85.28	0.000	**0.016**	3.48	0.995
	3	0.334	85.28	0.000	0.028	6.12	0.923
	4	0.334	85.28	0.000	0.025	5.54	0.887
	5	0.334	85.28	0.000	0.028	6.06	0.820
KM bwidth	0.1	0.334	85.28	0.000	0.027	5.84	0.838
	0.25	0.334	85.28	0.000	0.028	6.20	0.373
	0.5	0.334	85.28	0.000	0.062	13.52	0.001
RM radius	0.01	0.334	85.28	0.000	0.337	54.88	0.000
	0.1	0.334	85.28	0.000	0.337	54.88	0.000
	0.25	0.334	85.28	0.000	0.337	54.88	0.000
Caliper	0.1	0.334	85.28	0.000	0.036	7.94	0.957
	0.25	0.334	85.28	0.000	0.036	7.94	0.957
	0.5	0.334	85.28	0.000	0.036	7.94	0.957

Source: own computation based on data (2017)

4.2.2.1. Estimation of treatment effect: matching algorithms

PSM algorithm can be selected based on its own criteria: balancing test, Pseudo R-square (low), matched sample size (large) and LR chi-square (insignificant), the algorithm which are selected from four matching algorithm: nearest neighbor matching **(**NNM), radius matching **(**RM), caliper matching, and kernel matching **(**KM). Accordingly, a nearest-neighbor matching method with of 2 was found to be the best estimator of the data of wheat crop yields, household food consumption expenditure, household agricultural input expenditure and income of wheat crop (Table 19). As depicted in the table, relatively, this estimator resulted in the least pseudo-R-square (0.016), a large number of matched sample size for (79) adopter and for (107) non-adopter and balancing test after matching the percent of bias is below 5% and also its LR chi-square is insignificant. As showed (Table 20), the Average Treatment effect on the Treated (ATT) was computed based on the four alternative matching methods. Outcome variables are yield is measured in quintal and household income, food consumption expenditure and agricultural input expenditure which are measured in Ethiopia Birr (ETB) respectively.

The impact of wheat row planting on the household wheat product was based on a sample of matched treated and control groups, the estimated average treatment effect (ATT) significant effect on the product of participant farmers with significant t-statistic (5.56) at 1% significance level ($p < 0.001$). The average yields of wheat crop of adopter households in wheat row planting was higher by 4.93 quintals per hectare in given product year when compared with the average yields of non-adopter households. The nearest neighbors (2) matching method result revealed that the wheat crop net income of the farmers who were adopter of row planting of wheat was much greater with 6079.56 Ethiopian Birr than non-adopters in given product year, which was similar result with (Debelo, 2015) and (Yonas, 2013) studied on tef crop income, the result stated that the crops net income of wheat row planting technology adopters is greater than non-adopters. The wheat crop net food consumption expenditure of the farmers who were adopter of row planting of wheat was much greater with 5244.75 Ethiopian Birr than non-adopters in given product year; which was similar result with (Tsegaye and Bekele, 2012). The wheat crop net agricultural input expenditure of the farmers who were adopter of row planting of wheat was much greater with 4486.52 Ethiopian Birr than non-adopter in a given product year. From the table 20, it is clear that the average treatment effect on the treated (ATT) of wheat crop's average income with t-value 5.55, crop food consumption expenditure with t-value 3.50, crop agricultural input expenditure with t-value 3.15 and product with t-value 5.56, indicating the effective level of significance. So it is concluded in this analysis that the row planting of wheat adoption has positive yields, income, food consumption expenditure and agricultural input expenditure effect on the farm households of the study area. Hence, the adoption of row planting of wheat has a positive impact on the life of the adopters indicating positive welfare effect or reduction of poverty level on the side of the adopters.

Table 20:The Average Treatment effect on the Treated

Outcome Variable		Treated	Controls	Difference	BSE	T-stat
Wpdt	Unmatched	12.1392405	7.81308411	4.32615639	0.698314984	6.20
	ATT	12.1392405	7.20886076	4.93037975	0.88741955	5.56*
Inch	Unmatched	13967.0886	7704.85981	6262.22879	937.883871	6.68
	ATT	13967.0886	7887.53165	6079.55696	1096.37439	5.55*
Fceh	Unmatched	13558.2278	8050.65421	5507.57364	1273.4271	4.33
	ATT	13558.2278	8313.48101	5244.74684	1496.89042	3.50*
Aieh	Unmatched	12439.2405	7745.98131	4693.2592	1205.90225	3.89
	ATT	12439.2405	7952.72152	4486.51899	1423.62413	3.15*

Source: Own computation based on data (2017)

4.2.2.2. Sensitivity test for average treatment effect on the treated

Sensitivity analysis is a strong identifying assumption and must be justified. According to (Grilli and Rampichini, 2011) sensitivity analysis is the final diagnostic that must be performed to check the sensitivity of the estimated treatment effect to small changes in the specification of the propensity score. In table 21, the result was reported, as a different level of bounds tells us at which degree of unobserved positive or negative selection the effect would become significant (Samuel et al., 2013). The Q_mh+ statistic adjusts the Mantel-Haenszel (MH) statistic downward for the case of positive (unobserved) selection on the impact of row planting of wheat technology while Q_mh- statistic adjusts the MH statistic downward for the case of negative (unobserved) selection. From the result above, under the assumption of absence hidden bias (Γ=1), the Q_mh+ and Q_mh-test-statistic gives a similar result on the impacts of row planting of wheat technology on household yields, food consumption expenditure, agricultural input expenditure and income, indicating a significant treatment effect. The negative values of Q_mh+, therefore, indicate negative selection bias where the most likely participants of row planting of wheat technology tend to have lower yields, household food consumption expenditure, household agricultural input expenditure and household income even in the absence of adoption. Therefore, this can be interpreted as downward bias in estimated treatment effects. This bias is however not significant at different bound levels both for likely underestimation of the treatment effects and overestimation of the treatment effects as indicated by P_mh + and P_mh - values. The table also shows that the study was insensitive to a bias that will double or triple the odds of a change in gross margin as a result of the row planting technology. We conclude based on this concept of the sensitivity analysis shows that the significance level is unaffected even if the gamma values are relaxed in any desirable level. This shows that average treatment effect on treated is not sensitive to external change. Hence there are no external variables which affect the result above calculated for ATT (wheat crop yields, household food consumption expenditure, household agricultural input expenditure and income) result.

Table 21: Sensitivity test of external effect on ATT

Gamma	Q_mh+	Q_mh-	p_mh+	p_mh-
1	.	.	.	.
1.05	-.094055	-.094055	.537467	.537467
1.1	.	-.094055	.	.537467
1.15	-.094055	-.094055	.537467	.537467
1.2	.	-.094055	.	.537467
1.25	-.094055	-.094055	.537467	.537467
1.3	-.094055	-.094055	.537467	.537467
1.35	-.094055	-.094055	.537467	.537467
1.4	-.094055	.	.537467	.
1.45	.	-.094055	.	.537467
1.5	-.094055	-.094055	.537467	.537467

Gamma = odds of differential assignment due to unobserved factors

Q_mh+ = Mantel-Haenszel statistic (assumption: overestimation of treatment effect)

Q_mh- = Mantel-Haenszel statistic (assumption: underestimation of treatment effect)

p_mh+ = significance level (assumption: overestimation of treatment effect)

P_mh - = significance level (assumption: underestimation of treatment effect)

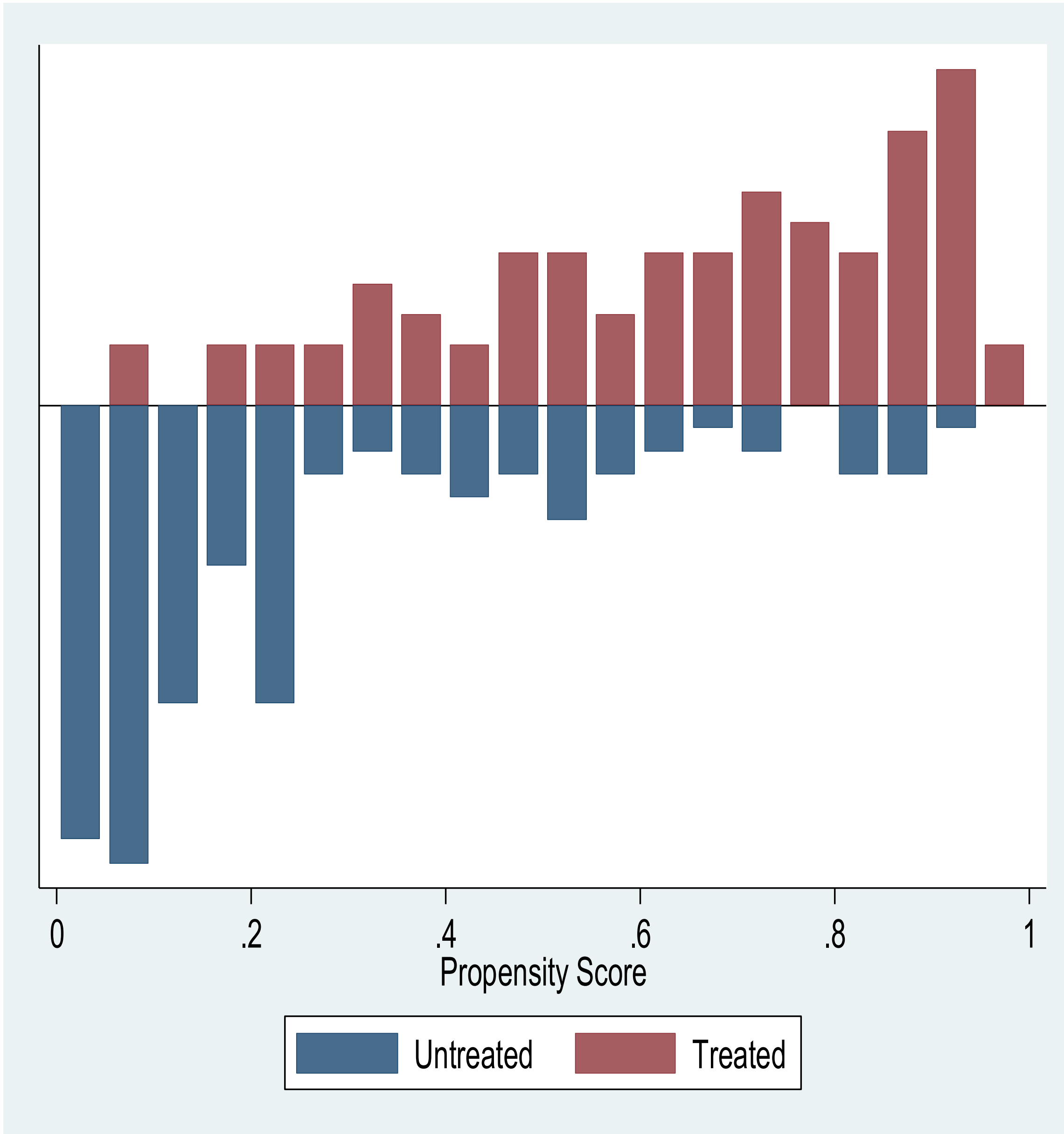

Figure 3: Propensity score distribution of unmatched sample
Source: own computation based data (2017)

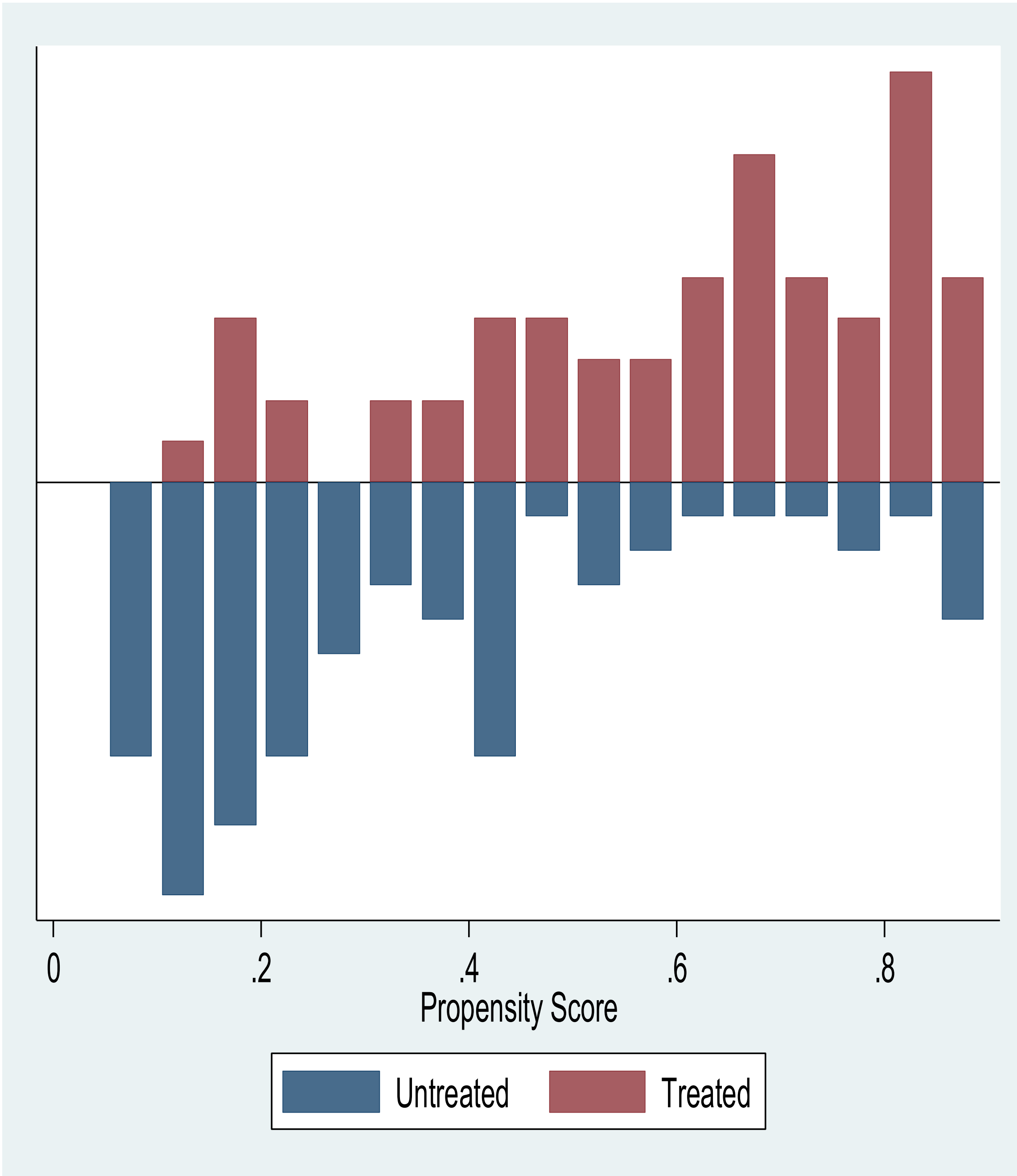

Figure 4: Propensity score distribution of matched sample
Source: own computation based data (2017)

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

This study compared the adopters and non-adopters differences achieved from wheat crop production through row planting methods. And it also identified factors that affected the local farmers in the study area on the application level of row planting in wheat crop production. Therefore, in this section summarizes the major findings of the study and proposes recommendations for Planning and policy purpose. Policy makers and planners of the program who want to plan as well as policy make they can use row planting of wheat how it brings better change on household wheat crop yield, food consumption expenditure, agricultural input expenditure and income which means in this research it was found that households who adopt row planting of wheat are better off in wheat crop yields, income, food consumption expenditure and agricultural input expenditure.

5.1. Conclusions

The need for applying modern agricultural technologies in Ethiopian agriculture is not doubtful. The agricultural sector of the country is well known for its being traditional and use of backward technologies. The destiny of the sector of increasing its contribution to the overall growth of the economy and securing food self-sufficiency depends on the development and adoption of appropriate technologies. Hence, new improved agricultural technologies such as row planting of wheat crop technology play a key role in enhancing agricultural yields, household food security and income.

In this study, we assessed the adoption of row planting of wheat technology and impact of row planting of wheat crop on farm household yields, food consumption expenditure, agricultural input expenditure and income. Both descriptive and econometrics methods were employed for data analysis. A propensity score matching approach was used to compare adopter households with non-adopters in terms of four key measure of household wellbeing; yields as measured by quintal and household food consumption expenditure, household agricultural input expenditure and income as measured by

Ethiopia Birr. The matching techniques employed were the nearest neighborhoods matching, radius matching, caliper matching, and kernel matching. Among the algorithms used nearest neighbor matching (2) was found to be the best estimator of data based on balancing test, pseudo R^2 and sample size. The results showed that row planting of wheat technology had significantly positive impact on farmers' yields, food consumption expenditure, agricultural input expenditure and income. In addition to that, factors such as; the age of households, education level households, family size, size of cultivated land, holding of livestock, use of credit services and extension services access were found to be important variables to affect farmers' tendency to adopt. The sensitivity analysis also showed that the estimates are almost free from unobserved covariates. Consequently, it can be concluded that the overall the results are remarkably robust and the analysis supports the robustness of the matching estimates.

The implication of the findings is straightforward; even if the adoption of row planting of wheat is quite low in Duna Woreda, those households who could use the technologies could improve their productivity, household food consumption expenditure, household agricultural input expenditure and household income. Therefore, it is used to scaling up the best wheat row planting technology and practices of the adopters to other farmers can be considered as one option to enhance farm yields, household income, household food consumption expenditure and household agricultural input expenditure in the study area while introducing new agricultural practices and technologies is another option.

5.2. Recommendations

Understanding the factors that influence or hinder adoption of agricultural technology is essential in planning and executing technology related programs for meeting the challenges of wheat production in our country. Therefore, to enhance row planting of wheat adoption by farmers, it's important for policy makers and planners of new technology to understand farmers need as well as their ability to adopt technology in order to come up with technology that will suit them. It is better to encourage row planting technology adoption because the results of this study signified that application of row planting of wheat increase substantially the yields, household food consumption expenditure, household agricultural input expenditure and household income of adopters.

Based on the results of this research, the following core points are presented as recommendations in order to improve the application level and revenue gained from row planting technology in the process of wheat grain production.

Improved wheat production technology involves the use of different practices, which require knowledge, and skill of application and management. Education was found to have a strong relation with the adoption of row planting of wheat production technology as it enhances wheat crop yields, household food consumption expenditure, household agricultural input expenditure and household income. Therefore, due emphasis has to be given towards strengthening rural farmers education at different levels for small farm households using farmers training centers.

Increasing the number of cooperatives organization in the rural area in which the farmers will be able to get credit are basis in enhancing the adoption of row planting wheat technology. Further, it is apparent from the study that if farmers get credit more easily, they would use row planting technology to enhance wheat crop yields, household food consumption expenditure, household agricultural input expenditure and household income. Thus, the credit facility should target poor farmers especially those who were not adopting the row planting technology due to lack of operating capital. This may encourage the farmers to do commercial farming practice in which they can build their asset to implement the adoption of row planting of wheat technology on their farms.

The agricultural research and extension activities need to consider additional modern agronomic practices. Extension services crucial activities in agricultural sector to improve participation of row planting of wheat technology, through which induce farm wheat crop yields, household food consumption expenditure, household agricultural input expenditure and household income. A significant proportion of farmers had no formal education; the extension program should be targeted to the less educated farmers for its effective delivery through special training, seminars, field demonstrations, and technical support should be facilitated to enhance the adoption rate of row planting wheat technology. The extension should contact farmers individually as well as in group to be awarded in terms of row planting of wheat is suitable to improve household food security and income.

The introduction of the above measures into the picture of technology adoption, therefore, could enhance the number of adopters and the cropped area under row planting technology. Hence, expansion in the level of technology adoption would consequently result in substantial wheat productivity, food security and income on a sustainable basis.

REFERENCE

Abate, B. (1989). Income Potential Assessment of Improved Wheat Varieties at Farm levels: 19 Proceedings of the Workshop on Problems and Prospects of Rural Development inEthiopia. Addis Ababa University, Addis Ababa. 41p.

Abdel-Aal E-SM, Sosulski FW, Hucl P. (1998). Origins, character- sticks and potentials of ancient wheat. Cereal Foods World 43, 708–715.

Abraham B, Araya H, Berhe T, Edwards S, Gujja B, Khadka R, Sen D, Koma Y, Sharif A, and Styger E. (2014). The system of crop intensification: Reports from the field on Improving agricultural production, food security, and resilience to climate change for multiple crops. Addis Ababa, Ethiopia.

Alemitu, m. (2011). Factors Affecting Adoption of Improved Haricot Bean Varieties and Associated Agronomic Practice in Dale Woreda, SNNPRS. MA Thesis a Hawassa University, Hawassa. 40p.

Alemu, T. (2014). Socio-economic and Institutional Factors Limiting Adoption of Wheat Row Planting in Ethiopia. Ethiopian Institute of Agricultural Research, Kulumsa Agricultural Research Center Asella, Ethiopia.

Almus, M. and D., Czarnitzki. (2003). The Effects of Public R&D Subsidies on Firms' Innovation Activities: The Case of Eastern Germany. *Journal of Business and Economic Statistics,* 21(2):, 226-2362.

Anderson, J. R. (2013). Rural extension services: World Bank Policy Research Working Paper, 2976, World Bank, Washington D.C. pp.18-24.

Angrist, J. D., and Imbens, G. W. (1995). Two-stage least squares estimates of average causal effects in models with variable treatment intensity. *Journal of the American Statistical Association,* 90(430), 431-442.

Arega B, Woldeamlak B, and Melanie N. (2013). Rural households' livelihood assets, strategies, and outcomes in drought-prone areas of the Amhara Region, Ethiopia: Case Study in Lay Gaint District.

Asres, K. (2003). The impact of incentive system on soil and water conservation activities in Ambasel Area, South Wollo, Ethiopia. M.Sc. Thesis Presented to the School of Graduate Studies of Alemaya University, Haromaya. 36p.

Astatke, A.M., Jabbar, M.A., Mohamed, Salem and T. Erkossa. (2002). Technical and Economic Performance of Animal-drawn Implements for Minimum Tillage: Experience on Vertisols in Ethiopia, 38(2).

ATA. (2013). Results of 2012 New Tef Technologies Demonstration Trials Draft Report VF. Addis Ababa, Ethiopia. 34p.

ATA. (2014). Results of 2013 New Tef Technologies Demonstration Trials Draft Report VF. Addis Ababa, Ethiopia. 20p.

ATA. (2012). Strengthening the tef value chain in Ethiopia. Ethiopian Agricultural Transformation Agency, Addis Ababa. 25p.

Augustine, L. and Mulugeta, M. (2005). Modeling Agricultural technology adoption using the software STATA, training manual presented at a training course organized by CIMMYTALP. Harare, Zimbabwe.

Baloch, A. W., A. M. Soomro, M. A. Javed, and M. Ahmed. (2002). Optimum plant density for high yield in rice (Oryza sativa L.). *Asian Journal of Plant Science,* 1(1):, 25 – 27.

Bandiera, O., and Rasul, I. (2010). Social Networks and Technology Adoption in Northern Mozambique. Discussion Paper Series, London, UK, Centre for Economic Policy Research CEPR, Pp, 20.

Becker, S. O., and A. Ichino. (2002). Estimation of Average Treatment Effects Based on Propensity Scores. *the Stata Journal,* 2(4), 358-377.

Behailu, T. (2009). The contribution of Wealth Status and Community Participation to Sustainability of Soil and Water Conservation Activities: The Case of Sigma Kebele, Soro Woreda, Hadiya Zone Shashemene: Adventist College.

Bekalu, Abebe and Tenaw, Workayehu. (2015). Effect of Method of Sowing on Yield and Yield Components of Tef. *Global Journal of Chemistry,* 2(1):, 2454-2490.

Belay, K. (2003). (2003). Agricultural extension in Ethiopia: The Case of participatory dem- onstration and training extension system. *Journal of Social Development in Africa; Ha- rare,* 18(1).

Berhane, H. (2009). The Impact of Agricultural Policies on Smallholder Innovation Capacities. MSc Thesis. 45p.

Berihun KH, Bihon KA, and Kibrom AW. (2014). Adoption and impact of agricultural technologies on Far Income: evidence from Southern Tigray, Northern Ethiopia. Int. J. Food Agric. Econ, 2(4):, 91-106.

Beyene, H. (2008). Adoption of Improved Tef and Wheat Production Technologies in Crop- Livestock Mixed System in Northern and Western Zones of Ethiopia. A Dissertation Presented to The University of Pretoria, South Africa.

Bola AA, Aliou D, and Omonona BT. (2012). The impact of improved agricultural technology adoption on sustainable Rice productivity and Rural Farmers‟‟ welfare in Nigeria: A local Average Treatment Effect (ATE) Technique.

Briggle and Curtis, B.C.A. (2002). Wheat in the world, 1-17. In Curtis, B.C., Rajaram, S., and MacPherson, H.G. (eds.) Bread wheat: Improvement and production. FAO, Rome Italy.

Bushuk, W. (1997). Wheat breeding for end-product use. (Wheat: prospects for global improvement. Proceedings of the 5th International Wheat Conference, Ankara, Turkey, 10-14 June 1996. ISBN 0-7923-4727-7.

Bwire, J. (2008). Factors Affecting Adoption of Improved meat goat Production in Rangelands of Sembabule District. MSc Thesis, Kampala.

Caliendo M. and Kopeinig S. (2008). SOME PRACTICAL GUIDANCE FOR THE IMPLEMENTATION OF PROPENSITY SCORE MATCHING pp. *Journal of Economic Surveys,* Vol. 22, No. 1, 3172.

Chatterjjee, B. N and S. Maiti. (1985). Principles and Practices of Rice Growing. 2nd ed. Oxford and 1BH Publishing Co New Delhi. 226p.

Chauhan, H.S, S.K.A, Anuruddhika, S.W., Manoja, D.K., Sakinda, and B.W. Upali. (2014). Effect of rice establishment methods on weedy rice infestation and grain yield of cultivated rice (O. Sativa L.) In Sri Lanka Crop Prot.55.

Christiaensen, L, L. Demery, & J. Kuhl. (2011). The (evolving) Role of Agriculture in Poverty reduction an Empirical Perspective. *Journal of Development Economics,* 296 (2):, 239–254.

CIMMYT. (2011). Wheat –Global alliance for improving food security and the livelihoods of the Resource-poor in the developing world. Proposal submitted by CIMMYT and ICARDA to the CGIAR Consortium Board. August 30, 2011.

Cramer, J. S. (2003). The origins and development of the logit model. In J. S. Cramer (Ed.), Logitmodels from economics and other fields (pp. 149–158). Cambridge, England: CambridgeUniversity Press.

CSA (Central Statistical Agency). (2007). Central Statistical Agency of Ethiopia.Demographic and Health survey; Addis Ababa.

CSA (Central Statistical Agency). (2013). Agricultural sample survey: area and production of major Crops, meher season.Vol.1.Addis Ababa, Ethiopia.

Dasgupta, S. (1989). Diffusion of Agricultural Innovations in Village India, Department of Sociology and Anthropology, University of Prince Edward Island, Canada.

David, P. (2011). "Using Propensity Scores to Adjust for Group Differences." San Francisco.

Debela. (2011). The impact of agricultural technology on farm production: the case of Beressa and Umbrello Watersheds.

Debelo, D. (2015). Analysis of Factors Influencing Adoption of Concho Tef: The Case of Wayne Tuqa District. Wayu Tuka District Agricultural Growth Program

Monitoring and Evaluation Expert, Ethiopia. *International Journal of African and Asian Studies*, 2409-6938.

Debelo, D. (2015). Does Adoption of Quncho Tef Increases Farmers' Crops Income? . *Journal of Economics and Sustainable Development,* 6(17): , 2222-2855.

Dehejia, R., and Wahba. S. (2002). Propensity score matching Methods for Nonexperimental Causal Studies. The Review of Economic and Statistics 84(1): 151-161.

DWFEDs. (2012). Duna Woreda Finance and economic Development sector report. Unpublished.

DWFEDs. (2013 and 2015). Duna Woreda Finance and Economic Development sector report. Unpublished.

Ejegayehu Yifter and Berhe Gebregewergs. (2016). Effect of wheat row planting technology adoption on small farms yields in Ofla Woreda, Ethiopia. *International Journal of Agricultural Extension and Rural Development* ISSN 3254-5428 Vol. 3 (5), pp. 184-196.

FAO (Food and Agriculture Organization of the United Nations). (2014a). "Food Balance Sheets."Rome, Italy. Accessed on July 2014 and retrieved from http://faostat. fao.org/site/368/Desktop Default.aspx? PageID=368#ancor.

FAO. (2010). Food and Agriculture Organization. Crop production. Available from:http://faostat.fao.org/ site/567/default.aspx#ancor. (Accessed 20120103).

FAO. (2009). How to feed the world in 2050. (www.fao.org/fileadmin/templates/wsfs/docs/ expert paper /Howto feed the World in 2050.

FAO. (2014). Voluntary Guidelines on Flag State Performance. In: FAO Fisheries and Aquaculture Department. Rome. [Cited 8 May 2016].

Feder, L., R.E.,Just and O., Zilberman, (1985). Adoption of Agricultural Innovation in Developing Countries: A survey.

Fufa, B., B. Behute, R. Simons, and T. Berhe. (2011). "Tef Diagnostic Report: Strengthening the Tef Value Chain in Ethiopia". Addis Ababa, Ethiopia.

Gashaw T, Alan B, Nicholas M, and Tanguy B. (2014). The impact of the use of new technologies on farmers wheat yield in Ethiopia. International Food Policy Research Institute (IFPRI). Washington.

Gertler and Schargrodsky. (2005). "The Benefits and Costs of Privatization in Argentina: A Microeconomic Analysis." In Privatization in Latin America—Myths and Reality, edited by Alberto Chong and Florencio Lopez-de-Silanes Stanford, CA: Stanford Univ.Press.

Getahun D, and W.a. (2000). An Assessment of the Adoption of Seed and Fertilizer Pack- ages and the Role Credit in Smallholder Maize Production in Sidama and North Omo Zone, Ethiopia. Mexico, D.F.; International Maize and Wheat Improvement Cen- her.

Greene, W. (2012). Econometric analysis 7th edition. USA, Pearson education Inc, pp.40-45.

Grilli, Leonardo, and Carla Rampichini. (2011). Propensity scores for the estimation of average treatment effects in observational studies.46P.

Gujarati, D. (2003). Basic Econometrics. 4th Edition. McGraw-Hill, New York. pp. 563-636.

HZPEDD, (2001). report of Hadiya Zone planning and Economic Development Department unpublished .

Hailu. (1991). Wheat production and research in Ethiopia.IPR, Addis Ababa.

Halcraw, H. (1984). Agricultural Policy Analysis, McGraw Hill Inc., USA .Pp.12-24.

Hattam, C. (2006). Adopting Organic Agriculture: An Investigation Using the Theory of Planned Behaviour. Gold Coast, Australia, Caroline Hattam.

Heckman, J. and Smith, J. (1999). The Pre-Program Earnings dip and the determinate of participation in a social program: implications for simple program evaluation strategies. Economic Journal, 109 (457):, 313-348.

Heckman, J., H. Ichimura, J. Smith, and P. Todd. (1998). Characterizing Selection Bias Using Experimental Data, Econometric a, 66: 1017-1098.

Heun M, Scha ¨fer-Pregl R, Klawan D, Castagna R, Accerbi M, Borghi B, Salamini F. (1997). The site of einkorn wheat domestication identified by DNA fingerprinting. Science 278, 1312–1314.

Hunt, J. G. (1999). Transformational/charismatic leadership's transformation of the field: A Historical essay. The Leadership Quarterly, 10(2), 129-144 Doi: 10.1016/S1048-9843 (99)00015-6.

HZPEDs. (2001). Hadiya Zone Planning and Economic Development sector report. Unpublished.

Ibrahim, K. (2013). Constraints to agricultural technology adoption in Uganda: Evidence from the 2005 / 06-2009/10 Uganda National Panel Survey.

ILO. (2004). Resolution 1: Resolution Concerning Household Income and Expenditure Statistics, adopted at the17th International Conference of Labor Statisticians, December. Geneva.

Jalan, J., and Ravallion, M. (2003). Estimating the benefit incidence of an antipoverty program by propensity score matching. *Journal of Business and Economics Statistics,* 21(1), 19 -30.

Jirstrom M, Anderson A, and Djurfeldt G, (2011). Smallholders caught in poverty–flickering signs of agricultural dynamism. In African Smallholders: food crops, markets, and policy. (Eds Djurfeldt et al.) London: CABI. Chapter, 4:74-106.

Kassie, M., Zikhali, P., Manjur, K., and Edward, E. (2009). Adoption of sustainable agriculture practices: Evidence from a semi-arid region of Ethiopia. Natural Resources Forum, 39, 189- 98.

Kumar, P., Yadava, R.K., Gollen, B., Kumar, S., Verma, R.K. & Yadav, S. (2011). Nutritional Contents and Medicinal Properties of Wheat: A Review. Life Sciences and Medicine Research (22), 1-10. NBE, (2013), Annual Report, Addis Ababa, Ethiopia.

Lavy, V. (2002). Evaluating the Effect of Teachers' Group Performance Incentives on Pupil Achievement. *The Journal of Political Economy,* 110(6):, 1286-1317.

Lechner, M. (1999). Program Heterogeneity and Propensity-score matching: An Application to the Evaluation of Active Labor Market Policies. The Review of Economics and Statistics 84(2): 205-220.

Legesse Dadi, Burton, M., and Ozanne, A. (2001). Adoption and intensity of fertilizer and herbicide use in the central highlands of Ethiopia. Agrekon, 40 (3), 316-332.

Lulit M, Ermias E, and Zelalem H, (2012). Public investment in irrigation and training for agriculture-Led development: a CGE approach for Ethiopia. Addis Ababa, Ethiopia.

Mamudu AA, Emelia G, and Samuel KD. (2012). Adoption of modern agricultural production technologies by farm households in Ghana: What factors influence their decisions? J. Biol. Agric. Healthcare 2(3).

MEDAC. (1999). Survey of the Ethiopian Economy Review of post-Reform Development (1992/93-1997). Addis Ababa, Ethiopia.

Mesfin, A. (2005). Analysis Of Factors Influencing Adoption Of Triticale and its impact. MSc Thesis.

Million, T. B. (2004). Determinants of Fertilizer Use in Gunung Area, Ethiopia. Proceedings of the workshop held to discuss the socio-economic research results of 1998-2002. August 6-8, 2002, Addis Ababa, Ethiopia. Pp 30. EARO, 2004.

MoA. (2010). Ministry of Agriculture.Animal and Plant Health Regulatory Directorate. Crop variety register IssueNo.13 Addis Ababa, Ethiopia.

MoA. (2011). Ministry of Agriculture. Animal and Plant Health Regulatory Directorate. Crop variety register Issue No. 14. Addis Ababa, Ethiopia.

MoA. (2012). Ministry of Agriculture. Animal and plant health regulatory Directorate. Crop variety register, Issue No.15. Addis Ababa, Ethiopia.

MOAD (Ministry of Agriculture). (2011). Agricultural Development Plans.Addis Ababa, Ethiopia, ARS Publications. 54 p.

MoFED. (2012). Ethiopian's progress towards eradicating poverty: An interim report on poverty analysis Study. Addis Ababa, Ethiopia.

Moser, C.M., and C. B. Barrett. (2006). The Complex Dynamics of Smallholder Technology Adoption: The Case of SRI in Madagascar. Agricultural Economics, 35(3): 373–388.

Mosher. (1966). Training Manual for Group Study of Getting Agriculture Moving. New York: Agricultural Development Council, 1966; Borton, Raymond E., editor, Case Studies to Accompany Getting Agriculture Moving. New York: Agricultural Development Council, 1967.

Nerlove. (1993). Spreadsheet-based sensitivity analysis calculations for matched samples. Center f or Health Care Research & Poli cy, Case Western Reserve University. Available online at http://www. chrp. org/prop ensit.

Nkonya, E., T. Schroeder and D. Norman, (1997). Factors affecting adoption of improved maize seed and fertilizer in North Tanzania. Indian j. Agri.econ. 48(1):1-12.

Pender, J., and Gebremedhin, B. (2007). Determinants of agricultural and land management practices and impacts on crop production and household income in the highlands of Tigray, Ethiopia. http://dx. doi.org/10.1093/jae/ejm028. *Journal of African Economies,* 17(3), 395-450.

Persson T. G. Tabellini and F. Tre bbi. (2003). Electoral Rules and Corruption. *Journal of the European Economic Association,* 1(4):, 958-989.

Posner, E. (2000). Wheat In: Kulp, K., et al. (Eds.) Handbook of cereal science and technology. pp. 1-99. Cop. New York: Marcel Dekker.

Rashid, S. (2010). Staple food prices in Ethiopia. Maputo, Mozambique.

Ravallion, M. (2005). Evaluating anti-poverty programs. World Bank Policy Research Paper No. 3625. Washington, D.C.: The World Bank.

Ray, G. (2001). Extension communication and management. Second Edition. Naya Prokash, Calcutta. pp.65-72.

Rosenbaum, P.R., and Rubin, D.B. (1983). The Central Role of the Propensity Score in Observational Studies for Causal Effects. Biometric, 70 (1): 41-55 .

Samuel Kiruku Ndungu1, Ibrahim Macharia2, Ruth Kahuthia-Gathu3 and Raphael Githaiga Wahome4. (2013). The impact of Organic Vegetable Production System in Kiambu and Kajiado Counties of Kenya. *Journal of Environmental Science and Engineering,* 256-266.

Sarah, M. (2014). IFPRI evaluates a new wheat package rollout in Ethiopia.

Setotaw Ferede, Gezahegn Ayele, And Hailemariam Teklewold. (2003). Impact Of Technology On Households Food Security In Tef And Wheat Farming Systems ofMoretna- Jiruworeda. Ethiopian Agricultural Research Organization (EARO), Research Report No.48.

Shewry, P. (2009). Wheat. Journal of Experimental Botany 60(6),. 1537-1553.

Shewry, P. (2007). Improving the protein content and composition of cereal grain. *Journal of Cereal Science,* 46(3), 239-250.

Shultz, T. (1964). Transforming Traditional Agriculture, Yale University Press, New Haven, USA.

Sianesi, B. (2004). An evaluation of the active labor market programs in Sweden Office of Labour Market Policy Evaluation (IFAU) working paper 2000:5.

Sianesi, B. (2004). An evaluation of the active labor market programs in Sweden Office of Labour Market Policy Evaluation (IFAU) working paper 2000:5.

Simmonds, D. (1989). Inherent Quality Factors in Wheat. In: Wheat and Wheat Quality in Australia.pp. 31-61. Melbourne: Australia Wheat Board.

Simtowe. (2011). Determinants of Agricultural Technology adoption: the Case of Improved Pigeon Pea Varieties in Tanzania.

Slafer, G.A. and E. H. Satorre. (1999). An introduction to the physiological – ecological analysis of wheat yield. In E. H. Satorre and G.A. Slafer (Eds.), Wheat: Ecology and phy- siology of yield determination, 3 - 12.

Smith, J., and P.Todd. (2005). Does matching overcome Lalonde's critique of nonexperimental estimators?. *Journal of Econometrics,* 125(1-2):, 305-353.

Solomon, A., Bekele, S., Franklin, S., and Hagos, M. (2011). Agricultural technology adoption, seed access constraints, and commercialization in Ethiopia. 3 (39). *Journal of Development and Agricultural Economics,* 436-447.

Storck, H., Berhanu Adenew, Bezabih Emana, Begander, R. and Getu Hailu. (1991). Management Strategies for Farming Systems in an Uncertain Environment and Approaches for their Improvement: Farming Systems and Resource Economics in Tropics, vol. 27, Wissenschaftsversg Vau Kiel KG, Germany.

Susan, C. (2011). "Technical and Allocative Efficiency of Smallholder maize farmers." MSc Thesis 2011Techane A., Mulat Demeke and Bezabih Emana.(2006). Determinants of fertilizer adop- on in Ethiopia. The case of major cereal producing areas. Agricultural society of Eth. - opia, Addis Ababa.

Techane A., Mulat Demeke and Bezabih Emana. (2006). Determinants of fertilizer adopt- on in Ethiopia. The case of major cereal producing areas. Agricultural society of Ethi- opia, Addis Ababa, Ethiopia.

Tolesa A, Bezabih E, Jema H, and Belaineh L. (2014). The impact of Wheat Row Planting on Yield of Smallholders in Selected Highland and Lowland Areas of Ethiopia. International Journal of Agriculture and Forestry 2014, 4(5):, 386-393.

Tolesa Alemu, Bezabih Emana, Jema Haji, and Belaineh Legesse. (2014). The impact of Wheat Row Planting on Yield of Smallholders in Arsi Zone of Ethiopia. *International Journal of Economics and Empirical Research,* 510-517.

Tsegaye, M.and Bekele, H. (2012). Impacts of Adoption of Improved Wheat Technologies on Household's‟ Food Consumption in Southeastern Ethiopia.Selected Poster prepared for Presentation at the International Association of Agricultural Economists (IAAE) Triennial Conference, Foz d Iguaçu, 18-24.

Van de Ban, and A. H. (1998). Agricultural Extension ((2nd Ed.) Ed.). The Netherlands: Blackwell Science.

Vandercasteenlen, J., Mekdim, D., Mintlen, B., and Alemayehu, S. (2013). The impact of the promotion of row planting on farmers' teff yields in Ethiopia. Ethiopia Strategy Support Program II, ESSP research note 27. International Food Policy Research Institute.

Vasil, I.K. and Vasil, V. (1999). Transgenic Cereals: Triticum aestivum (wheat). In: Vasil, I.K. (Ed.) Molecular Improvement of Cereal Crops. pp. 133- 147 Kluwer Academic Publishers.

World Bank (2008). Agriculture Development Report Agriculture for Development.The World Bank. Washington, DC, USA.

World Bank (2014). Ethiopia poverty Assessment. Document of the WB for official use only.

Yamane, T. (1967). Statistics, an Introductory Analysis, 2nd Ed., New York: Harper and Row.

Yonas, B. (2013). The Impact of Row Planting of Tef Crop on Rural Household Income.Master thesis, Mekelle University, Mekelle. 48p.

Yonas, B. (2013). The impact of row planting of teff crop on rural Household income: A case of Tahtay Maychew wereda, Tigrai, Ethiopia.

Yotopoulos, A. (1967). Allocate Efficiency in Economic Development: A Cross-Section Analysis of Epirus Farming, Center for Planning and Economic Research,18 Monograph Series, F. Constantinidus and C. Mehalas, Athens. pp.17-23.

APPENDICES

Appendix A: QUESTIONNAIRES

TITLE**: The ADOPTION AND IMPACT**

OF ROW PLANTING OF WHEAT CROP ON HOUSEHOLD

LIVELIHOOD, A CASE STUDY OF DUNA WOREDA, HADIYA ZONE, ETHIOPIA.

JIMMA UNIVERSITY

DEPARTMENT OF ECONOMICS,

ECONOMIC POLICY ANALYSIS MSc PROGRAM

Questionnaire

Questionnaire numbers………………….... Interviewer's…………………….

Date of interviews ……………………….... signature………………………...

Dear Respondents:

I, Negese Tamirat, am prospective graduate of Masters of science in Economic Police Analysis in Jimma University, College of Business and Economics, dealing Master's thesis. Therefore I would like to assure you that questionnaire is used only for the academic purposes. Thank you for your cooperation.

Instructions to Enumerators

1. Make a brief introduction to the respondent before starting the interview (greet them, tell your name, get her/his name, and make clear the purpose and objective of the study that you are undertaking).

2. Please ask the question clearly and patiently until the respondent understands.

3. During the process put the answers of each respondent both in the space provided and encircle the choice or tick mark as requiring

1: General information

1.1 Kebele………………………………………………………….

1.2 Village…………………………………………………………

1.3 Name of household head……………………………………….

1.4 Age of household head (in year)………………………………

1.5 Sex of household head……………………. Male=1 Female=0

1.6 Education level of household head (in year school), 1 for illiterates (0), 2 for primary (1-5), 3 for secondary (6-8) and 4 for tertiary (above grade 9).

II: Demography characteristics of household head

2: About family information

2.1 How many family members live in your home? In number……………………….

2.2 Are all they participating in household farm activity? 1= Yes, 0=No.

2.3 If No #2.2, how many are they participating in household farm activity? ....

2.4 Do you face labor shortage to practice row planting? 1=Yes, 0=No

2.5 If yes #2.4, how do you solve labor shortage problem

a) By hiring b) Asking for cooperation c) All d) Others (Specify)………………..

3: About both row planting and broadcast of wheat information

3.1 Did you have ever information about row planting of wheat the past time? 1=Yes 0=No

3.2 If Yes #3.1, where did you get that information?

a) Extension agents b) Friends and families c) Others (please specify)………………

3.3 Did you adopt row planting of wheat technology in the year 2008 E.C? 1= Yes, 0=No

3.4 If yes #3.3, what are impacts on wheat crop production?

a) Increased household income b) Reduce fertilizer consumption

c) Minimized seeding rates d) all e) other specify…………………………………..

3.5 If yes # 3.3, what was the area under row planted wheat? ....Ha

3.6 What was total the area under both rows planted and broadcast of wheat? .... Ha

3.7 If No #3.3, why did not adopt row planting of wheat technology?

i. It requires labor time ii. It takes time when plowing and sowing in line

iii. It is low productive than traditional sowing practices

iv. Other specify…………………………………………………………

3.8 Which method is more productive in sowing wheat?

a) Row planting b) Broadcasting c) others sowing method

3.9 How many you produced from each sowing methods?

Type of sowing	Cultivated land in a hectare	Seed used (quintal)	Used fertilizer (quintal)	Total Production (quintal)	Income from sales in Birr
Row planting wheat					
Broadcasting wheat					
Others sowing system					

3.10 Did you use an improved variety of wheat seed year 2008 E. C wheat cropping season? 1= Yes, 0= No.

3.11 If yes #3.10, do you which variety? a) Local b) improved c) Both

3.12 How do you perceive the effectiveness of row planting method of seeding on the improvement of Wheat crop production? 1=very good 2=good 3=poor 4=if other, specify ……………………………………………………………………………………..

3.13 Describe the benefits and drawbacks you have encountered on the application of row planting method on wheat seeding.

Advantages………………………………………………………………………………

Disadvantages…………………………………………………………………………..

3.14 Did you apply the broadcast method of wheat seeding? 1=yes 2=no

3.15 If yes #3.14, what was the reason? 1=easy to apply 2=to avoid risk of crop failure

3=to harvest large yield amount 4=low labor cost 5=suitable for my land 6=if other, specify…………………………………………………………………………………

3.16 Who conduct the work of sowing through a broadcast method? 1=any one in household 2=adult person in household 3=skilled person in household 4=other specify……………………

3.17 How do you describe the amount of wheat yield production through a broadcasting method? 1=high 2=moderate 3=low 4=other (specify)……………………………….

3.18 Did you get labor assistance from peoples, other than your family members? Fill table.

No	Practices		For wheat field covered by broadcasting		For wheat field covered by row planting		Cost (in birr)
			Number of persons Engage	Number of days	Numbers of persons	Numbers of days	
1	Preparation	1st					
		2nd					
		3rd					
2	Seeding						
3	Weeding	1st					
		2nd					
4	Harvesting						
5	Gathering						
6	Threshing						

4: About farm land size and productivity information

4.1How many hectare farm land do you have? ....

4.2 If do you have farm land, how did you get?

Type of farm land	Mark(x)	In hectare	Remark
1 by own land			
2 by rent			
3 by share (1/2)			
3 by gift			

4.3 Does farm land size increase as well as productivity of wheat increase? Yes, No.

4.4 If yes #4.3, how many quintals do you get per hectare? ……………………………

4.5 What was wheat crop income from agricultural products in 2008E.C?

Type of crops	Cultivated area in hectare	Production in Quintal	Income from sales in Birr
1 Cereal crop			
Wheat			
Teff			
Maize			
Sorghum			
Been			
Others			
2 Vegetables			
Onion			
Keysir			
Tomatoes			
Karote			
Potatoes			
Others			

5: About livestock holding

5.1 Do you have livestock's and their products? 1=Yes, 0=No.

5.2 If yes #5.1, how many do you have and get income from it, the year 2008 E.C?

Types of livestock		Total owned	Income from sales
Cattles'	Oxen		
	Cows		
	Heifer		
	Bull		
	Calve		
	Total		
Sheep and Goats	Goat		
	Sheep		
	Chicken		
	Total		
Marine	Mules		
	Horses		
	Donkey		
	Total		

5.3 What do you use to farming? Oxen or others specify………………………………

5.4 Do you have a change in your wheat productivity when the number of oxen increases? 1=Yes, 0=No.

5.5 If yes #5.4 how can it increase productivity wheat crop?

a) It uses to farming than others

b) It uses to cover of input cost wheat product due to price more than others.

6: Membership local organization and access to credit information

6.1 Are you member of any social institution? 1= Yes, 0= No

6.2. If your answer is yes to #6.1, in which social group?

a) Equp b) Edir c) Social network d) Other, specify…………………………………

6.3 Do you get credit access in your locality? 1=Yes 0= No

6.4 If yes #6.3, for what purpose do you use? a) For food consumption

b) For farm input consumption C) others specify…………………………………

7: About extension services information

7.1 Do you get enough service from extension agents? 1=Yes 0= No.

7.2 If yes #7.1, a) always b) sometimes C) unfortunately

8: About using recommended technology input information.

8.1 How did you use agricultural input for wheat crop productivity in 2008 E.C? Mark (x)

Types inputs		Fully user recommended amount (3	Half of use recommended amount (2)	None of the use recommended amount (1)
Fertilizer	DAP			
	UERA			
	Compose			
Improved wheat seed				
Chemical	Herbicide			
	Fungicide			
	Insecticide			
	Others			

Codes: 1= for non-user of recommended amount of inputs

2= for half user of recommended amount of inputs

3= for full user of recommended amount of inputs

8.2 If you did not apply fertilizer in wheat crop production, what is your reason?

Type of fertilizer not applied yet…………………………………………………

Reason for not applying……………………………………………………………

9: Non-farm activities

1. If you have non-farm activity, indicate and estimate your annual earnings from each source.

Sources of income	Amount of income (Birr)	
Wage of household head	Earnings per Month	Total earning of per Month
Self-employed in own business		
Pension		
Remittances		
Handcrafting		
Safety net program		
Petty trade (livestock, crop, vegetable, coffee)		
Milling		
From pottery and weaving		
Others		
Total		

10: Different expenditure of household

1. Household expenditure for the agricultural input to produce wheat crop year 2008E.C

Type of inputs	Quantity in quintal	Cost in Birr
wheat seed		
Fertilizers		
Pesticide		
Others		

2. Expenditure of household on food and Nonfood in year 2008 E.C.

Type of food	From their own agriculture products		From market		Total expenditure	
	Quantity	Price in Birr	Quantity	Price in Birr	Quantity	Price in Birr
Sorghum						
Wheat						
Teff						
Maize						

Beans						
Barley						
Vegetables						
Oilseeds						
Fruits						
Oil, meat						
animals products						
Drinks						
Nonfood expense						
Others						

Appendix - Table 22: logit and marginal result

. corr ageh sexh fsize edu clsize tlu usecrids rai afl exten
(obs=187)

	ageh	sexh	fsize	edu	clsize	tlu	usecrids	rai	afl	exten
ageh	1.0000									
sexh	0.0464	1.0000								
fsize	-0.1677	0.0890	1.0000							
edu	-0.1117	-0.0565	0.3748	1.0000						
clsize	-0.2079	0.0326	0.2894	0.3512	1.0000					
tlu	0.0422	0.1716	0.2476	0.2690	0.2450	1.0000				
usecrids	0.0770	0.0502	-0.0016	0.0721	0.0860	0.1168	1.0000			
rai	0.1426	0.0456	-0.0924	-0.1384	-0.1622	0.0091	0.1444	1.0000		
afl	0.1908	0.0059	0.0976	0.1242	0.1017	0.1346	0.0268	-0.0247	1.0000	
exten	-0.0584	-0.0160	0.0797	0.1610	0.2133	0.1623	0.3476	0.0866	0.2743	1.0000

. reg rpwh ageh fsize clsize tlu

Source	SS	df	MS
Model	12.063906	4	3.01597651
Residual	33.3823305	181	.184432765
Total	45.4462366	185	.245655333

Number of obs =	186
F(4, 181) =	16.35
Prob > F =	0.0000
R-squared =	0.2655
Adj R-squared =	0.2492
Root MSE =	.42946

rpwh	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
ageh	-.0078049	.002429	-3.21	0.002	-.0125976	-.0030122
fsize	.0678131	.0249415	2.72	0.007	.0185996	.1170267
clsize	.2553674	.0894653	2.85	0.005	.0788383	.4318965
tlu	.0382094	.0105902	3.61	0.000	.0173132	.0591057
_cons	-.5124255	.2842776	-1.80	0.073	-1.07335	.048499

. vif

Variable	VIF	1/VIF
clsize	1.17	0.856783
fsize	1.14	0.875191
tlu	1.11	0.898472
ageh	1.07	0.931311
Mean VIF	1.12	

```
. logit rpwh ageh sexh fsize edu clsize tlu usecrids rai afl exten,robust

Iteration 0:   log pseudolikelihood =  -127.6625
Iteration 1:   log pseudolikelihood = -85.407203
Iteration 2:   log pseudolikelihood = -85.039196
Iteration 3:   log pseudolikelihood = -85.037972
Iteration 4:   log pseudolikelihood = -85.037972

Logistic regression                               Number of obs   =        187
                                                  Wald chi2(10)   =      60.75
                                                  Prob > chi2     =     0.0000
Log pseudolikelihood = -85.037972                 Pseudo R2       =     0.3339
```

rpwh	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
ageh	-.0467232	.0156098	-2.99	0.003	-.0773179	-.0161285
sexh	.116301	.4559993	0.26	0.799	-.7774412	1.010043
fsize	.319241	.1512633	2.11	0.035	.0227703	.6157117
edu	.693629	.2711641	2.56	0.011	.1621571	1.225101
clsize	.9678345	.5360575	1.81	0.071	-.082819	2.018488
tlu	.1399694	.0716798	1.95	0.051	-.0005204	.2804592
usecrids	.9171961	.405024	2.26	0.024	.1233637	1.711028
rai	.5425498	.3887685	1.40	0.163	-.2194224	1.304522
afl	.1734129	.454173	0.38	0.703	-.7167499	1.063576
exten	1.046396	.384173	2.72	0.006	.2934311	1.799362
_cons	-6.696468	1.859443	-3.60	0.000	-10.34091	-3.052027

```
. logistic rpwh ageh sexh fsize edu clsize tlu usecrids rai afl exten,robust

Logistic regression                               Number of obs   =        187
                                                  Wald chi2(10)   =      60.75
                                                  Prob > chi2     =     0.0000
Log pseudolikelihood = -85.037972                 Pseudo R2       =     0.3339
```

rpwh	Odds Ratio	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
ageh	.9543515	.0148973	-2.99	0.003	.9255956	.9840008
sexh	1.123334	.5122395	0.26	0.799	.4595805	2.74572
fsize	1.376083	.2081509	2.11	0.035	1.023032	1.850973
edu	2.000964	.5425896	2.56	0.011	1.176045	3.40451
clsize	2.632238	1.411031	1.81	0.071	.9205178	7.526935
tlu	1.150239	.0824488	1.95	0.051	.9994797	1.323737
usecrids	2.502264	1.013477	2.26	0.024	1.131296	5.534651
rai	1.720388	.6688326	1.40	0.163	.8029825	3.685927
afl	1.189357	.5401739	0.38	0.703	.4883368	2.89671
exten	2.847372	1.093883	2.72	0.006	1.341021	6.045786
_cons	.0012353	.0022969	-3.60	0.000	.0000323	.047263

```
. mfx

Marginal effects after logit
      y  = Pr(rpwh) (predict)
         =  .39036247
```

variable	dy/dx	Std. Err.	z	P>|z|	[95% C.I.]		X
ageh	-.0111192	.00379	-2.94	0.003	-.018544	-.003695	56.8449
sexh*	.027526	.10717	0.26	0.797	-.182527	.237579	.700535
fsize	.0759728	.03596	2.11	0.035	.005492	.146454	5.41711
edu	.1650696	.06489	2.54	0.011	.037891	.292248	2.54011
clsize	.2303249	.1266	1.82	0.069	-.017801	.478451	2.38503
tlu	.0333099	.01708	1.95	0.051	-.000174	.066793	10.6642
usecrids*	.2149421	.09182	2.34	0.019	.034977	.394907	.502674
rai*	.1279105	.09114	1.40	0.160	-.050724	.306545	.534759
afl*	.0409221	.10635	0.38	0.700	-.167526	.24937	.700535
exten*	.236481	.08394	2.82	0.005	.071953	.401009	.631016

(*) dy/dx is for discrete change of dummy variable from 0 to 1

```
. estat gof, group(10)
```

Logistic model for rpwh, goodness-of-fit test

```
  (Table collapsed on quantiles of estimated probabilities)

       number of observations =       187
             number of groups =        10
      Hosmer-Lemeshow chi2(8) =         5.22
                  Prob > chi2 =         0.7337

. estat classification

Logistic model for rpwh
```

Classified	True D	True ~D	Total
+	59	17	76
-	21	90	111
Total	80	107	187

Classified + if predicted Pr(D) >= .5
True D defined as rpwh != 0

Sensitivity	Pr(+| D)	73.75%
Specificity	Pr(-|~D)	84.11%
Positive predictive value	Pr(D| +)	77.63%
Negative predictive value	Pr(~D| -)	81.08%
False + rate for true ~D	Pr(+|~D)	15.89%
False - rate for true D	Pr(-| D)	26.25%
False + rate for classified +	Pr(~D| +)	22.37%
False - rate for classified -	Pr(D| -)	18.92%
Correctly classified		79.68%

.

Appendix- Table 23: participation income

```
. tab rpwh,sum( inch)
```

RPWH	Summary of INCH Mean	Std. Dev.	Freq.
0	7704.8598	693.59654	107
1	14030	9632.1902	80
Total	10410.802	7037.4944	187

```
. *summary of ps
.
. sum  _pscore ,detail
```

psmatch2: Propensity Score

	Percentiles	Smallest		
1%	.0194508	.0185059		
5%	.0302465	.0194508		
10%	.0477313	.0222954	Obs	187
25%	.1167812	.024231	Sum of Wgt.	187
50%	.3846597		Mean	.4239539
		Largest	Std. Dev.	.3119892
75%	.7156807	.9487506		
90%	.8808181	.9494905	Variance	.0973372
95%	.930891	.9501667	Skewness	.260914
99%	.9501667	.9819809	Kurtosis	1.627901

Appendix - Table 24: summary of propensity score of participation

```
. sum  _pscore if  rpwh==1
```

Variable	Obs	Mean	Std. Dev.	Min	Max
_pscore	80	.6504626	.2409041	.0513547	.9819809

```
. sum  _pscore if  rpwh==0
```

Variable	Obs	Mean	Std. Dev.	Min	Max
_pscore	107	.2546016	.2446928	.0185059	.9486339

Appendix- Table 25: result of ATT using propensity score matching

```
. psmatch2  ($ylist $xlist), outcome(inch) neighbor(1) common  logit
```

Variable	Sample	Treated	Controls	Difference	S.E.	T-stat
inch	Unmatched	13967.0886	7704.85981	6262.22879	937.883871	6.68
	ATT	13967.0886	7935.94937	6031.13924	1097.7794	5.49

Note: S.E. does not take into account that the propensity score is estimated.

psmatch2: Treatment assignment	psmatch2: Common support On suppor	Total
Untreated	107	107
Treated	79	79
Total	186	186

```
. psmatch2 ($ylist $xlist), outcome(inch) neighbor(2) common logit
```

Variable	Sample	Treated	Controls	Difference	S.E.	T-stat
inch	Unmatched	13967.0886	7704.85981	6262.22879	937.883871	6.68
	ATT	13967.0886	7887.53165	6079.55696	1096.37439	5.55

Note: S.E. does not take into account that the propensity score is estimated.

psmatch2: Treatment assignment	psmatch2: Common support On suppor	Total
Untreated	107	107
Treated	79	79
Total	186	186

```
. psmatch2 ($ylist $xlist), outcome(inch) neighbor(3) common logit
```

Variable	Sample	Treated	Controls	Difference	S.E.	T-stat
inch	Unmatched	13967.0886	7704.85981	6262.22879	937.883871	6.68
	ATT	13967.0886	7903.88186	6063.20675	1096.20786	5.53

Note: S.E. does not take into account that the propensity score is estimated.

psmatch2: Treatment assignment	psmatch2: Common support On suppor	Total
Untreated	107	107
Treated	79	79
Total	186	186

```
. psmatch2 ($ylist $xlist), outcome(inch) neighbor(4) common logit
```

Variable	Sample	Treated	Controls	Difference	S.E.	T-stat
inch	Unmatched	13967.0886	7704.85981	6262.22879	937.883871	6.68
	ATT	13967.0886	7854.05063	6113.03797	1095.83011	5.58

Note: S.E. does not take into account that the propensity score is estimated.

psmatch2: Treatment assignment	psmatch2: Common support On suppor	Total
Untreated	107	107
Treated	79	79
Total	186	186

```
. psmatch2 ($ylist $xlist), outcome(inch) neighbor(5) common logit
```

Variable	Sample	Treated	Controls	Difference	S.E.	T-stat
inch	Unmatched	13967.0886	7704.85981	6262.22879	937.883871	6.68
	ATT	13967.0886	7828.17722	6138.91139	1095.62773	5.60

Note: S.E. does not take into account that the propensity score is estimated.

psmatch2: Treatment assignment	psmatch2: Common support On suppor	Total
Untreated	107	107
Treated	79	79
Total	186	186

. psmatch2 ($ylist $xlist), kernel outcome(inch)bwidth(0.1)common logit

Variable	Sample	Treated	Controls	Difference	S.E.	T-stat
inch	Unmatched	13967.0886	7704.85981	6262.22879	937.883871	6.68
	ATT	13967.0886	7857.11979	6109.96882	1096.98269	5.57

Note: S.E. does not take into account that the propensity score is estimated.

psmatch2: Treatment assignment	psmatch2: Common support On suppor	Total
Untreated	107	107
Treated	79	79
Total	186	186

. psmatch2 ($ylist $xlist), kernel outcome(inch)bwidth(0.25)common logit

Variable	Sample	Treated	Controls	Difference	S.E.	T-stat
inch	Unmatched	13967.0886	7704.85981	6262.22879	937.883871	6.68
	ATT	13967.0886	7825.70985	6141.37875	1096.04005	5.60

Note: S.E. does not take into account that the propensity score is estimated.

psmatch2: Treatment assignment	psmatch2: Common support On suppor	Total
Untreated	107	107
Treated	79	79
Total	186	186

```
. psmatch2 ($ylist $xlist), kernel outcome(inch)bwidth(0.5)common  logit
```

Variable	Sample	Treated	Controls	Difference	S.E.	T-stat
inch	Unmatched	13967.0886	7704.85981	6262.22879	937.883871	6.68
	ATT	13967.0886	7765.62977	6201.45884	1093.39002	5.67

Note: S.E. does not take into account that the propensity score is estimated.

psmatch2: Treatment assignment	psmatch2: Common support On suppor	Total
Untreated	107	107
Treated	79	79
Total	186	186

```
. psmatch2 ($ylist $xlist), radius bw(0.01) outcome(inch) common  logit
```

Variable	Sample	Treated	Controls	Difference	S.E.	T-stat
inch	Unmatched	13967.0886	7704.85981	6262.22879	937.883871	6.68
	ATT	13967.0886	7704.85981	6262.22879	1089.45127	5.75

Note: S.E. does not take into account that the propensity score is estimated.

psmatch2: Treatment assignment	psmatch2: Common support On suppor	Total
Untreated	107	107
Treated	79	79
Total	186	186

```
. psmatch2 ($ylist $xlist), radius bw(0.1) outcome(inch) common  logit
```

Variable	Sample	Treated	Controls	Difference	S.E.	T-stat
inch	Unmatched	13967.0886	7704.85981	6262.22879	937.883871	6.68
	ATT	13967.0886	7704.85981	6262.22879	1089.45127	5.75

Note: S.E. does not take into account that the propensity score is estimated.

psmatch2: Treatment assignment	psmatch2: Common support On suppor	Total
Untreated	107	107
Treated	79	79
Total	186	186

```
. psmatch2 ($ylist $xlist), radius bw(0.25) outcome(inch) common  logit
```

Variable	Sample	Treated	Controls	Difference	S.E.	T-stat
inch	Unmatched	13967.0886	7704.85981	6262.22879	937.883871	6.68
	ATT	13967.0886	7704.85981	6262.22879	1089.45127	5.75

Note: S.E. does not take into account that the propensity score is estimated.

psmatch2: Treatment assignment	psmatch2: Common support On suppor	Total
Untreated	107	107
Treated	79	79
Total	186	186

. psmatch2 ($ylist $xlist), caliper(0.1) outcome(inch) common logit

Variable	Sample	Treated	Controls	Difference	S.E.	T-stat
inch	Unmatched	13967.0886	7704.85981	6262.22879	937.883871	6.68
	ATT	13967.0886	7935.94937	6031.13924	1097.7794	5.49

Note: S.E. does not take into account that the propensity score is estimated.

psmatch2: Treatment assignment	psmatch2: Common support On suppor	Total
Untreated	107	107
Treated	79	79
Total	186	186

. psmatch2 ($ylist $xlist), caliper(0.25) outcome(inch) common logit

Variable	Sample	Treated	Controls	Difference	S.E.	T-stat
inch	Unmatched	13967.0886	7704.85981	6262.22879	937.883871	6.68
	ATT	13967.0886	7935.94937	6031.13924	1097.7794	5.49

Note: S.E. does not take into account that the propensity score is estimated.

psmatch2: Treatment assignment	psmatch2: Common support On suppor	Total
Untreated	107	107
Treated	79	79
Total	186	186

```
. psmatch2 ($ylist $xlist), caliper(0.5) outcome(inch) common  logit
```

Variable	Sample	Treated	Controls	Difference	S.E.	T-stat
inch	Unmatched	13967.0886	7704.85981	6262.22879	937.883871	6.68
	ATT	13967.0886	7935.94937	6031.13924	1097.7794	5.49

Note: S.E. does not take into account that the propensity score is estimated.

psmatch2: Treatment assignment	psmatch2: Common support On suppor	Total
Untreated	107	107
Treated	79	79
Total	186	186

Appendix – Table 26: propensity score matching test

.

```
. pstest   _pscore $xlist ,both sum
```

Variable	Unmatched Matched	Mean Treated	Mean Control	%bias	%reduct |bias|	t-test t	t-test p>|t|	V(T)/ V(C)
_pscore	U	.64589	.25463	161.8		10.89	0.000	0.96
	M	.64589	.64575	0.1	100.0	0.00	0.997	0.98
sexh	U	.72152	.68224	8.5		0.57	0.566	.
	M	.72152	.68354	8.3	3.3	0.52	0.604	.
ageh	U	52.684	60.019	-56.1		-3.80	0.000	1.18
	M	52.684	53.886	-9.2	83.6	-0.59	0.553	1.35
edu	U	2.8734	2.2804	82.7		5.58	0.000	1.03
	M	2.8734	2.8734	0.0	100.0	0.00	1.000	1.11
clsize	U	2.538	2.2687	75.3		5.07	0.000	0.98
	M	2.538	2.5032	9.7	87.1	0.70	0.488	1.78*
fsize	U	5.9241	5.0187	68.6		4.77	0.000	2.30*
	M	5.9241	5.7468	13.4	80.4	0.81	0.420	1.77*
tlu	U	11.809	9.7664	67.4		4.61	0.000	1.48
	M	11.809	12.17	-11.9	82.3	-0.80	0.426	2.13*
usecrids	U	.64557	.39252	52.1		3.50	0.001	.
	M	.64557	.65823	-2.6	95.0	-0.17	0.868	.
rai	U	.56962	.51402	11.1		0.75	0.455	.
	M	.56962	.56962	0.0	100.0	0.00	1.000	.
afl	U	.74684	.66355	18.2		1.22	0.223	.
	M	.74684	.8481	-22.2	-21.6	-1.59	0.115	.
exten	U	.82278	.48598	75.3		4.98	0.000	.
	M	.82278	.89873	-17.0	77.4	-1.38	0.170	.

* if variance ratio outside [0.64; 1.56] for U and [0.64; 1.56] for M

Sample	Ps R2	LR chi2	p>chi2	MeanBias	MedBias	B	R	%Var
Unmatched	0.330	83.61	0.000	61.5	67.4	160.2*	0.77	17
Matched	0.035	7.69	0.741	8.6	9.2	44.5*	3.16*	50

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

Table 27: Propensity score, nearest neighbor matching, radius matching, caliper matching, and kernel matching results

Outcome variables	Algorithms		Number of Adopter	Number of non Adopter	ATT	BSE	t-value
wheat product (in quintal)	NNM Neighbor	1	79	107	4.86	0.904	5.38
		2	79	107	**4.93**	0.887	5.56
		3	79	107	4.96	0.879	5.64
		4	79	107	4.69	0.875	5.37
		5	79	107	4.58	0.874	5.24
	KM bwidth	0.1	79	107	4.72	0.867	5.44
		0.25	79	107	4.61	0.856	5.38
		0.5	79	107	4.42	0.824	5.37
	RM radius	0.01	79	107	4.33	0.774	5.59
		0.1	79	107	4.33	0.774	5.59
		0.25	79	107	4.33	0.774	5.59
	Caliper	0.1	79	107	4.86	0.904	5.38
		0.25	79	107	4.86	0.904	5.38
		0.5	79	107	4.86	0.904	5.38
	Where BSE=Bootstrapped standard errors with 100 replications, ATT = average treatment effect on the treated, NNM = nearest neighbor matching, KM = kernel matching , RM = radius matching.						

Source: Own computation based on data (2017)

Table 28: Propensity score, nearest neighbor matching, radius matching, caliper matching, and kernel matching results

Outcome variables	Algorithms		Number of Adopter	Number of non Adopter	ATT	BSE	t-value
Income of wheat product	NNM Neighbor	1	79	107	6031.14	1097.78	5.49
		2	79	107	**6079.56**	1096.37	5.55
		3	79	107	6063.20	1096.20	5.53
		4	79	107	6113.04	1095.83	5.58
		5	79	107	6138.91	1095.63	5.60
	KM bwidth	0.1	79	107	6109.97	1096.98	5.57
		0.25	79	107	6141.38	1096.04	5.60
		0.5	79	107	6201.46	1093.39	5.67
	RM radius	0.01	79	107	6262.23	1089.45	5.75
		0.1	79	107	6262.23	1089.45	5.75
		0.25	79	107	6262.23	1089.45	5.75
	Caliper	0.1	79	107	6031.14	1097.78	5.49
		0.25	79	107	6031.14	1097.78	5.49
		0.5	79	107	6031.14	1097.78	5.49
	Where BSE=Bootstrapped standard errors with 100 replications, ATT = average treatment effect on the treated, NNM = nearest neighbor matching, KM = kernel matching , RM = radius matching, ETB = Ethiopian Birr.						

Source: Own computation based on data (2017)

Table 29: Propensity score, nearest neighbor matching, radius matching, caliper matching, and kernel matching results

Outcome variables	Algorithms		Number of Adopter	Number of non Adopter	ATT	BSE	t-value
Food consumption expenditure of wheat product	NNM Neighbor	1	79	107	5202.02	1501.04	3.47
		2	79	107	**5244.75**	1496.89	3.50
		3	79	107	5164.05	1495.60	3.45
		4	79	107	5188.04	1493.33	3.47
		5	79	107	5120.94	1492.18	3.43
	KM bwidth	0.1	79	107	5205.08	1492.41	3.49
		0.25	79	107	5153.71	1490.50	3.46
		0.5	79	107	5247.99	1485.12	3.53
	RM radius	0.01	79	107	5507.57	1477.12	3.73
		0.1	79	107	5507.57	1477.12	3.73
		0.25	79	107	5507.57	1477.12	3.73
	Caliper	0.1	79	107	5202.02	1501.04	3.47
		0.25	79	107	5202.02	1501.04	3.47
		0.5	79	107	5202.02	1501.04	3.47
	Where BSE=Bootstrapped standard errors with 100 replications, ATT = average treatment effect on the treated, NNM = nearest neighbor matching, KM = kernel matching , RM = radius matching, ETB = Ethiopian Birr.						

Source: Own computation based on data (2017)

Table 30: Propensity score, nearest neighbor matching, radius matching, caliper matching, and kernel matching results

Outcome variables	Algorithms		Number of Adopter	Number of non Adopter	ATT	BSE	t-value
Agricultural imput expenditure of wheat product	NNM Neighbor	1	79	107	4364.05	1430.98	3.05
		2	79	107	**4486.52**	1423.62	3.15
		3	79	107	4420.17	1420.29	3.11
		4	79	107	4479.49	1416.80	3.16
		5	79	107	4398.66	1415.54	3.11
	KM bwidth	0.1	79	107	4459.80	1416.15	3.15
		0.25	79	107	4380.49	1413.73	3.10
		0.5	79	107	1500.12	1406.92	3.20
	RM radius	0.01	79	107	4693.26	1396.75	3.36
		0.1	79	107	4693.26	1396.75	3.36
		0.25	79	107	4693.26	1396.75	3.36
	Caliper	0.1	79	107	4364.05	1430.98	3.05
		0.25	79	107	4364.05	1430.98	3.05
		0.5	79	107	4364.05	1430.98	3.05
	Where BSE=Bootstrapped standard errors with 100 replications, ATT = average treatment effect on the treated, NNM = nearest neighbor matching, KM = kernel matching , RM = radius matching, ETB = Ethiopian Birr.						

Source: Own computation based on data (2017)

Appendix – Table 31: conversion estimation of livestock

Livestock categories	TLU
Ox and Cow	1.00
Horse(adult	1.10
Horse (young)	0.75
Camel	1.25
Heifer	0.75
Goat and Sheep (adult)	0.13
Goat and Sheep (young)	0.06
Calf	0.25
Donkey (adult)	0.70
Donkey (young)	0.35
Chicken	0.013

Source: (Storck et al., 1991)