DETERMINANTS OF IMPROVED TEFF VARIETY (QUNCHO) ADOPTION AND ITS IMPACT ON PRODUCTIVITY: THE CASE OF KIRAMU DISTRICT, OROMIA REGIONAL STATE, ETHIOPIA

MSC THESIS

TEMESGEN OLANI

AUGUST, 2020

JIMMA, ETHIOPIA

DETERMINANTS OF IMPROVED TEFF VARIETY (QUNCHO) ADOPTION AND ITS IMPACT ON PRODUCTIVITY: THE CASE OF KIRAMU DISTRICT, OROMIA REGIONAL STATE, ETHIOPIA

By

Temesgen Olani

MSc Thesis

Submitted to Jimma University College of Agriculture and Veterinary Medicine, Department of Agricultural Economics and Agribusiness Management, in partial fulfillment of the requirements for the Masters of Science Degree in Agricultural Economics

August, 2020

Jimma, Ethiopia

DEDICATION

I dedicated this thesis manuscript to my lovely mother Mijane Wirtu, my father Olani Abdisa, and Jamara Olani, Chuche Olani and miss Derartu Getu and for all my family .

STATEMENT OF THE AUTHOR

I declare that this thesis, determinant of improved teff variety (quncho) adoption and its impact on productivity in Kiramu district, Oromia Regional State Ethiopia, is the outcome of my own work and all sources of materials used for this thesis have been duly acknowledged. This thesis has been submitted in partial fulfillment of the requirements for MSc. degree at Jimma University and is deposited at the University Library to be available to borrowers under rules of the library. I solemnly declare that this thesis is not submitted to any other institutions anywhere for the award of any academic degree, diploma, or certificate. Brief quotations from this thesis are allowable without special permission provided that accurate acknowledgement of the source is made. Requests of permission for extended quotation from or reproduction of this manuscript in whole or part may be granted by the head Department of Agricultural Economics or the Dean of the School of Graduate Studies when in his/her judgment the proposed use of the material is in the interest of scholarship. In all other instances, however, permission must be obtained from the author.

Name: Temesgen Olani Signature: ________

Place: Jimma University, Jimma. Date of submission: June, 10/ 2020

BIOGRAPHICAL SKETCH

The author was born on April 18, 1994 in Bagin Kebele, Kiramu district, East Wollega Zone, Oromia National Regional State, Ethiopia. He attended Grade (1-10) at Agemsa elementary and high school. Then after, he attended preparatory (11-12) at Gida Ayana Senior Secondary School from September 2010 to June 2012. After he successfully passed EGSEC (Ethiopian General Secondary Education Certificate) he joined Mettu University, Gambella Faculty of Agriculture and Natural Resource Management in November, 2012 and he graduated with BSc in Agricultural Economics on July 12, 2015. In February 2016 he had employed in East Wollega Zone, Wayu Tuka Woreda as Trade and Market development office till he employed to Mettu University, Bedele College of Agriculture and Forestry in November, 2017. He served as assistance graduate until he joined Jimma University on October 24, 2018 to pursue MSc. degree in Agricultural Economics program.

ACKNOWLEDGMENT

Before everything, i would like to praise and give great appreciation for Almighty God who has been my ability in all downs and ups of my life. The first gratitude goes to my major advisor Dr. Admassu Tesso for his constructive comments and he was always motivated me to strive to do more, without him the accomplishment of this research would have been difficult, and my appreciation goes to my co- advisor Mr. Haile Mariam Legesse for his advice and suggestion on my data collection, entering and analyzing of this thesis manuscript.

My deepest gratitude goes to my mother Mijane Wirtu and my father Olani Abdisa and all my brothers and sisters for paying and assisting me in conducting this study. Also my appreciation extends to all JUCAVM stuffs, especially the department of Agricultural economics and Agribusiness management and all my friends: Mr. Amanuel Birhanu, Efrem Asfaw, Bikila Tesfa, Abera Jaleta, Miss Derartu Getu and all my beloved classmates and lovely friends for shared their views at different stages of the paper and who gave me their time to hear my problems and afforded me valuable data. At the last but not least, my indebtedness goes to Mettu University, Bedele College of Agriculture and Forestry for sponsoring and facilitating me on this difficult situation. Finally, i thanks all post graduate students, for you all academic life that we shared together and you are great respectable in my everyday life.

LIST OF ABBREVIATION

ATA	Agricultural Transformation Agency
CSA	Central Statistical Agency
DAs	Development Agents
DZARC	Debrezeit Agricultural Research Center
FAO	Food and Agriculture Organization
GTP	Growth Transformation Plan
HHs	Households
IFPRI	International Food Policy Research Institute
MoARD	Ministry of Agriculture and Rural Development
NGO	Non-Governmental Organization
PAs	Peasant Associations
TLU	Tropical Livestock Unit
UNDP	United Nations Development Program

TABLE OF CONTENTS

LIST OF TABLES

Page

LIST OF FIGURES

Page

APPENDIX TABLES

Page

DETERMINANTS OF IMPROVED TEFF VARIETY (QUNCHO) ADOPTION AND ITS IMPACT ON PRODUCTIVITY: THE CASE OF KIRAMU DISTRICT, OROMIA REGIONAL STATE, ETHIOPIA

ABSTRACT

This study was aimed at identifying the determinants of use intensity of improved teff variety (quncho) adoption, its status of adoption and examining its impacts on productivity in terms of output per hectare. Quantitative and qualitative data were collected from primary and secondary sources for this study. Multistage sampling techniques were employed to determine sample size in study area. Totally 327 households head were randomly selected from the three kebeles. Which consists 131 of them were adopters and 196 were non-adopters of improved teff variety (quncho). Both descriptive and inferential statistics were employed for the data analysis. Tobit model was used to identify the determinants of use intensity improved teff variety (quncho), propensity Score Matching (PSM) technique was used to examine impact of adoption of improved teff(quncho) variety on farm productivity. The results of the Tobit model showed age of the household head, off/non-farm income, number of livestock size, land certificate, protestant and access to training have positive and significant influence on use intensity of improved teff(quncho) variety adoption. On the other hand, dependency ratio, Orthodox and Muslim have negative influence on use intensity of improved teff variety (quncho) adoption. The propensity Score Matching result indicates that teff productivity of adopter households is 859.24 kg/ha *of higher than non-adopters and the result is statistically significant. Therefore, collective actions of government agents, agricultural experts, NGOs and seed providers advised to work together on the way of expanding new technologies in rural communities and aware farm households about the potential benefits of those technologies and sustain their positive impact on productivity.*

Key words: Adoption, Tobit model, Impact Analysis, Improved teff variety (quncho), Productivity, propensity score matching

1. INTRODUCTION

1.1 Back Ground of the Study

Agricultural growth is essential for increasing economic development and feeding growing populations in fewer developing countries (Mendola, 2007). For fostering agricultural growth, productivity improving crop technology can be an option for rural farmers to get rid of hunger and food insecurity by increasing agricultural production (Ghimire *et al.,* 2015). Promoting and developing the adoption of yield increasing crop varieties in a sustainable manner is a crucial role to improve the rural farmers' lively hood (Asfaw *et al.,* 2012). According to Global Agricultural Productivity Index (2018) report, global agricultural productivity growth is not accelerating fast enough to sustainably meet the food, feed, fiber and fuel needs of nearly 10 billion people in 2050. The highest demand growth for many agricultural products is coming from regions with high rates of population growth and low rates of agricultural productivity, particularly in sub-Saharan Africa.

In Ethiopia, agriculture has proven to be the backbone of its economy for millennia (Lefort, 2012). The share of agriculture in Ethiopia's gross domestic product was 31.19 percent, industry contributed approximately 27.26 percent and the services sector contributed about 36.52 percent in 2018 (UNDP, 2018). But, low productivity growth and food insecurity remains a significant issue in the country (World Bank, 2011). Recently, Ethiopian Government set a clear agricultural production and productivity development policy to tackle the challenges and lift millions of smallholder farmers out of the food insecurity trap. Particularly, improving the production and productivity of major staple crops widely grown by poor smallholder farmers (Jaleta *et al.,* 2015).

For example Plan for Accelerated and Sustainable Development to End Poverty (PASDEP (2005/06-2009/10)); Growth and Transformation Plan I (GTP I (2010/11-2014/15)) and Growth and Transformation Plan II (GTP II (2015/16- 2019/20)), by having the objectives to increase the sector's productivity through promoting agricultural technologies and their enabling factors (i.e. Fertilizers, improved seeds, and better management practices, credit access and etc.) to reduce food insecurity, poverty and unemployment (Chipeta *et al.,* 2015).

Despite of these efforts in Ethiopia, productivity gains are not as such adequate in the country (Hailu *et al.,* 2014; Ahmed *et al.,* 2014). This is mainly due to severe weather fluctuation, inappropriate economic policies and low adoptions of improved agricultural technologies and prolonged civil unrest (Beshir *et al.,* 2012). Nevertheless, cereal crops accounts for a large proportion of the agricultural production in the country (Debela *et al.,* 2011). Teff was estimated that 24.17% or about 3.07 million hectares of land and its productivity 17.12% or 54 million quintals were produced among cereal crops of 81.39 % or more than 10 million hectares in 2018/2019 of the main season (CSA, 2019). In Ethiopia teff contributes up to 600 kcal/day in urban areas compared to only 200 kcal/day in rural areas (CSA, 2018).

According to Abraham (2015) teff is one of Ethiopia's indigenous crop which is important for providing food and livelihoods to many people. It is a daily food staple for about 60 % of the country's total population. Teff grain is mainly used for making *enjera*, a spongy flatbread, the main national dish in Ethiopia and Eritrea (Fufa *et al.,* 2011). It is also valued for its fine straw, which is used for animal feed as well as mixed with mud for building purposes (Tareke *et al*., 2011).

Teff is one of the major requirement crop productions in Ethiopia. However, its productivity is rather low. On average, teff yields were 17.48 quintals per hectare, compared to cereal crops such as maize which was approximately 39.44 and, wheat 27.36 quintals per hectare (CSA, 2018). This is because of low adoption of improved technologies among farm households (Admassie and Ayele, 2010). Hence, developing and achieving agricultural productivity requires disseminating yield increasing technologies at the accurate time with the affordable price (Doss, 2003; Alemu, 2019; Ahmed *et al.,* 2018; Minten and Berrett, 2008). Admassie and Ayele (2010) also states that one of the means by which farm level productivity can be increased is through the introduction and dissemination of improved agricultural technologies to farm households. Improved seed variety increases the yield potential of farm households (Etsehiwot, 2018).

Agricultural production like teff, maize and sorghum were highly produced in kiramu district. Moreover teff is a daily consumption in the district. According to Kiramu district agricultural and natural resource office report of 2019, improved teff varieties such as; Quncho (Dz-Cr-387 RIL355), Guduru, Kena, Dagim, and Boset was highly produced within rural farmers. Particularly Quncho (Dz-Cr-387) variety has become popular since five years in the study area. According to ATA (2012) quncho variety is one of the new crop varieties which are rapidly expanding to the most teff growing areas of the country with the genetic capacity of the crop's production more than 30 quintals or 3000 kilograms of yield per hectares of land, which is three times more than the local teff on research station. But, in a study area 1,853 Kilograms per hectare were obtained from on farm during the main season of 2019/2020. This indicates that the productivity of improved teff variety (quncho) on farm trial level is very low. This low productivity is due to low level of adoption of agricultural technologies (Mulatu *et al.*, 2005). So this study aims to address the impact of improved teff variety (quncho) adoption on rural households' teff productivity and identify major factors that affect use intensity of improved teff variety (quncho) adoption in study area.

1.2 Statement of the Problem

Ethiopia is one of the poorest and most food insecure countries in the world (World Bank, 2018). Food insecurity problem is associated with low performance of agricultural productivity (Ayenew and Kopainsky, 2014). In the last few years, Ethiopia has achieved significant progress in increasing agricultural production and productivity. However, much of the increase has come from area expansion rather than by wide-spread productivity growth and food insecurity remains a significant issue in the country (World Bank, 2011). This insufficient productivity is due to the use of lower yielding varieties tied with unimproved traditional practices that ultimately contribute to the low national average yield of major cereal in the country (Diao and Pratt, 2007).

Adoptions of improved crop varieties like teff have an impact on agricultural productivity and improving the food security status of rural households in Ethiopia. In Ethiopia this low yield is due to low adoption of improved teff technologies is believed to be the main factors affecting the teff production in Ethiopia (Abewa *et al*., 2014). This calls for the adoption of productivity enhancing technologies and improvement in the efficiency and productivity as it is becoming no longer possible to increase output by expanding the area under cultivation of improved technologies (Asfaw *et al*., 2012; Headey, Dereje and Taffesse, 2014).

To improve productivity of teff, several efforts have been undertaken by the national agricultural research system such as developing and disseminating high yielding varieties, disease resistance and stable varieties with in different weather conditions (Kebede *et al*., 2017). For instance, forty two (42) improved teff varieties were released until 2017 (Berehe, 2018). In spite of these efforts, the rate of adoption of improved varieties in the country has remained low (Dibaba *et al*., 2019).

Several studies were conducted on adoption of improved teff technologies in different regions of Ethiopia (Dawit, 2020; Vandercasteelen *et al.*, 2014; Bayisa, 2014 and Chala *et al.*, 2018). However, none of these studies were conducted on the impact of improved teff variety (quncho) adoption on productivity. Other studies were conducted on determinants of teff technology adoption and its impact on productivity (Etsehiwot, 2018; Alemu, 2019; Dibaba *et al.,* 2018), they focuses on combination of improved agricultural technologies. They didn't emphasis on specific components of the technology packages.

More precisely, there have been some empirical studies conducted to identify determinants of adoption of quncho teff variety adoption (Dibaba *et al.,* 2019; Debelo, 2015), they focuses on the perception of farmers toward quncho variety and factors which influence adoption of quncho teff, they didn't addressed the impact of improved teff variety(quncho) adoption on productivity. Specifically determinants of improved teff variety (quncho) adoption and its impact on productivity were not studied. As the best of the author's knowledge, no similar studies were undertaken on the impact of improved teff variety (quncho) adoption on productivity in Ethiopia as well as in the study area. Therefore, this study aims to address the impact of improved teff variety (quncho) adoption on productivity in Kiramu district and to identify the determinants that affect use intensity of improved teff variety (quncho) adoption in the study area.

1.3 Research Questions

- ✓ What is the status of improved teff variety (quncho) adoption in the study area?
- ✓ What are the determinants of use intensity of improved teff variety (quncho) adoption in the study area?
- ✓ What is the impact of improved teff variety (quncho) adoption on productivity of teff growers in the study area?

1.4 Objectives of the Study

1.4.1 General Objective

- ❖ To analyze the determinants of improved teff variety (quncho) adoption and its impact on productivity in Kiramu District, Oromia Regional State, Ethiopia.

1.4.2 Specific Objectives

- ✓ To assess the status of improved teff variety (quncho) adoption in the study area.
- ✓ To identify the determinants of use intensity of improved teff variety (quncho) adoption in the study area.
- ✓ To examine the impact of improved teff variety (quncho) adoption on productivity in study area.

1.5 Significance of the study

This study has a contribution aimed at filling the gap existed in the literature on the impacts of improved teff variety (quncho) adoption on productivity. The findings provides vital information for farm households by initiating them on adopting improved teff variety (quncho) to increase productivity of the quncho teff growers, as well as for better food secured. It also used in guiding policy makers and development planners on agricultural technologies introducing and dissemination on the study area. It builds a bridge by expanding the information about the low improved teff variety (quncho) within farm households in study area and shows it to concerned bodies and input suppliers. Moreover, the findings may also provide future research directions for those who may be interested in conducting further research in related area.

1.6 Scope and Limitation of the study

The study focused on impact of improved teff variety (quncho) adoption on productivity in Kiramu District, Oromia Regional State, Ethiopia. The study covered and used cross-sectional data collected from farm households of the three districts of the zone. In the study area, there was 2876 number of households head. Since the difficulty to get all households, is limited to 327 sample teff producers’ households' in the district, which only represent the study area. Moreover, since most farmers did not tell the real information about their productivity, it was difficult to obtain accurate data on productivity. Quality of information is depending on the willingness to respond, knowledge about modern technologies and recalling capacity of respondents. However, maximum effort made to gather reliable information by convincing farm households to address the objectives of the study.

1.7 Organization of the study

This paper is organized into five major chapters to address the aims of the study. It started by introducing the background of the study and follows Chapter two review both theoretical and empirical literatures. The theoretical literature includes the review of different theories regarding technology adoption and productivity; the empirical review part containing literature of developing countries and Ethiopia regarding determinants of technology adoption and its impact on productivity has been reviewed. This is followed by chapter three of methodology part; Chapter four presents the Results and discussion part of the paper, and the last chapter, means chapter five gave conclusions and recommendations of study.

2. LITERATURE REVIEW

The literature review encompasses the theoretical literatures and empirical evidences that describe adoption of agricultural technologies, farmers' decision making behavior in adoption of improved crop varieties, adoption of teff technology and its diffusion in Ethiopia. Impact model concepts, overview of teff and its production in Ethiopia and emphasized on the adoption of improved teff variety (quncho) and impact of improved teff variety (quncho) adoption has been reviewed.

2.1 Theoretical Literature Review

2.1.1 Theoretical Perspectives on Agricultural technology adoption

Adoption is a decision to use or to continue using a given technology. It is not permanent rather it could change at any time due to a number of reasons (Mishra *et al.,* 2015). According to Rogers' (2003) five-stage model or "the innovation-diffusion model" is the prominent model that an individual passes through five stages to adopt improved technologies. This is started from hearing about an innovation, and these stages are described as knowledge, persuasion, decision, implementation and evaluation stages.

Roger (2003) Rogers adoption stages have hierarchal passes that an adopter individual are passed through: Knowledge is the first stage where an individual is aware about new technology and how to use it. In this stage critical question like why, what and how are always raised because individuals want to know more about the modern technologies. After an individual became aware about the technology he/she builds favorable or unfavorable attitude towards the new technology that forms the so-called persuasion, i.e. persuading whether to adopt or not to adopt. The third stage is decision stage where an individual decides to use or not to use a given technology. The last stage is implementation where an individual puts the new technology into use, and at confirmation individuals evaluate the results of the new technology and the individual looks for support for his or her decision

The adoption of high yielding crop varieties by farmers in developing countries has been viewed as the solution to lower incomes in agriculture; as a result, many donor agencies have invested substantial resources in agricultural technologies in developing countries. However, most of the new agricultural technologies have not fully achieved the desired goals (Faltermeier and Abdulai, 2009). This observation has, therefore, spawned numerous studies about agricultural technology adoption and their impact on smallholders' welfare in developing countries in the recent years (Becerril and Abdulai, 2010, Mendola, 2007).

The adoption of new technologies such as fertilizer and improved seed is central to agricultural growth and poverty reduction efforts (Tura *et al.*, 2010). The majority of poor households in developing countries are depending on subsistence agriculture for their own food consumption and as a source of income. Over the past few decades, various initiatives have been aimed at increasing food production by closing the technology gap faced by subsistence farmers. Such initiatives have worked either directly, through the supply of new technologies such as fertilizer, seeds of improved plant varieties or new animal breeds, or more indirectly, through agricultural extension and advisory services, or both (Larsen, 2015).

As Doss *et al*. (2003) explained that technology adoption is taking place across eastern Africa but considerable scope remains to improve the productivity of smallholder agriculture in higher potential regions with high levels of adoption. They said extension was the variable most highly correlated with technology adoption, and extension services continue to play an important role in disseminating information on new varieties and how to manage them. Information on the adoption and risk taking behavior of farmers is the one way by which farm level productivity can be increased through the introduction and dissemination of improved agricultural technologies to farmers (Admassie and Ayele, 2010).

Numerous studies, including (Teklewold *et al.*, 2013;Feleke and Zegeye, 2006; Asfaw *et al.*, 2012) argued the effective way to improve agricultural productivity is through adoption of improved technologies. In addition to productivity improvement, technology adoption can lower per unit cost of production, increase the supply of food, and raise incomes of adopters. It can also improve nutritional status and reduces risks of crop failure (Fitsum *et al.*, 2012). Increasing adoption rates enhancing technologies is, therefore, essential for boosting crop production and improves the welfare of the rural community. However, the adoption rate of agricultural technologies is very low in Ethiopia (Ahmed *et al.*, 2016).

2.2 Methodological Perspectives on Technology Adoption and Impact Evaluation

There are several studies conducted on impact of adopting agricultural technologies on productivity or households' status of living. The following are some of the preferable models usually employed by number of authors.

2.2.1 Methodological perspectives on technology adoption

Discrete choice models: The decision made to adopt or not to adopt depends on farmers' decision. Farmers' decision to adopt improved varieties or not to adopt is the preferences comparison made by a farm household. To adopt or not to adopt a technology is often a discrete choice. Discrete choice models have widely been used in estimating models that involve discrete economic decision-making processes. Discrete choice models have widely been used in estimating models that involve discrete economic decision-making processes (Guerrem and Moon, 2006). The two commonly used discrete choice models in the adoption studies are the probit and logit models.

Probit analysis is alternative of logit model. The major difference between logit and probit models lies in the assumption on the distribution of the error terms in the model. The difference lies in fact that logistic function has harder "flat tails" (Klieštik *et al.,* 2015). Logit provides a better fit in the presence of extreme independent variable levels and conversely that probit better fit random effects models with moderate data sets. For the logit model, the errors are assumed to follow the standard logistic distribution while for the probit, the errors are assumed to follow a normal distribution (Hahn and Soyer, 2005).

Other econometric models like Tobit and Double Hurdle models are the most widely used models in analytical frame work of different scientific researches. Both are alternatively used to identify factors which affect adoption and the intensity of adoption (Alene *et al.,* 2000). Tobit model can be estimated with maximum likelihood estimation, a general method for obtaining parameter estimates and performing statistical inference on the estimates (Hallahan, 1997). Tobit model distinguish factors that affect the farmers' choice of an option should not necessarily be the same as those that affect the intensity of use (Alene *et al.,* 2000) .

Heckman model addresses the problem associated with the zero observations by considering the respondents' self-selection means that the entire zero observations which comes from the respondents' deliberate choices. This model differs from Tobit model by assuming that, sets of different variables could be used in the two-step estimations, however, this makes Heckit model similar to the double hurdle model. Heckman and double hurdle models are similar in identifying the rules governing the discrete outcomes, which are determined by the selection and level of use decisions. However, the Heckit assumes that there will be no zero observations in the second stage once the first-stage selection is passed (Feder and Umali (1993).

In the double hurdle model, the decision to participate in an activity is made first and then the decision regarding the level of participation in the activity follows. This model estimation procedure involves running a probit regression to identify the decision to participate in the adopting improved teff variety using all sample population in the first stage, and a truncated regression model on the participating households to analyze the extent of participation, in the second stage. Hence double hurdle model has used to estimate the probability and intensity of adoption of improved agricultural technology (Gujarati, 1995).

Tobit model was chosen for this study because of it has an advantage over other analytical models in that, it reveals both the probability of adoption and intensity of use of the technology (Maddala, 1992). Tobit model has both discrete and continuous part is appropriate because it handles both the probability and intensity of adoption at the same time. Tobit model is more appropriate to give reliable output of both discrete and continuous variable combination (Augustine and Mulugeta, 2005). The advantage of the Tobit model is that, it does not only measure the probability of adoption of technology but also takes care of the intensity of its adoption (Shiyani *et al*, .2000; Adesina and Zinnah, 1993). In this study Tobit model was used to analyze the determinants of use intensity of improved teff variety (quncho) adoption in the study area.

2.2.2 Methodological perspective on impact evaluation

Program impact evaluation studies the effect of an intervention on final welfare outcomes, rather than the program implementation process. Impact evaluation establishes whether the intervention had a welfare effect on individuals, households, and communities, and whether this effect can be attributed to the concerned intervention (Tolesa, 2014). Estimating the impact of a program requires separating its effect from intervening factors which may be correlated with the outcomes, but not caused by the program. To ensure methodological rigor, an impact evaluation must estimate the counterfactual, that is, what would have happened had the intervention never taken place (Baker, 2000). Researchers categorize establishing control and treatment groups in to three: randomization/pure experimental design; non-experimental design and quasi-experimental design.

An experimental approach: An experimental approach is an impact evaluation approach that constructs an estimate of the counterfactual situations by randomly assigning households to treatment (participant) and control (nonparticipant) groups. Random assignment ensures that both groups are statistically similar (that is, drawn from the same distribution) in both observable and unobservable characteristics, thus avoiding program placement and self-selection biases (Kinati *et al*., 2014). In a randomized experiment, individuals are randomly placed into two groups, namely, those that involve in the program or those that not involve in the program. Participants selected for treatment may choose not to be treated, or may not comply with all aspects of the treatment regime (Baum, 2013).

Non-experimental approaches: According to Bryson *et al. (*2002) there are two broad categories of non-experimental approach; before and after estimator and cross-sectional estimator. The essential idea of the before-after estimator is to compare the outcomes of group of individuals after participating in a programme with outcomes of the same or a broadly equivalent group before participating and to view the difference as the estimate of TT. This operates by comparing a before-after estimate for participants with a before-after estimate for non-participants and regarding the difference as TT. Cross-section estimators use non-participants to derive the counter factual for participants.

Quasi-experimental methods: Quasi experimental methods have been developed to net out the impacts of other factors. These include; double difference or difference-in-difference (DID) reflexive comparison and propensity score matching (PSM). Quasi-experimental method is the only alternative when neither a baseline survey nor randomizations are feasible options. The main benefit of quasi-experimental designs is that they can draw on existing data sources and are thus often quicker and cheaper to implement, and they can be performed after a project has been implemented, given sufficient existing data((Jalan and Ravallion, 2003).

Regression discontinuity design approach can be used when there is some kind of criterion that must be met before people participate in the intervention being evaluated. This is known as a threshold. A threshold rule determines eligibility for participation in the programme /policy/ and is usually based on a continuous variable assessed for all potentially eligible individuals (White and Sabarwal, 2014). This method compares outcomes of a group of individuals just above the cut-off point for eligibility with a group of individuals just below it. The major technical problem of this method is that it assesses the marginal impact of the program only around the cut-off point for eligibility and nothing can be said of individuals far away from it (Caliendo and Kopeining, 2008).

Double difference (Diff in diff): also known as the 'double difference' method compares the changes in outcome over time between treatment and comparison groups to estimate impact. DID gives a stronger impact estimate than single difference, which only compares the difference in outcomes between treatment and comparison groups following the intervention (at t+1). Applying the DID method removes the difference in the outcome between treatment and comparison groups at the baseline. Nonetheless, this method is best used in conjunction with other matching methods such as PSM or RDD. If DID is used without matching, the researchers should test the 'parallel trends assumption', i.e., that the trend in outcomes in treatment and comparison areas was similar before the intervention (White and Sabarwal, 2014).

Reflexive comparison: Is one of quasi experimental methods when there is a base line survey/data/ of participants before and after the intervention.

Instrumental variable: In the IV approach, selection bias on unobserved characteristics is corrected by finding a variable (or instrument) that is correlated with participation but not correlated with unobserved characteristics affecting the outcome**.**

Propensity score matching (PSM): Is one of quasi-experimental method to estimate causal treatment effects. PSM is a method to match program participants with non-participants typically using individual observable characteristics. Each program participant is paired with a small group of non-participants in the comparison group that are most similar in the probability of participating in the program (Becker and Ichino, 2002). Unlike econometric regression methods, PSM compares only comparable observations and does not rely on parametric assumptions to identify the impacts of programs and it does not impose a functional form of the outcome, thereby avoiding assumptions on functional form and error term distributions. Results from the matching method are easy to explain to policy makers, since the idea of comparison of similar group is quite intuitive. Propensity score matching model (PSM) was used when possible to create a comparison group from a sample of non-participants closest to the treated group in the absence of baseline data using observable variables. From the above-described impact evaluation approaches, the study uses PSM, because absence of baseline data on productivity of households specially based on improved teff variety (quncho) adoption before and after participation in program.

2.3 Teff production trend and its importance in Ethiopia

Cereal crops are the major food crops both in terms of the area coverage and volume of production and accounts for 95% of agricultural production in Ethiopia and contributed 86.68% of the grain production. Maize, wheat, and teff are the most important cereals in terms of volume, accounting for a total of 77% of all cereal production. While maize, teff, wheat and sorghum have made 26.80%, 16.76%, 15.81% and 16.20% of the grain production respectively (CSA, 2016).

As Nyman *et al*. (1989) mentioned Cereal crops are the major sources of carbohydrate and protein contents. They contribute 70% of calorie and 50% of protein consumption in human nutrition and cereals are a source of dietary fiber, contributing to about 50% of the fiber. Carbohydrate is composition of 80% of teff grain and it has a starch content of 73%. Comparing of teff to other cereal grains such as sorghum, 13 teff varieties have amylose content ranged from 20 to 26 percent (Bultosa, 2007).

According to FAO (2020) teff grains are white, mixed or red, with the white fetching the highest and red the lowest price. Teff accounts for about two-third of the daily protein intake in the Ethiopian diet and is mainly used for making different kinds of enjera (pancake-like flat bread), porridge and feed. Enjera is eaten in most households but it can require up to three days for the teff flour to ferment. Teff is also used in making a local alcoholic drink called arak'e or katikalla and a native beer called t'ella or fersso. The straw is used for reinforcing mud for plastering wooden walls of buildings and for livestock feed.

The protein content of teff grain is found between the ranges of 8 to 11 percent which is similar to other cereals such as wheat. The major fractional protein storages of teff grain is glutelins (45%) and albumins (37%), while the minor constituent is prolamins (12 %) (Tatham *et al.*, 1996, Bekele *et al.,* 1995), teff is also the major source of essential fatty acid, fiber, minerals (especially calcium and iron), and phytochemicals. The crude fat content in 13 Ethiopian teff varieties ranged 3 - 2 % with mean of 2.3%, the crude fiber, total and soluble dietary fiber content of teff is much higher than wheat, sorghum, rice and maize (Bultosa, 2007). The crop is grown both in Belg (short rainy season) and meher (long rainy season). Despite the wide area coverage, the various cropping system and agro ecologies where teff grows, it suffers less from epidemic damages from diseases and insect pests (Kebebew *et al.*, 2013).

In Ethiopia, teff production contributes significantly to the economy in terms of cash income and food security, especially for the smallholder teff producers in rural areas (Ademe *et al.*, 2018). More than 90% of the World teff is grown in Ethiopia. Teff is indigenous crop to Ethiopia and is a fundamental part of the culture, tradition and food security of its people. It cultivated approximately above 2.8 million hectares and endowed on 28.5 percent of land area. Teff contributes up to 600 kcal/day in urban areas compared to only 200 kcal/day in rural areas (CSA, 2015).

Demeke and DiMarcantonio (2013), in Ethiopia teff is grown mainly in Oromia and Amhara regions. Husen *et al.* (2017) Oromia is the highest teff producer in the country, it produced on 371,931 ha by 184,923 small households and 324 large scale farmers. The farmers harvested 5, 656, 16.5 ton, whereas Amhara region is the second largest teff producer in the country, the crop is produced by 228,502 smallholders and 426 large scale farmers on 184,648 ha. These farmers harvested about 5,159,33ton per year.

Teff is one of the most important crops for farm income and food security in Ethiopia. Adopting improved teff varieties have an impact for increasing agricultural productivity and improving the food security status of smallholder farmers in Ethiopia. Adoption and wider diffusion of improved teff varieties (quncho) are playing a vital role overriding present situation of food insecurity in many parts of Ethiopia (Dibaba *et al*, 2019). According to Dibaba *et al.* (2018) adoptions of improved crop varieties like teff have an impact for increasing agricultural productivity and improving the food security status of smallholder farmers in Ethiopia and adoption of improved teff varieties had significant impact on teff productivity of adopters as compared to the non-adopters with increased teff productivity.

2.4 Agricultural Technology Adoption and Diffusion

Adoption is a decision-making process, in which an individual goes through a number of mental stages before making a final decision to adopt an innovation. Decision-making process is the process through which an individual passes from first knowledge of an innovation, to forming an attitude toward an innovation, to a decision to adopt or reject, to implementation of new idea, and to confirmation of the decision (Getu, 2014).

According to Feder *et al*. (1982) adoption is classified as an individual (farm level) adoption and aggregate adoption. 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. In the context of aggregate adoption behavior, diffusion is defined as the spread of new technology within a region. This implies that aggregate adoption is measured by the aggregate level of specific new technology with a given geographical area or within the given population.

The decision-making process is the process through which an individual passes from first knowledge of an innovation, to forming an attitude toward an innovation, to a decision to adopt or reject, to implementation of new ideas, and to confirmation of the decision (Roger, 2003). According to Hailu (2008), adoption and diffusion of technology are two interrelated concepts describing the decision to use or not to use and the dispersion of a given technology among economic units over a period of time. Technological diffusion trajectories by the use of S-shaped curves (Lechman, 2015). According to Chandio and Yuansheng (2018) the factors that influence the adoption extent of technology is characteristics or attributes of technologies; the adopters or farmers which is the object of change agent (extension worker, professional, etc.); and the socio-economic, biological, physical environment in which the technology take place. Adoption of increasing agricultural new technology can be an important option for the farmers to get rid of hunger and food in security by improving crop productivity, reducing food price and making more food accessible for the poor households.

According to Barrett (2001) in Ethiopia farmers continue to lose in terms of crop yields despite introduction of new agricultural technologies since the cost of fertilizers and improved seeds continue to be high. He further said that, if the technology is not cost reducing, farmers are not likely to adopt it in future seasons unless policy options such as provision of credit facilities are effective. In Ethiopia, low adoption of improved production technologies was attributed to unavailability of improved technologies, unavailability and high cost of required inputs, lack of access to and high interest rates on credit and policies that discourage improved technology adoption such as promotion of state farms (Getahun *et al.*, 2000).

According to Hailu and Chilot (1992) and Getahun *et al.* (2000) in Ethiopia, low adoption of improved production technologies was attributed to unavailability of improved technologies, unavailability and high cost of required inputs, lack of access to and high interest rates on credit and policies that discourage improved technology adoption such as promotion of state farmers.

The farmers' perceptions of improved teff varieties-specific characteristics significantly determine adoption decisions, which suggest the need to go beyond the commonly considered socio-economic, demographic and institutional factors in adoption process. Information about the benefits of improved teff varieties should be given for farmers to increase farmer's awareness about the preferences and develop farmer's attitude towards improved teff varieties. Therefore, the research centers and extension system has to give more attention to participatory research which considers farmers' priorities and needs (Dibaba *et al.,* 2019).

The adoption of new technologies such as fertilizer and improved seeds is a fundamental factor for growing agricultural productivity and enhancing food security(Tura *et al,* 2010). The most common agricultural technologies include improved varieties of seeds. Adoption of these new technologies increases agricultural productivity, which can be seen through the outward movement of the production frontier. Such technologies are believed to be major factors for the success of the green revolution experienced by Asian countries (Colman and Young, 1989). In Ethiopia, farmers continue to lose in terms of crop yields despite introduction of new agricultural technologies since the cost of fertilizers and improved seeds continue to be high. If the technology is not cost reducing, farmers are not likely to adopt it in future seasons unless policy options such as provision of credit facilities are effective (Barrett, 2001).

Crop productivity per unit area of land in Ethiopia remains very low due to various constraints including the limited use of appropriate productivity boosting technologies and appropriate crop production husbandry practices. Crop pests and diseases do also contribute to the low level of productivity and huge post-harvest losses of up to 30%. For the majority of the smallholder producers, the economic benefit derived from the cropping enterprise is unsatisfactory because of the limited level of value addition to the produce and the inadequate integration with market (FAO, 2020). Study by Saka and Lawal (2009) determinants of adoption and productivity of improved rice varieties in southwestern Nigeria stated that land area cultivated to rice, frequency of extension contact and the yield rating of the improved rice varieties were significant determinants of farmers' decision to adopt improved rice varieties while with an average technical efficiency score of 78.4%, rice farmers have room to increase their productivity by increasing their farm size, quantity of improved seed and fertilizer.

The study which was conducted on impact of improved maize varieties on farm productivity and wellbeing: evidence from the East Hararghe Zone of Ethiopia by Ahmed *et al.* (2017) showed that the adoption of improved maize varieties leads to significant gains of consumption expenditure per adult equivalent. Non-adopters would have gained from the adoption of improved maize varieties. The study also indicated that those farmers who adopt improved maize varieties have a significant treatment effect gain compared with their non-adopter counterparts. Inorganic fertilizers and improved maize varieties significantly increase maize yields when adopted as a package. The impact is greater at the lower end of the yield distribution than at the upper end. A positive effect of partial adoption is experienced only in the lower quartile of yield distribution (Nyangena and Juma, 2014).

Intensity is the level of adoption of a given technology. The number of hectares planted with improved seed (also tested as the percentage of each farm planted to improved seed) or the amount of input applied per hectare will be referred to as the intensity of adoption of the respective technologies (Federet al., 1985). Ouma *et al.* (2014) the effect of intensity of adoption of improved maize varieties on household food security measured by per capita consumption expenditure, per capita maize consumption and farmer’s assessment. Intensity of adoption of improved maize varieties varies continuously and policies that increase maize productivity and ease farmer’s adoption constraints can enhance food security of households. The households’ effort to disseminate row planting of wheat will highly contribute to increasing income among farm households. Other agronomic practices along with the row planting method need to be considered for increasing wheat crop yield, household food consumption expenditure, household agricultural input expenditure and household income as well as for the successful promotion, adoption and scaling up of wheat row planting practices (Negese, *et al.*, 2016).

The research conducted by Asfaw *et al.* (2012) on impact of modern agricultural technologies on smallholder welfare: Evidence from Tanzania and Ethiopia, explained that adoption of improved agricultural technologies has significant positive impact consumption expenditure in per adult equivalent in terms of rural Ethiopia and Tanzania. And the potential role of technology adoption in improving rural household welfare as higher consumption expenditure from improved technologies translate into lower poverty, higher food security and greater ability to withstand risk. The determinants of adoption highlighted inadequate local supply of seed, access to information and perception about the new cultivars as key constraints for technology adoption.

A study which was conducted by Mulugeta and Hundie (2012) on the impacts of adoption of improved wheat technologies on households' food consumption in southeastern Ethiopia showed that adoption of improved wheat technologies has a robust and positive effect on farmers’ food consumption per adult equivalent per day. Abera (2008) adopters of teff technologies have increased their production by 39%, than non-adopters. Teff farmers allocated only 20% of their teff area to improved varieties due to shortage of desirable varieties. Since teff is the most well-known and widely consumed grain in Ethiopia for thousands of years, its importance beyond being staple food to the nations of the country is strongly tied to the socio-cultural settings of the country. Even though it is popularly consumed cereal, it was not given due attention the same as that of other grains in improving its productivity in major teff producing areas in the country (Getu, 2014).

As Ministry of Agriculture (2014) report in Ethiopia, total of 35 varieties have been released through the National Agricultural Research centers. Four of the released varieties, like: Magna (DZ-01-196), Enatite (DZ-01354), Dukem (DZ-01-974), and Quncho (DZ-Cr-387 RIL355) are widely adopted by farmers with optimum rainfall in different parts of the country, while the relatively early maturing varieties of Tsedey (DZ-Cr37), Gemechis (DZ-Cr-387 RIL127), Simada (DZ-Cr-285 RIL295), and Boset (DZ-Cr-409 RIL50d) are recommended for terminal low moisture stress areas (Minten *et al.*, 2018).

In other hand, Berehe (2018) said forty two (42) varieties are releases until 2017. Those like: Asgori, Magna, Enatite, Wellenkomi, Mengesha, Melko,Gibe, Dukem, Holetta key, Ambo Toke and etc. are for optimum rain fall areas, varieties like: Tsedey, Gerado, Key Tena, Gemechis, Melkassa, Boset and Were-kiyu are produced in low rain fall (terminal drought prone) areas and also Gimbichu, Dega Tef, Dima, Adet, Quncho, Gunduru, Kena, Estub, Kora and Dagim are varieties for high land (water lodging) areas. Quncho (DZ-Cr-387) variety is one of the new crop varieties which are rapidly expanding to the most teff growing areas of the country with the genetic capacity of the crop's production more than 30 quintals per hectares of land, which is three times more than the local teff (ATA,2012) as cited by (Dibaba *et al.*, 2019) .

2.5. Review of Empirical Study

2.5.1. Adoption of improved Agricultural technologies in Ethiopia

Milkias and Abdulahi (2018) studied on determinants of improved improved highland maize variety adoption in Toke Kutaye District, Oromia Regional State, Ethiopia. They revealed that variables such as farm size, household income, access to credit, contact with extension agents, participation in training, and field day were positively and significantly influenced whereas, age of household and market distance negatively influenced adoption and intensity of use of improved

highland maize varieties in the study area.
Younger farmers, famers with larger land size, farmer living closer to market, and farmers w ho had closer contact with the extension system are more likely to adopt new technology and use it more(Admassie and Ayele, 2010).

Farming experience implies accumulated farming knowledge and skill which has contribution for adoption. Amore experienced grower may have a lower level of uncertainty about the innovation's performance. Farmers with higher experience appear to have often full information and better knowledge and were able to evaluate the advantage of the technology in question (Mulgeta, 2009). Study conducted by Kebede *et al.(*2017*)* conducted on Determinants of Adoption of Wheat Production Technology Package by Smallholder Farmers: Evidences from Eastern Ethiopia the tobit model revealed that Gender, age of the household head, education status of the household head, farm size, distance to market, distance to FTC (Farmers' Training Centers), cooperative membership, dependency ratio, and annual income of the households were found to significantly affect the adoption of wheat technology packages.

According to Jaleta *et al.*(2015) impact of improved maize variety adoption on household food security in Ethiopia, an endogenous switching regression approach: education of household head, farm size, social network, and better agro-ecologic potential for maize production are the major determinants of household decisions to adopt improved maize varieties. The average per-capita food consumption is high for adopters and the impact of improved maize varieties adoption on per-capita food consumption is slightly higher for non-adopters had they adopted improved maize varieties. Farmers' knowledge of households on adopting improved varieties influences the decision of household to adopt improved technologies.

Gari (2017) studied that access to credit and total wheat produced were found to influence volume of wheat sold/commercialized/ positively and significantly and Education status and oxen owned had shown negative and significant relationship with volume of wheat sold/commercialized/. The emphasis has to be given on identifying new technology, advice on the use of modern agricultural inputs, a need for strengthening the existing credit institution and increasing their number, and there is a need for improvement of market and marketing systems.

2.5.2 Determinants of use intensity of improved teff technology adoption in Ethiopia

Asfaw *et al. (*2011) results show that knowledge of existing varieties, perception about the attributes of improved varieties, household wealth (livestock and land) and availability of active labor force are major determinants for adoption of improved technologies. Adoption is affected by different factors, such as: economic, technological, demographic and institutional factors. This is pointed out that one of the means by which farm level productivity can be increased is through the introduction and dissemination of improved agricultural technologies to farmers and found that farmers with larger land size, farmer living closer to market, and farmers who had closer contact with the extension system are more likely to adopt new technology than their counterfactuals. Having experience, participation in crop production training, education level, distance to nearest marketing center and the characteristics of new technologies like yield superiority and maturity of the new crops over local cultivars have a positive and significant effect on the farm households' adoption decision and intensity of production of improved teff (Bayissa, 2014).

Study conducted by Debelo (2015) on factors influencing adoption of quncho teff variety in Wayu Tuqa district emphasized that farmers with better education level show willingness to take new ideas than less educated and farmers having higher livestock were better adopter than the lower livestock holders and also farmers nearest to market and high frequency of extension service were better adopter than the farmers who were not. productive labor of households in terms' man equivalent, number of development agents' contact with the household per cropping year, ability of family food requirements meeting, as well as crops net income of the households were positively associated with adoption of quncho teff. Study conducted by Dibaba *et al.* (2018) on determinants of improved teff varieties adoption and its impact on productivity in non-traditional teff growing areas of western Ethiopia, showed that dependent members of the households, land allocated to cereal and horticultural crops had negative and significance effect on area under improved teff varieties, while livestock ownership (heifer and poultry), access to training and information on teff, being progressive farmer and social networks have contributed positively and significantly to improved teff varieties adoption.

2.5.3. Impact of improved teff technology adoption on productivity

The adoption of improved agricultural technologies has a significant positive impact on farmers' integration into output market (Asfaw *et al.,* 2011). Study conducted by Etsehiwot (2018), the result of endogenous switching regression model reveals that farmer's choice of single and combination choice of agricultural technologies (i.e. improved teff variety, fertilizer and row planting) has a positive and significant impact on productivity of teff. Low production and productivity which are mainly associated with poor adoption of improved technologies were the major problems which determine teff productivity. Using improved agricultural technologies increase productivity in smallholder agriculture and thus raise household income (Mulatu, 2019).

The growing of teff in rows mostly improves teff land productivity compared to the traditional practice of broadcasting. Row planting increased teff yield on farmers' experimental plot by 12 to 16 percent (Vandercasteelen *et al.,* 2016). Basha and Dembi (2018) found that Tseday and Boset improved teff varieties demonstration showed better yield performance when compared to the local variety. They concluded farmers in mid land district of Guji Zone should use both varieties in order to increase their teff production and productivity. Study conducted by Dibaba *et al.* (2018) on determinants of improved teff varieties adoption and its impact on productivity in non-traditional teff growing areas of western Ethiopia, showed that the PSM result shows that adopters of quncho got 11,790.59 birr higher than non-adopters. Adoption of improved teff varieties had significant impact on teff productivity of adopters as compared to the non-adopters with increased teff productivity over 276.6 kg/ha(Dibaba, 2018).

Tesfaye (2015) who did on economic analysis of teff yield response to different sowing methods in Illu Ababora Zone, Ethiopia stated that hand broadcasting method, ATA machine broadcasting method, row planting and transplanting method were evaluated. The yield obtained from the row planting was 42 % higher than hand broadcasting method. The transplanting method improves the yield of teff crop by 44% than the yield obtained through row planting method. Nevertheless, the net benefit obtained from transplanting (12,670 birr/ha) was found to be 45% less than the broadcasting (18476 birr/ha) method.

Impact of technology adoption on agricultural productivity and income in case study of improved teff variety adoption in North Eastern Ethiopia which conducted by Alemu (2019) emphasized that adopter farmers have generated 24% higher farm income from the resulted increase of agricultural output due to adoption. In addition, farm income of households in the survey responds differently to other production factors. The resulted change in farm income due to a unit change in land, capital and other seeds was significant and positive impact on agricultural productivity of households. Average Treatment effect on the Treated (ATT) on productivity of teff is 656.43 kg while the controls groups harvested around 379.82 kg. The average treatment effect on the treated (ATT) of teff productivity is greater compared to the non-adopters that has brought about 42.14%, indicating change for being participated on improved teff production compared to non-users.

The farmers' preferences with improved teff varieties-specific characteristics significantly determine adoption decisions of improved quncho teff variety, which suggest the need to go beyond the commonly considered socio-economic, demographic and institutional factors in the adoption process. There is a need to target small-holder farmers' characteristics, priorities and production constraints while improved teff varietal developments considering users preferences (Dibaba *et al.*, 2019).

2.6 Conceptual Framework

In developing countries technology adoptions are influenced by so many factors. Such as: factors related to the characteristics of producers i.e., the farmers; factors related to the characteristics and relative performance of the technology and program and institutional factors, this is the conceptualized evidence obtained from (Teklewold *et al.*, 2013) and (Shiferaw *et al.*, 2009). The factors related to the characteristics of producers include education level, experience with the activity, age, gender, level of wealth, farm size, plot characteristics, labor availability, resource endowment, risk aversion, etc. The factors related to the characteristics and performance of the technology and practices include food and cash generation functions of the product, the perception by individuals of the characteristics, complexity and performance of the innovation, its availability and that of complementary inputs, the relative profitability of its adoption compared to substitute technologies, the period of recovery of investment, local adoption patterns of the technology, the susceptibility of the technology to environmental hazards, etc.

The institutional factors include availability of credit, the availability and quality of information on the technologies, accessibility of markets for products and inputs factors, the land tenure system, and the availability of adequate infrastructure, extension support, etc. Enabling policies and programs, market linkages, access to institutional support and credit were found to play a positive role in stimulating farmer investment in and adoption of sustainable technologies

(Shiferaw *et al.*, 2009). According to Bayissa (2014) the house hold experience, participation in crop production training, education level, distance to nearest marketing center and the characteristics of new technologies like yield superiority and maturity of the new crops over local cultivars have a positive and significant effect on the farm households' adoption decision and intensity of production of improved teff varieties

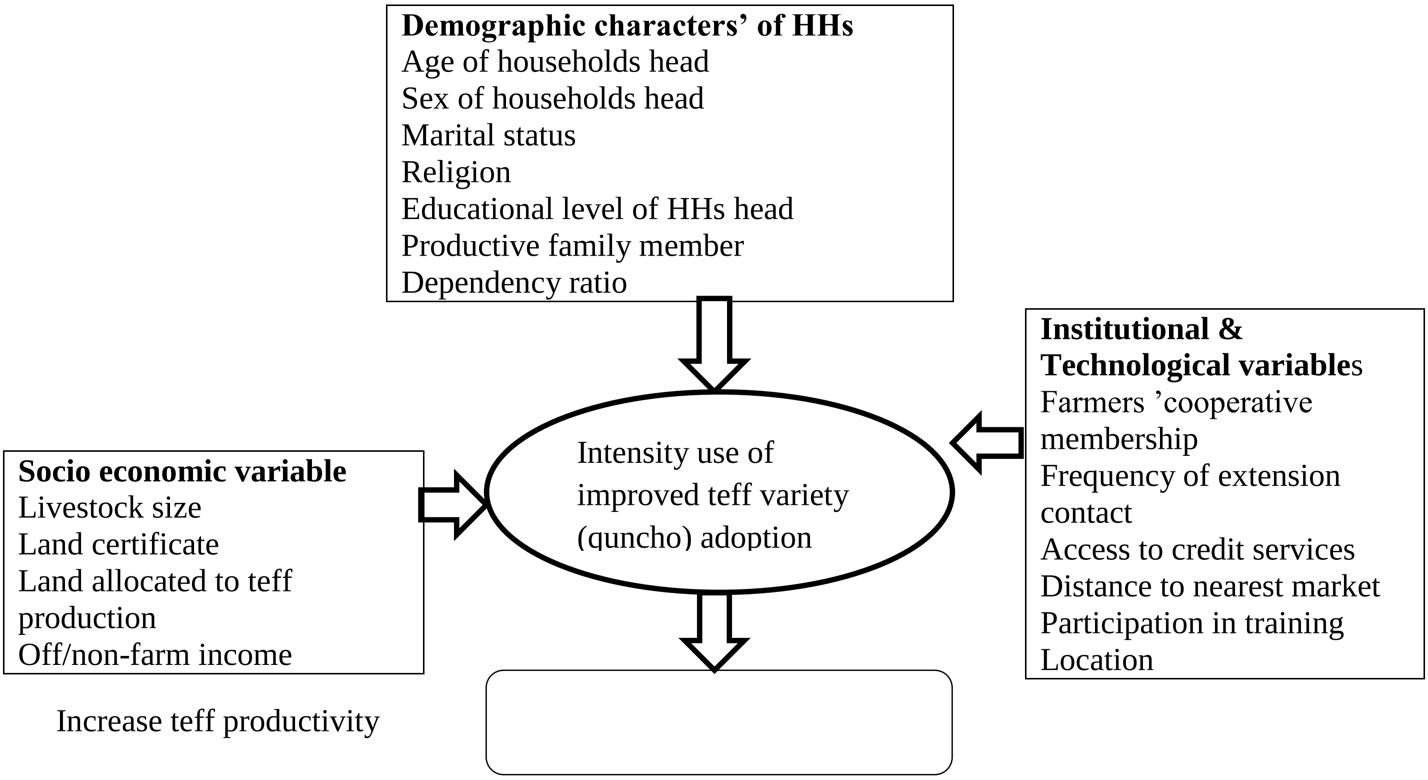

Figure 1: Conceptual Frame work: Source: Author Design

3. RESEARCH METHODOLOGY

This chapter provides an explanation of the methodology employed to address the objectives of the study. This chapter contains six sections: Section one describes the study area. Section two presents data types, sources and methods of data collection, Section three states on sample size determination and sampling technique, four presents methods of data analysis, and section five gives econometric model specification. And section six provides definition of variables and working hypothesis.

3.1. Description of the Study Area

The study was conducted in Kiramu district of East Wollega Zone, Oromia National Regional State of Ethiopia. Kiramu district is 458 Kms far from Addis Ababa and 140Kms from Nekemte town of its Zonal Town. Kiramu district is one of the 17 administrative districts in the East wollega zone. This district is bounded with Amuru district of Horro Guduru Wollega Zone in the East, Gida Ayana district in West, Bure district of Amhara Regional state in North, and Abe Dongoro district of Horro Guduru Wollega zones in South. The district have totally 19(Nineteen) kebeles, among those 15 kebeles are rural kebeles and 4 are urban kebeles. The total population of the district is 77,151. Out of these 21% of them are urban residents and 79% are rural residents. Geographically the altitude varies from 750 up to 3020 meter above sea level and its temperature is 28℃. The district is classified into three agro ecological zones; namely, highlands (4.91%), Midlands, (53.17%) and lowlands (41.92%). Almost all households are depending on agriculture.

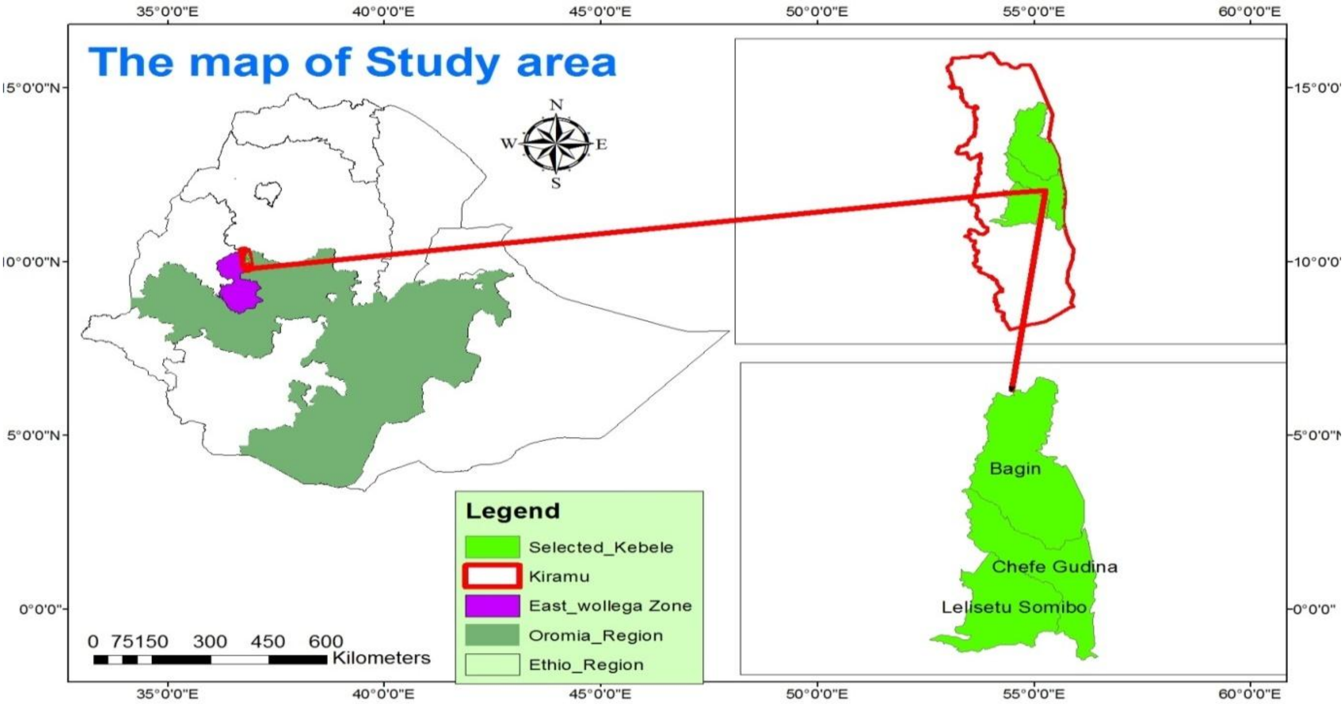

Figure 2: Map of the study area Source: The Ethiopian National Mapping Agency

3.2 Data Types, Sources and Methods of Data collection

For this study both quantitative and qualitative data were collected from primary and secondary data sources. Primary data was collected from respondent households. Structured questioner was designed and used to collect quantitative data related to the study and three enumerators were recruited based on their ability to speak local language like Afan Oromo and trained to facilitate the task of data collection for these three kebeles. Direct observation was undertaken both by the researcher and the enumerators.

The qualitative data were collected by using Focus Group Discussion (FGD) and key informant interviews. In the study area totally six(6) Focus Group Discussions(FGD), means two from each kebele were selected who those haven't selected in individual interview which consists of eight to twelve individuals from model farmers, experienced farmers and elders. The key informant interview was conducted with two experts from district agricultural and natural resource office and one development agent from each kebele experts (DAs) were interviewed. Secondary data was collected from published and unpublished journals, internets and from district office documents. Totally this survey was conducted from December, 2019 to January, 2020

3.3 Sample Size Determination and Sampling Technique

Multistage sampling methods were implemented to select districts, villages and farm households. In the first stage Kiramu district was selected purposively based on teff production potential and the road accessibility for conducting survey in the rural areas. In the second stage, three kebeles like: Bagin, Chefe Gudina and Lelistu Sombo were purposively selected from the district based on participation on producing improved teff variety (quncho) for more than three production years continuously. Finally, 131 and 196 of sample respondents have been selected randomly from both producers and non-producers of improved teff variety (quncho) respectively.

Depending on the proportion for adopter and non-adopters the sample size of the household heads for this study was determined by applying Kothari (2004) sample size determination formula:

$$n = \frac{Z^2 pqN}{e^2(N-1)+Z^2pq} = \frac{(1.96)^2 * 0.6 * 0.4 * 2{,}876}{(0.05)^2\ (2{,}876-1) + (1.96)^2 * 0.6 * 0.4}$$

n = 327, Where: n=sample size;

N= Households number in the three kebeles (2,876);

Z=95% confidence interval under normal curve (1.96); e=acceptable error term (0.05);

P and q are estimates of the proportion of population to be sampled; means the probability of adopters (p) represents by 0.4 and the rest 0.6 represent the probability of non-adopters

This P and q means the amount of probability of adopters is (P=1,150/2,876=0.4 and q= 1,726/2,876 = 0.6). Then, ((P=0.4 and q= 0.6), p + q=1), then totally 327 households were selected as the following

Table 1: Sample Kebeles

Name of sampled Kebeles	Total Households						Sampled Households					
	Adopter		Non Adopter		Total		Adopter		Non- Adopter		Total	
	M	F	M	F	M	F	M	F	M	F	M	F
Bagin	311	68	552	121	863	189	29	14	56	21	85	35
Chefe Gudina	340	44	356	96	696	140	34	10	34	18	68	28
Lalistu Sombo	335	52	490	111	825	163	36	8	41	26	77	34
Total	986	164	1,398	328	2,384	492	99	32	131	65	230	97

Source: Own Survey, 2020

3.4 Methods of Data Analysis

For this study the quantitative data was analyzed by using descriptive and inferential statistics, as well as econometrics models. Descriptive statistics like: mean, percentages, charts, bar graphs and standard deviation were used to analyze descriptive statistics. While inferential statistics like chi-square and t -test were also applied to test the statistical significance of the dummy and continuous independent variables respectively. Econometric models such as Tobit model was used to analyse the determinants of use intensity that affect improved teff variety (quncho) adoption. Propensity score matching (PSM) was used to examine impacts of adopting improved teff variety (quncho) on productivity of teff growers in the study area. The qualitative data collected from Focus Group Discussions (FGD) and key informant interviews was analyzed by narrative explanation with supported by quantitative data. Finally, the finding was analyzed with the help of (SPSS ver.20, and STATA 14.2)

3.5 Econometric Model Specification

3.5.1 Tobit Model Specification

Tobit Model: The censored normal regression model is also known as the tobit model. Tobit model can be estimated with maximum likelihood estimation, a general method for obtaining parameter estimates and performing statistical inference on the estimates (Hallahan, 1997). Tobit model was used to determine the influence of various personal, demographic, socio-economic, institutional and psychological variables on adoption and intensity of use of improved technologies (Milkias and Abdullahi, 2018). The Tobit model is a hybrid of a discrete and continuous dependent variable describing the relationship between the dependent variable and a vector of explanatory variables. Tobit model was used to analyze under the assumption that the two decisions are affected by the same set of factors (Greene, 2003).

Determinants and intensity of adoption of improved teff variety (quncho) adoption were investigated by using Tobit model. Dependent variable in the model is index value ranging from 0 to 1. A value of 0 indicates non-adopter, index value 1 represents the full adopter of the technology component (adopted without discontinuity), and the values between 0 and 1 indicate the level of the adoption within the range of the Tobit Model.

Following Maddala (1997), the Tobit model assumes there is a latent unobservable dependent variable Y* which is a linear function of a set of independent variables Xi and an error term δi. Observed variable Y is equal to the latent variable Y* if and only if the latent variable is greater than zero but less or equal to zero if otherwise. The model is specified as;

$$Y^* = \beta Xi + \mu i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

Y*= latent variable (which is not observable)

Xi = Vector of explanatory variable

β = vector of unknown parameters to be estimated

μi = an independent normally distributed error term with zero mean and constant variance

$$\begin{cases} yi^* = \beta xi + \mu i & if\ yi^* > 0 \\ 0 = & if\ yi^* \leq 0 \end{cases} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2)}$$

Censored regression models are usually estimated by the Maximum Likelihood (ML) method. The log likelihood function is specified with an assumption that the error term ε follows a normal distribution with mean 0 and variance σ2.

$$L = \prod_{Yi*>0} \frac{1}{\sigma} f\left(\frac{Yi - \beta iXi}{\sigma}\right) \prod_{Yi* \leq 0} F\left(\frac{-\beta Xi}{\sigma}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(3)}$$

Where f and F are respectively, the density function and cumulative distribution function of Yi*, ∏yi*>0 means the product over those i for which yi*>0, and ∏yi*≤0 means the product over those i for which yi*≤0. The interpretation of Tobit model coefficients is the same with that of uncensored linear model coefficients.

The marginal effect of an explanatory variable on the expected value of the dependent variable is:

$$\frac{\partial E(Yi)}{\partial (Xi)} = F(z)\beta i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(4)}$$

Where, $\frac{\beta iXi}{\sigma}$ is denoted by Z. The change in the probability of adopting a technology as independent variable Xi change is:

$$\frac{\partial F(z)}{\partial Xi} = f(z)\frac{\beta i}{\sigma} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (5)$$

The change in the intensity of adoption with respect to a change in an explanatory variable among adopters is estimated by: `

$$\frac{\partial E\left(\frac{Yi}{Yi^{*}>0}\right)}{\partial Xi} = \beta i\left[1 - Z\frac{f(z)}{F(z)} - \left(\frac{f(z)}{F(z)}\right)^{2}\right] \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (6)$$

Where: F (z) - is the cumulative normal distribution of Z,

f(z) - is the value of the derivative of the normal curve at a given point (i.e., unit normal density),

Z - Is the z-score for the area under normal curve, is a vector of Tobit maximum likelihood estimates and σ - Is the standard error of the error term.

In line with this, determinants of intensity of improved teff variety (quncho) adoption were investigated by using Tobit model. The dependent variable in the model is index value ranging from 0 to 1. A value of 0 indicates non-adopter, index value 1 represents the full adopter of the improved quncho teff and the values between 0 and 1 indicate the level of the adoption within the range of the Tobit Model.

Propensity score matching (PSM) specifications: is a method to match program participating farmers and non-participating farmers based on their baseline similarities and clear out those factors to single out only program impacts (Admassu and Workneh, 2016).

Steps of Propensity Score Matching (PSM) Model

Step 1: Estimate Propensity Scores

The first step in PSM method is to estimate the propensity scores by using either logit or probit models. The logit /probit model indicated that the probabilities are bounded between zero and one. Means the dependent variable is dichotomous, taking two values, 1 if an individual participates on adoption of improved teff (quncho) variety and 0 otherwise. The binary logistic regression model has been chosen for this study, because the binary logistic distribution has more density mass in the bounds and it is the best model to predict the households' probability of adoption and to estimate the propensity score (Arpino and Mealli, 2009). This study was intended to analyze which and how much the hypothesized repressors' were related to the involvement in adoption of improved teff(quncho) variety and the teff productivity. In estimating the logit model, the dependent variable is involvement in adoption of improved teff vareity (quncho), which takes the value of 1 if a household is involved in adoption of improved teff(quncho) variety' and 0 otherwise.

In the logit model, the slope coefficients of a variable gives the change in the log of the odds associated with a unit change in the variable, holding all other variables constant. The rate of change in the probability of an event happening is given by βjPi(1- Pi), where βj is the partial regression coefficient of the j^{th} regressor. But in evaluating Pi, all the variables included in the analysis are involved (Gujarati, 2004).

Step 2: Choosing Region of Common Support

According to Baum (2013) the impact of a treatment on individual i, σi is the difference between potential outcomes with and without treatment: σ_i = Y1i −Y0i.

$$\tau i = Yi(Di = 1) - Yi(Di = 0) \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (1)$$

Whereas stated as 0 and 1 correspond to non-treatment and treatment respectively. To evaluate the impact of a program over the population, we may compute the average treatment effect (ATE):

$$\tau ATT = E(\tau/D = 1) = E[\, Y(1)/D = 1] - E[\; Y(0)/D = 1] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

As the counterfactual mean for those being treated, $E[\, Y(1)/D = 1]$ is not observed, one has to choose a proper substitute for it in order to estimate ATT. One may think to use the mean outcome of the untreated individuals, $E[\; Y(0)/D = 0]$ as a substitute to the counterfactual mean for those being treated, $E[Y(0)/D = 1]$. However, this is not a good idea especially in non-experimental studies, since it is likely that components which determine the treatment decision also determine the outcome variable of interest.

In this particular case, variables that determine household's decision to participate in adoption of improved teff variety (quncho) could also affect household's farm productivity. Therefore, the outcomes of individuals from treatment and comparison group would differ even in the absence of treatment leading to a self-selection bias.

By rearranging, and subtracting $E[\,Y(0)/D=1]$ from both sides of equation (2), one can get the following specification for ATT.

Most often, we want to compute the average treatment effect on the treated (ATT):

$E\big[\,Y(1)/D=1-E[\,Y(0)/D=0]=\tau ATT+E[\,Y(0)/D=1]-E[\,Y(0)/D=0]\big]$……… (3)

Both terms in the left hand side are observables and ATT can be identified, if and only if $E[\,Y(0)/D=1]-E[Y(o)/D=0]=0$. i.e., when there is no self-selection bias. This condition can be ensured only in social experiments where treatments are assigned to units randomly (i.e., when there is no self-selection bias). In non-experimental studies one has to introduce some identifying assumptions to solve the selection problem. In order to determine if matching is likely to effectively reduce selection bias, it is essential to understand the two underlying assumptions under which the PSM is most likely to work:

Common assumptions in the PSM: In non-experimental studies one has to introduce some identifying assumptions to solve the selection problem. The following are two strong assumptions to solve the selection problem.

Conditional independence assumption: there exists a set X of observable covariates such that after controlling for these covariates, the potential outcomes are independent of treatment status: (Y1, Y0) ⊥D|X2 Common support: for each value for X, there is a positive probability of being both treated and untreated: $Y(0), Y(1)\ \cup D/X, \forall X$

Where: ∪ indicates independence, Y (0) is non-involvement, Y (1) involvement and X –is a set of observable characteristics. Hence, after adjusting for observable differences, the mean of the potential outcome is the same for D=1 and D=0 and

$E[Y0/D=1,X]=E[\,Y0/D=0,X]$……………………………………………………… (4).

The propensity score is defined as the probability of participation for household i given a set X which is household's characteristics, P(x)=pr (D=1). Propensity scores are derived from discrete choice models, and are then used to construct the comparison groups. Matching the probability of participation, given covariates solves the problem of selection bias using PSM (Liebenehm *et al.,* 2009). The distribution of observables X is the same for both participants and non- participants given that the propensity score is balancing score (Liebenehm *et al.*, 2009). This assumption is also known as selection on observables, and it requires that all variables relevant to the probability of adoption may be observed and included in X. This allows the untreated units to be used to construct an unbiased counterfactual for the treatment group.

Independence indicates that given a set of observable covariates (X) which are not affected by treatment (in our case, involvement in adoption of improved teff variety and potential outcome (teff productivity) are independent of treatment assignment (independent of how adoption of ITVs' involvement decision is made by the household.

The common support assumption: The common support region is the area which contains the minimum and maximum propensity scores of treatment and control group households respectively. It requires deleting of all observations whose propensity scores is smaller than the minimum and larger than the maximum of treatment and control, respectively (Caliendo and Kopeinig, 2008). This assumption rules out perfect predictability of D given X.

That is $0 < P(D = 1|X) < 1$. Given the above two assumptions:

$$\tau ATT = E[Y1 - Yo/D = 0, p(X)] = E[Y(1)/D = 1, p(X)] - E[Y(0)/D = 0, p(X)] \ldots\ldots (5)$$

This assumption improves the quality of the matches as it excludes the tails of the distribution of P(X), though this is done at the cost that sample may be considerably reduced. It implies that the probability of adopting improved teff(quncho) variety for each possible value of the vector X is strictly within the unit interval with the probability of not adopting improved teff (quncho) variety. This assumption of common support ensures that there is sufficient overlap in the characteristics of adopting and not adopting units to find adequate matches.

Matching Algorithm: The next stage is to choose the matching algorithm which best estimates the p-score. The choice of matching method involves a trade-off between matching quality and its variance. There is different matching algorithms /estimators/ in theory. The most common are Nearest Neighbor (NN) matching, Caliper, Kernel and radius matching.

Nearest Neighbor (NN) matching: In nearest neighborhood matching, an individual from a comparison group is chosen as a matching partner for a treated individual that is closest in terms of propensity score. In this nearest neighbor matching, each person in the treatment group chooses individual(s) with the closest propensity score to them (Caliendo and Kopeinig, 2005). Here the adopter of improved teff (quncho) variety chooses an individual who are closest to them. The matching can be done with or without replacement of observations. The nearest neighbor matching method matches each farmer from the adopter of improved teff (quncho) variety group with the farmer from the non-adopter of improved teff(quncho) variety group having the closest propensity score. In this matching if the closest neighbor is far away risks faces the matches. This risk can be reduced by using radius matching method, which imposes a maximum tolerance on the difference in propensity scores (Heinrich *et al.,* 2010).

Kernel matching: In Kernel based matching; each person in the treatment group is matched to a weighted sum of individuals who have similar propensity score with greatest weight being given to people with closer scores (Caliendo and Kopeinig, 2005). The major advantage of the kernel matching method is that it produces Average Treatment effect on the Treated (ATT) estimates with lower variance since it utilizes greater information; its limitation is that some of the observations used may be poor match. That means adopters who are adopter of improved teff (quncho) variety are matched to a weighted sum of individual adopters with greatest weighted of their closest.

Caliper matching: In caliper matching an individual from the comparison group is chosen as a partner for a treated individual that lies within a given caliper (propensity score range) and is closest in terms of propensity score. If the dimension of the neighborhood is very small, it is possible that some treated units are not matched because the neighborhood does not contain a control unit (Caliendo and Kopeinig, 2005).

Radius Matching: Like caliper but, matches a treatment Unit i to multiple comparison units within a band. Nearest neighbor, matching faces the risk of bad matches if the closest neighbor is far away. This can be avoided by imposing a tolerance level on the maximum propensity score distance (caliper). By this matching, bad matches avoided and hence the matching quality rises. This is an alternative way of imposing the common support condition. Dehejia and Wahba (2002) suggest a variant of caliper matching is called radius matching. The basic idea of this variant is to use not only the nearest neighbor within each caliper but all of the comparison members within the caliper. A benefit of this approach is that it uses only as many comparison units as available within the caliper and therefore allows for usage of extra (fewer) units when good matches are not available. Hence, it shares the attractive feature of oversampling mentioned above, but avoids the risk of bad matches

Step 3: Evaluate quality of matching: One important concern that should be taken care of while doing PSM is balancing test or checked if the matching procedure is able to balance the distribution of the relevant variables in both the control and treatment groups. The basic idea of all approaches is to compare the situation before and after matching and check if there remain any differences after conditioning on the propensity score (Caliendo and Kopeinig, 2008).

Step 4: Evaluate outcomes: The main purpose of the propensity score estimation is to balance the observed distributions of covariates across two participants (participants and non-participants of HHs). Hence, to ascertain that (1) there is sufficient common support region (overlapping of the estimated propensity scores) for the two groups of farm households and (2) the differences in the covariates in the matched two groups have been eliminated. These two issues are the necessary conditions for the reliability of the subsequent estimate of the program impacts (Huluka and Negatu, 2016). The teff productivity of farm households have been used to estimate the impact of improved teff(quncho) variety. Teff productivity is the teff production obtained from a hectare of land which is measured in kilogram.

Standard bias: There are many methods of covariate balancing tests; literatures show that the standardized tests of mean differences is the most commonly applied method. Standard bias is used to quantify the bias between treated and control groups. For each variable and propensity score, the standardized bias is computed before and after matching as:

$$SB(X) = 100.\frac{X1-X0}{\sqrt{0.5(V1(X)+V0(X)}} \quad (6)$$

Where X1 and X0 are the sample means for the treatment and control groups (V1(X) and V0(X) are the corresponding variance (Caliendo and Kopeining, 2008). The bias reduction (BR) can be computed as:

$$BR = 100(1-\frac{B(X)after}{B(X)before} \quad (7)$$

The possible problem with the SB approach is that one does not have a clear indication for the success of the matching procedure.

Step 5: Sensitivity Analysis: Is used to show how strongly an unmeasured variable must influence the selection process in order to undermine the implication of matching analysis (Caliendo *et al., 200*5) as cited by Adem (2016). The estimation of treatment effects with matching estimators is based on the un-confoundedness or selection on observables assumption. However, if there are unobserved variables which affect assignment into treatment and the outcome variable simultaneously, a 'hidden bias' might arise (Rosenbaum, 2002). In other word, if treatment and outcomes are also influenced by unobservable characteristics, then CIA fails and the estimation of ATTs are biased.

Average Treatment effect on the Treated (ATT): It used to evaluate the impact of adoption of improved teff(quncho) variety on its user. It is the difference between the outcome of treated and the outcome of treated observations if they had not been treated (counterfactual) computed as:

$ATT = E(Yi^T - Yi^C|D = 1) = E(Yi^T|D = 1) - E(Yi^C|D = 1)$………………………… (8)

Where, D is the treated sample respondent.

3.6 Variables Description and Its Measurement

Dependent variable: It is a dummy variable which represents 1 for households who adopt improved teff variety (quncho) and, 0 otherwise. Adopters are households who had participated to produce improved teff(quncho) variety during the survey year of 2019/2020, and non-adopters are a household who had not participated on adopting improved teff (quncho) variety and the proportions of use intensity of improved teff (quncho) variety adoption.

Outcome variable: Is a continuous variable which farm households obtain from producing improved teff (quncho) variety. Productivity gained from adopting improved teff (quncho) variety measured by Kilograms per hectare. i.e. productivity in Kilograms / hectare.

Independent variables

Independent variables are variables that independently influence households adoption of improved teff (quncho) variety includes; demographic, socio-economic, institutional and technological factors. Those factors are discussed by different scholars: that several papers are analyzed as different factors affecting technology adoption in Ethiopia. Availability of farm land, numbers of livestock holding and access to different productive assets have been affecting productivity of households in Ethiopia.

Such independent variables are:

Age: It is the Age of household head at the time of the survey. Age is a continuous variable measured in years, which is expected to influence technology adoption positively/ negatively. The hypothesis emphasizes that the older farm households have more probability on adopting new technologies than younger farm households. Older farmer got experience within increasing his/her age to accept new farming practices. Age of the households head is positively affect technology adoption (Admassie and Ayele, 2004) and Kebede *et al.* (2017) revealed that elders were found to be better adopters of wheat technology package than the juniors, which could be related to less labor demanding aspects of wheat technology package. But, in contrary age is a negatively proportional with technology adoption of improved varieties (Melesse ,2018 ; Milkias and Abdulahi, 2018).

Sex: The variable represents the biological characteristics of being male or female. It is dummy variable with values of 1 if the household head is male and 0 otherwise. It hypothesizes as male headed households have more probability to adopt improved teff variety (quncho) than female headed households. Here male households have freedom of mobility; participate in different meetings and trainings. Those male headed households who have more access to information to use innovation than female headed households, which have a capacity to influence by the cultural norms and traditions. Those male headed households can easily adopt improved agricultural new technologies. In the most parts of rural Ethiopia; women are disfavored groups of the society who couldn't easily access information about technology due to the prevailing socio-cultural values and norms. Male headed households of adopters' households were significantly higher than that of female-headed households (Tesfaye et *al.*, 2016). According to Melesse (2018) being female headed households is negatively influence technology adoption decisions.

Marital status: Is a dummy variable which emphasizes the households' head of marital status. It denotes as 1 if households head being married and 0 for not. It hypothesized that being married households have more adopter of improved teff variety (quncho) than not married. Abadi (2014) assumed that married households can handle and manage their overall livelihood (social duties and farm activities) better than households who are not that enabled them to produce more and generate more income.

Religion: Orthodox is dummy variable for being an orthodox follower:
= 1 if household head is Orthodox Follower, 0 otherwise
Protestant: Dummy variable for being protestant Christian followers. 1 if household head is follower of protestant Christian, 0 otherwise

Moslem = dummy variable for being a Moslem: = 1 if household head is Moslem, 0 otherwise.

It hypothesized that most of religion beliefs that adopting new varieties are banned. Here most religious leaders, preachers and elders are passing their time in churches and mosques. So they haven't time to adopt improved varieties. Admassie and Ayele,(2010) states that in many cases a technology is introduced to an area that includes farmers of different customs and traditions. These differences may be most notable between communities or betw een members of several groups living in the same community.

Education level: Is continuous variables which measured in 'years of schooling' which ranked according to their grade classes of farm households. Education has affecting improved teff variety (quncho) adoption positively. The hypothesis emphasized that the more educated households head have more probability to adopt improved teff variety (quncho) than less educated households. Educational status of a farmer may directly affect adoption and application of new agricultural technologies (Dibaba *et al.*, 2019). Limited knowledge and education level are identified as a major constraints for technology adoption(Asfaw and Admassie, 2004).

Productive family member: It is a continuous Variable which indicates active family members (enough for work) of the farm households between 15 & 64 years old to adult equivalent. The larger the productive family members have the more labor force available for the production purpose. It force plays a vital role in determining adoption and intensity of use of agricultural technologies. The existence of labor force in rural households usually encourages them to show interest in trying some agricultural technologies. Of course, the influence of labor availability on adoption depends on the characteristics of the technology to be adopted. When the new technologies in relative to the older ones are more attractive and labor intensive, farmers with more labor would tend to adopt those improved technologies. The active family labor force positively affects the adoption of improved varieties. The probable reason for this finding was that improved practices are labor intensive and hence the household with relatively high labor force uses the technologies on their farm plots better than others. (Asfaw *et al.*,2012; Melesse, 2018; Beshir *et al.*, 2012)

Dependency Ratio: This is a continuous variable measured in numbers. It refers to the proportion of economically inactive labor force (less than 15 and above 65 years old) to the active labor force (Between 15 and 65 years old) with in households. The dependency ratio have negative relationship with the adoption of improved teff(quncho) variety. It is hypothesized that the more the dependency ratio in a household, the less in production and less participation in adoption of improved technologies (Abera, 2015).

Land certificate: Land certificate is a dummy variable which states the license given to an individual farmer to being land ownership from government. It denotes as "1 if having certificate and 0 for not". It expresses that a farm households who have land certificate is probability to adopt improved teff variety (quncho) than others. Land certification has a positive impact on land investments, such as tree planting, terracing, applying manure, and increasing agricultural productivity (Tsegaye *et al.,* 2012). According to Admassu and Workneh (2016) having land certificate is a positive relationship with adoption of improved maize varieties.

Location: It's a dummy variable which denotes as 1 for midland and 0 for lowland. From this study since three of the kebeles located in mid land and lowland, the author categorized as this options. It is hypothesizes that the farmers who are in midland have more profitable than lowlands, because naturally teff choose the moderate temperature than other crops. So, adopting improved varieties have positive impact for moderate location producers. Tolesa (2014) states that location significantly affects adoption and impact of improved agricultural practices and wheat production efficiency.

Frequency of extension contact: is the frequency of personal communication between adopter respondent households and extension agents for the adoption of improved teff variety (quncho). It denotes by counting the frequency, which states in time. It hypothesizes as a farm household head who frequently contact extension agents have probability to adopt improved teff variety (quncho) than other framers. Beshir *et al*. (2012) and Wubeneh and Sanders (2006) noted that extension services has a positive effect on fertilizer adoption rate. Moreover, extension agents are the major sources of information and training for farmers regarding improved agricultural technologies. A farm household whose friends, neighbors and relatives cultivated improved teff (quncho) variety has experiencing to adopt improved teff (quncho) variety than others (Dibaba *et al.,* 2019). Farmers who have a frequent contact with extension agents have more information that would influence farm household's demand for new technologies (Ahmed *et al.,* 2016).

Off-farm/ non- farm income: Participation of households in off/non-farm income helps the households to generate additional income that can help to improve their agricultural practices. It is a dummy variable which represent "1 for households who participated on off/non-farm and

0 for farm activity". It hypothesized that households who participate on off/non-farm, more probability of adoption and intensity of use of improved teff variety (quncho) adoption, because of money that they earn from non-farm leads the households to engage in the participation as well as adoption of new varieties. Off/non-farm income could best be taken as an important ingredient of adopting chemical fertilizer in such a way that farmers could easily afford fertilizer cost; and these farmers are mostly exposed to new and updated information since they move from one town to another and contacted with different people with different background (kassa *et al.*, 2014). According to Admassie and Ayele (2004) on-farm income, gender and access to information are the major factors affecting technology adoption.

Distance to the nearest market: It is a continuous variable measured in kilograms that the respondent household travel to reach the nearby the market. It hypothesized that farm households who are nearest to the market have probability to adopt improved teff variety (quncho) than the others. Milkias and Abdulahi (2018) found that distance of farm house holds from the market is negatively influencing adoption and intensity of use of improved highland maize varieties. Distance to output market and adoption have negative relation with improved teff varieties adoption (Etsehiwot, 2018).

Livestock Sizes: refers to the amount of livestock which the respondent farm house holds owned. It is a continuous variables measured by tropical livestock unit. It is hypothesizes that farmers having large livestock can easily adopt improved technologies and it's positively influencing improved teff variety (quncho) adoption. It implies that a farmer who has number of livestock will be more likely to adopt improved teff variety (quncho). This may be due to relatively having more livestock offer a means for a better propensity to buy improved teff variety (quncho) for adoption purpose. Nigatu *et al*. (2018) emphasized that farmers who have large number of livestock might consider their asset base as a mechanism of ensuring any risk associated with the adoption of improved maize variety.

Access to Credit Service: is dummy variable, which denotes as "1 for access credit and 0 otherwise". It is hypothesized that a farm households who access to credit services have a probability to adopt improved teff variety (quncho) than non-adopters. The high price of improved seed was frequently listed as a constraint to adoption. Credit services are the major sources for improved agricultural technologies to solve financial constraints. Price may be a constraint because farmers cannot purchase the inputs due to limited credit markets or because the marginal levels of output from improved varieties do not justify the use of improved inputs

(Doss *et al*, 2003). If farmers can get access to credit, they can purchase improved technologies (Beshir *et al.*, 2012).

Participation in Training: It is a dummy variable which states that the farm households who are accesses to training about improved teff varieties from woreda or kebele agricultural experts, DAs and other agricultural institutions. It denotes 1 for whom to participate, 0 otherwise. Access to agricultural training is necessary for increasing agricultural production. Farm households who have participated in demonstrations and training have developed a positive attitude towards improved teff technology is supported by many studies in Ethiopia. The farmers who participated on training improved teff varieties have got better yield performance than others who haven't got any training on adoption of improved teff varieties (Basha and Dembi, 2018). According to Etsehiwot (2018) access to training has believed to be an important factor enhancing adoption of agricultural technologies.

Farmers' cooperative membership: Is a dummy variable that emphasizes as" 1" if a member, otherwise "0". It hypothesized that a farmer household's head who is the member of farmers' cooperatives have a probability to adopt improved teff variety (quncho) than not being the farmers' cooperatives. A member of farmers' cooperative has information about impact of improved varieties on productivity and positively affecting adoption of new technologies (Admassie and Ayele, 2004).

Land allotted to teff production: is continuous variables which represent the land which cultivated by teff production. It aims to increase farmers' production thereby enhancing market oriented production. More cultivated land size of teff varieties was expected to increase the productivity of adopting improved teff variety (quncho). In order to be market oriented, farmers need to first adopt new more varieties (Mulugeta, 2000) and (Taha, 2007) reported that cultivated land size have a positive relationship with adoption of new varieties.

Table 2: Summary of variable description and their Measurement

Variables	Types of Variables	Description and its Measurement	Hypothesis
Dependent Variable			
Adoption Land allocated to IQV	Dummy Continuous	Adoption level of farm hhs, it denotes '1 if adopters; 0 otherwise' Use intensity of land allocated to Quncho variety	
Outcome variable			
Teff productivity	Continuous	Teff productivity which gained from adoption of ITV(Q)s measured by Kilograms per hectare (Kg/ha)	
Independent variables			
Age of hh head	Continuous	Age of hhs head in Years	+/-
Sex of hh head	Dummy	Sex of hhs head, denotes by 1 if male; 0 otherwise	+for male
Education Level	Continuous	Education level of hhs head in years of schooling	+
Productive family members	Continuous	Active family members(enough for work) of the farm hhs between 15 & 64 years old to adult equivalent	+
Dependency Ratio	Continuous	Dependent family members (<15 years & > 64 yrs) to working family members (15-64 yrs) in the household, measured in number	_
Off/non/farm income	Dummy	Household annual income other than farm income, it denotes 1 if household had non-farm income source, 0 otherwise	+
Land certificate	Dummy	Households who have land certificate for being land ownership, 1 if yes; 0 otherwise	+for yes
Marital status	Dummy	Denoted 1 if households got married; 0 otherwise	+married
Orthodox	Dummy	= 1 if household head is Orthodox Follower, 0 otherwise Protestant: Dummy variable for being protestant Christian	+/-
Protestant	Dummy	1 if household head is follower of protestant Christian, 0 otherwise	+/-
Moslem	Dummy	1 if household head is Moslem, 0 otherwise	+/-
Location	Dummy	1 if mid land; 0 otherwise	+ midland
Farmers' cooperative membership	Dummy	Households who are being farmers' cooperative membership, 1 if yes; 0 otherwise	+
Participation in Training	Dummy	Households who participate on training about improved teff varieties,1 if access; 0 otherwise	+ +
Access to credit services	Dummy	Households who access to credit utilization, 1 if accessed 0 not	+
Frequency of extension contact	Continuous	Number of extension contact measured in 'time' in a production year	+
Distance to the nearest market.	Continuous	Distance of the nearest market from the hhs resident in Kilometers	-
Livestock sizes	Continuous	Number of livestock owned by respondent hhs in Tropical livestock Unit(TLU)	+
Land allotted to teff production	Continuous	land allocated for teff cultivation in hectare	+

Source: Own Source, 2020

4. RESULTS AND DISCUSSION

Result and discussion consists of three sub sections: The first one is description of sample household performance characteristics. The second subsection is estimation of adoption status of improved teff variety (quncho) adoption. The third sub-section is estimation results of impact study on productivity which include propensity score matching, treatment effect and sensitivity analysis results

4.1 Descriptive Results

The study presents the descriptive and inferential results explaining the variables which affect adoption of improved teff(quncho) variety among smallholder farmers' and examining the propensity of adoption of improved teff (quncho) variety and its impact on productivity. It analyzed through the statistical analysis of descriptive tools and empirical results of econometric models.

4.1.1 Household Performance characteristics

4.1.1.1 Characteristics of respondents for continuous variables

Age of Household Head: As indicated on the table below the mean age of households head for the adopter of improved teff(quncho) variety was 40.17 years and for non-adopter the mean age was 33.88 years. The t-test result indicated that adopter households were elder than non-adopters at 10% significant level. This is because of older farmers have more farming experiencing than non-adopters. Farmers with higher experience appear to have often full information and better knowledge and were able to evaluate the advantage of the technology. This is congruent with the findings of (Abadi *et al, 1999*; Mulgeta (2009).

Productive family members: This variable indicated that the mean of productive family members for adopter households have more greater than for the non-adopters by 0.41 factors. i.e. the mean of labor availability for adopter households was 2.96 and for non-adopter households was 2.55 at 1% level of significance. The t test result indicated that adopter of improved teff (quncho) variety have more labor availability than non-adopters. Because of the adopters need more work force than non-adopters (Beshir *et al.,* 2012).

Tropical Livestock Unit (TLU): The mean livestock size for adopter households were 11.59 and 8.40 for non-adopter households at 10% significance level. The t test result indicated that farm households who were adopters of improved teff(quncho) variety has more livestock than non-adopters of improved teff(quncho) variety. Because of livestock are assets which generate cash by selling them to buy the modern varieties for adoption purpose. Supported by (Techane, 2002) shows those households with larger TLU have better economic strength and financial position to purchase sufficient amount of fertilizer.

Dependency Ratio: From the table below the mean dependency ratio of adopter households were 0.36 and for non-adopter were 0.52 at 10% level of significance. This result showed that a farm households who are adopter of improved teff(quncho) variety has less dependency ratio than non-adopters of improved teff(quncho) variety. Here households who have more dependent family members are not effective for adopting improved teff(quncho) variety, because they are not active for working in the field.

Frequency of extension contact: The mean of frequency of extension contact for adopter households were 2.37 and for non-adopters were 2.03 at 1% level of significance. The t test result indicated that adopter farm households are more frequent to contact DAs, experts, and extension agents than non-adopters for the sake of adopting improved technologies. Because of as frequent to contact DAs, and agricultural experts the farm households got information about modern technologies and conciseness to adopt those modern varieties. When farmers have regular contact with extension agent, probability of using production enhancing inputs would increase through increased awareness from the extension organization. This is in line with the findings of (Asfaw *et al.,* 2012; Kidane, 2001)

Table 3: Characteristics of respondents for continuous variables

Variables	Mean			
	Adopters	Non adopters	t-value	p-value
Age of households head	40.17557	33.88776	-6.3611***	0.0000
Education level of HH head	6.221374	6.040816	-0.4891	0.6251
Productive family members	2.959695	2.545918	-2.6642***	0.0081
TLU	11.59174	8.401582	-6.6534***	0.0000
Dependency ratio	.5026718	.6993367	5.2197***	0.0000
Frequency of extension contact	2.374046	2.035714	-2.0012**	0.0462
Distance to the nearest market	57.59542	60.48469	1.0676	0.2865
Land allotted to teff production	2.101374	1.779541	-0.6180	0.5370

Note: ***, ** indicates significance level at 1% and 5% respectively
Source: Author calculation from survey data, 2020

4.1.1.2 Characteristics of respondents for dummy variables

Land Certificate: land certificate means the license given for farm households being the owner of the land from government. From the table below households who have land certificate were 91(69.46%) for adopter households and 86(30.53%) for non-adopters at 1% significance level. The chi2 result indicated that a farm households who have licensed for his/her land owner were adopter of improved teff(quncho)variety than non-adopters at 1% level of significance .

Participation in Training: From below table farm households who have participated in training was adopters of improved teff(quncho) variety than non-adopters. The chi ^{2} test indicated that 59.54% of adopter was the hhs who participate on training at 5% level of significance.

Marital Status: Marital status of households has positive relationship with adoption of improved varieties. The chi2 result indicates that 88.55% of adopters of farm households are married households at 5% level of significance. This indicates that rather than being sole working, together is more energizer. Being Synergy gives high amount of production than solely farmers.

Table 4: Characteristics of respondents for dummy variables

Variables	Adopters (n=131)		Non adopters(n=196)		Total		χ2 – value
	N	Percentage	N	Percentage	N	Percentage	
Sex of household head							0.1819
Male	99	75.57%	144	73.47%	243	74.31%	
Female	32	24.43%	52	26.53%	84	25.69%	
Off/ nonfarm income							19.0160
Has nonfarm income	51	38.93%	34	17.35%	85	25.99%	
Has farm income	80	61.07%	162	82.65%	242	74.01%	
Land certificate							20.7055***
Has land certificate	91	69.46%	86	43.88%	177	54.13%	
Hasn't land certificate	40	30.53%	110	56.12%	150	45.87%	
Farmers' cooperative membership							2.3298
Yes	91	69.46%	120	61.22%	209	63.91%	
No	40	30.53%	76	38.78%	118	36.09%	
Access to credit services							0.3412
Access	40	30.53%	54	27.55%	94	28.75%	
Not access	91	69.46%	142	72.45%	233	71.25%	
Participation in Training							4.9968*
Participate	78	59.54%	92	46.94%	170	51.99%	
Not participate	53	40.46%	104	53.06%	157	48.01%	
Marital status							6.4234*
Married	116	88.55%	152	77.55%	268	81.96%	
Not married	15	11.45%	44	22.45%	59	18.04%	
Religion							12.26
Orthodox	40	30.53%	81	41.32 %	121	37%	
Protestant	81	61.83%	84	42.86 %	165	50.46%	
Muslim	10	7.63 %	31	15.82 %	41	12.54%	
Location							1.4111
midland	88	67.18%	119	60.71%	207	63.30%	
lowland	43	32.82%	77	39.29%	120	36.70%	

Note: ***, * indicates significance level at 1% and 10% respectively

Source: Author calculation using survey data, 2020

4.1.2 Comparison of households in terms of average teff productivity

The descriptive result of the outcome variable is mentioned in the table below, indicated that average teff productivity gained from improved quncho teff variety is 1853.14 kg/ha and 857.40 kg/ha for adopters and non-adopters respectively. It implies that the adopter households got more teff yield than non-adopters of improved teff (quncho) variety. This result showed that there is a significant difference between adopter households and non-adopter households of improved teff (quncho) variety. The t-test also showed that statistically significant difference at 1% probability level.

Table 5: Comparison of households in terms of average teff productivity in kg/hectare

Group of HHs	Observation	Mean of productivity (Kg/Ha)	Std. Dev.	t-value
Adopters	131	1853.142	281.9244	
Non-adopters	196	857.4082	298.1105	
Combined	327	1256.311	568.9122	-30.2434***
Diff		995.7336		

Note: *** means significance at 1% probability level

Source: Author calculation from survey result, 2020

4.1.3 Adoption Status of farm households on improved teff (quncho) variety

4.1.3.1 Adoption Status of improved teff(quncho) variety by Sampled Kebeles

The adoption status of improved teff (quncho) variety of the three years of adoption in the samples kebele was mentioned below according to its frequency and percentage of adoption. Out of this 43(32.82%), 44(33.59%), 44(33.59%) of farm households are adopting improved teff (quncho) variety in the Bagin, Chefé Gudina and Lalistu Sombo kebeles respectively. In the study area, 60% of farm households are non-adopters of improved teff (quncho) variety adoption and 40% of the farm households are adopters of improved teff(quncho) variety. This indicated that till now the highest part farm households are refusing to adopt improved technologies.

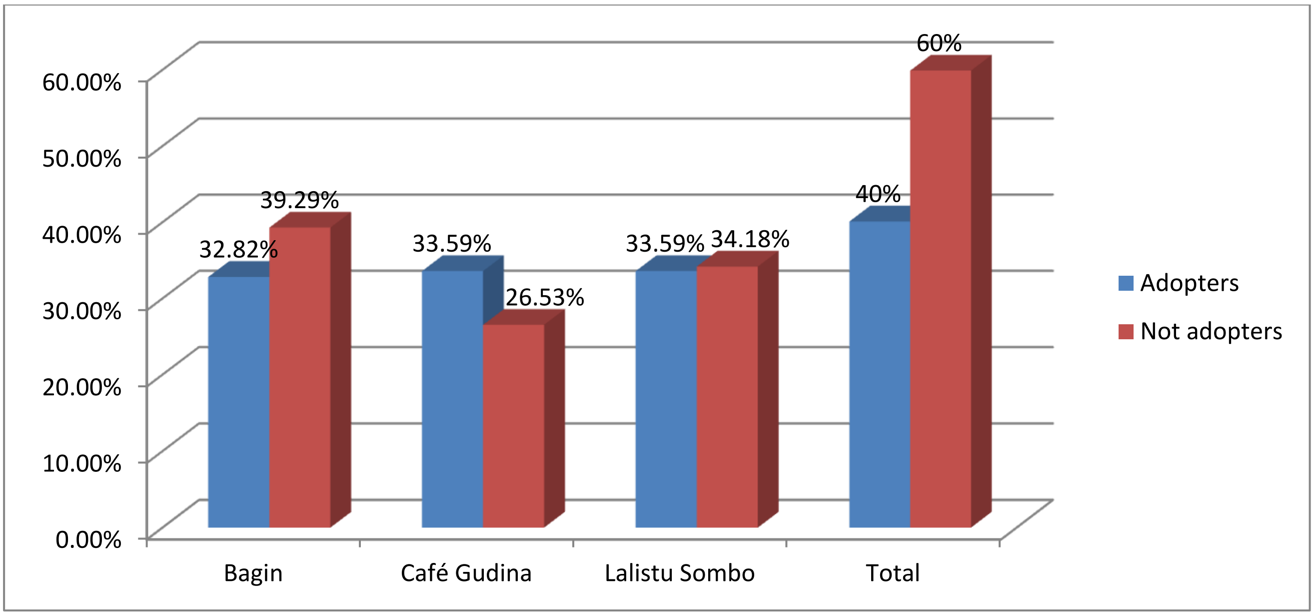

Figure 3: Adoption Status of Sampled Kebeles on improved teff (quncho) variety

Source: Author calculation using survey data, 2020

The explanation result which given from key informant interview and the conducted survey indicated that most producer of improved teff variety (quncho) adopter used by row planting, means 75.57% used in row planting and the rest 24.43% of them used broadcasting.

Table 6: Planting Methods

Variables	Adopters (n=131)		Non adopters(n=196)		Total		χ2 – value
	N	Percentage	N	Percentage	N	Percentage	
Planting Method							53.8155***
Row planting	99	75.57%	67	34.18%	166	50.76%	
Broadcasting	32	24.43%	129	65.82%	161	49.24%	

Source: own calculation from survey result and key informant interview, 2020

Key informant interview informs that to fasten row planting with in farm community: different awareness was given to farmers as demonstrations, training, and direct assistance in their farm land were taken by woreda and kebele experts. But, most respondent households blamed that government agents, DAs and experts didn't respond them in time. Also they key informants and respondent farm households rose pests and termites were haven't got solution. Because of lack of emphasis on farmers productivity during teff maturity, matured teff was deteriorates by pests, weather condition and termites. So, they need assistance from all concerned bodies, government and NGOs to sustain their farm productivity.

4.1.4 Adoption status of households by land allotted to teff production

Alemayehu *et al. (*2012) addressed that Ethiopian farms are classified into two major groups: smallholder farms (less than 25.2ha) and large commercial farms (more than 25.2ha). The majority of farmers in Ethiopia are smallholder farms, producing mostly for own consumption and generating only a small marketed surplus. Here from the graph bellow out of 53.43% of teff operated land, only 15.26% of land was operated for improved quncho teff variety. This states as most farmers didn't allocate more of their farm land for improved Quncho variety and also in study area about 80% of farm households or more than three times of households are producing improved teff variety (quncho) on less than two hectares of land.

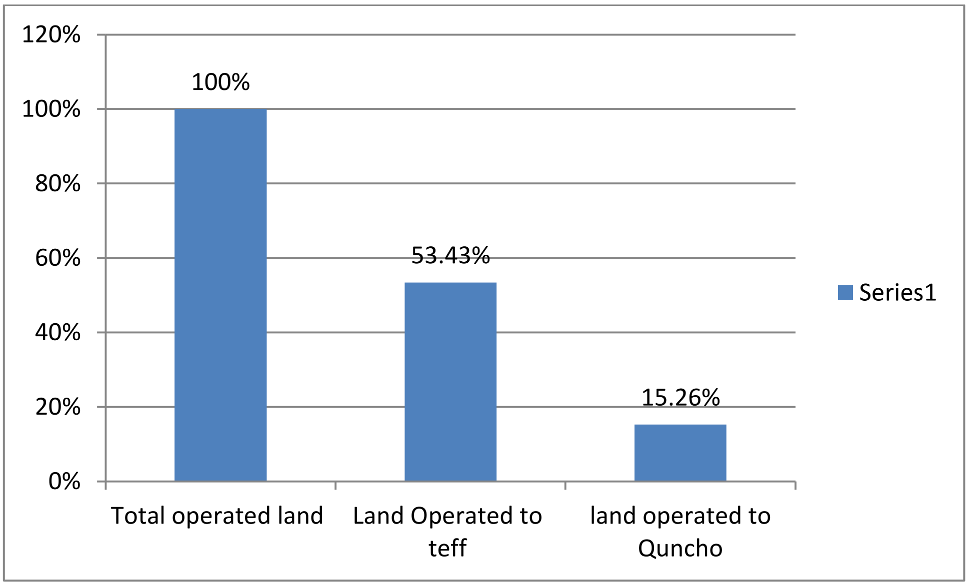

Figure 4: Adoption status of households by operated land

Source: own calculation from survey result, 2020

4.2 Results of Econometrics Model Analysis

This section describes econometric analysis which was followed to identify the factors that determines adoption of improved teff variety (quncho) on households' teff productivity. These determinants are analyzed by binary logit model and PSM was used to explain the impact of adopting teff variety (quncho) on teff productivity. It explains the estimation of propensity scores, defining common support region, choosing matching algorism, testing matching quality, calculating average treatment effect on treated and sensitivity analysis.

4.2.1 Estimation of propensity scores

In the propensity Score Matching, the first step is to estimate the propensity scores by using either logit or probit models. Caliendo and Kopeining (2008) noted that the logit model which has more density mass in the bounds could be used to estimate propensity scores. The logit model is used to estimate the adoption probability in this study. The logit result of this finding indicated that a McFadden pseudo R2 value of 0.278 and log likelihood value of -158.90 According to thumb rule of McFadden pseudo R2 of the model should be 20 to 40 to explain the goodness of fit of the model. Pseudo- R2 indicates how well the independent variables explain the probability of involvement in dependent variable (Caliendo and Kopeinig, 2008). The LR chi2 test statistic (122.50) indicates that explanatory variables are jointly highly significant at 1% and these states that there is a relationship between the dependent and explanatory variables included in the model used. Therefore, in this study logit model was used to estimate the propensity score for matching households who adopt improved teff(quncho) variety with non-adopters.

4.2.2 Diagnostic Tests

Once you have fit the logistic regression model, you need to begin the process of model assessment. The first step in the process is usually to assess the significance of variables in the model. The likelihood ratio test for overall significance of the p coefficients for the independent variables in the model is performed in using the following equation (Verbeek, 2017).

$$G = -2[\ln(H0) - \ln(H1)]$$

Where H1 is the log likelihood of the fitted model and Ho is found by fitting constant only model.

The other important test is to produce classification table. The classification table tells us how good the fitted model is for prediction purposes.

Table 7: Classification table of the model

Logistic model for adoption

	--------- True -------		
Classified	D	~D	Total
+	91	38	129
-	40	158	198
Total	131	196	327

Classified + if predicted Pr (D) >= .5

True D defined as adoption! = 0

Sensitivity	Pr(+/ D)	69.47%
Specificity	Pr(-/~D)	80.61%
Positive predictive value	Pr(D/ +)	70.54%
Negative predictive value	Pr(~D/ -)	79.80%
False + rate for true ~D	Pr(+/~D)	19.39%
False - rate for true D	Pr(- /D)	30.53%
False + rate for classified +	Pr(~D/ +)	29.46%
False - rate for classified -	Pr(D/ -)	20.20%
Correctly classified		76.15%

Source: own calculation from survey data, 2020

As we can see from the above table, of the 327 samples included in the analysis, 76.15 percent of them are correctly classified on the basis of their personal (household) characteristics. Thus, the overall rate of correct classification is estimated to be 76.15, with 69.47% (91/131=69.47%) of the participants correctly classified (specificity) and 80.61% (158/196= 80.61%) of the non-participants correctly classified (sensitivity). As expected, classification is sensitive to the relative sizes of each component group, and always favors classification into the larger group.

Before running Tobit model, explanatory variables were checked for problems of multi-collinearity, endogeneity and heteroscedasticity. Following Gujarati (1995) the problem of multicollinearity for continuous explanatory variables was investigated using a technique of variance inflation factor (VIF) and tolerance level (TOL), where each continuous explanatory variable is regressed on all the other continuous explanatory variables. The larger is the value of VIF is the more worrying for the multicollinearity or collinear is the variable (Xi). As a rule of thumb, if the VIF of a variable exceeds 10 and R2 exceeds 0.90 the variable is said to be highly collinear. The values of VIF were less than ten (<10) and hence no signals of multicollinearity problems, on the table below there is no multicollinearity.

Healy (1984) as cited by Beshir *et al*. (2012) to observe the degree of association between dummy explanatory variables contingency coefficients were computed. Contingency coefficient is a chi-square based measure of association where a value 0.75 or above indicates a stronger relationship between explanatory variables. This is checked and it is less than 0.75, means there no multicollinearity between dummy independent variables. For endogeneity an attempt was made to exclude dependent variable as explanatory variable. To avoid heteroscedasticity problem, robust standard error was estimated. Therefore, the relationship between the adoption index (dependent variable) and predictor variables were computed by employing a propensity Score Matching (PSM) model. According to Abadi (2014) the robust standard errors computed from the model was become less than 3 indicate that there is no heteroscedasticity problem. Here from the result of bellow model the robust standards are also less than 3 which imply that there is no heteroscedasticity problem.

4.2.3 Determinants of use intensity of improved teff variety (quncho) adoption

Tobit model is an extension of the probit model and it is really one approach to dealing with the problem of censored data. Tobit model was chosen for this study because of it has an advantage over other analytical models in that, it reveals both the probability of adoption and intensity of use of the technology (maddala, 1992). So, Tobit model is more appropriate to give reliable output of both discrete and continuous variable combination. The Tobit model was employed to identify the determinants of the technology package adoption and analyze farmers' probability of technology adoption and the intensity of adoption.

Table 8: Determinants of use intensity of improved teff (quncho) variety adoption: Tobit Model

Number of obs = 327

F(17, 310) = 10.30

Prob > F = 0.0000

Log pseudolikelihood = -354.65434 Pseudo R2 = 0.170

Land allotted IQT	Coef.	Robust Std. Err.	P>t	dy/dx
Sex	-.2822422	.0887631	0.416	-.2822422
Age	.0436487	.0024197	0.001	.0436487***
Education	.0626759	.0108834	0.086	.0626759*
Productive family members	-.2149584	.024961	0.121	-.2149584
Off/non-farm income	.8060156	.0688741	0.002	.8060156***
Livestock size	.1291184	.0074648	0.000	.1291184***
Land certificate	.8917025	.0820623	0.001	.8917025***
Dependency ratio	-3.38084	.1409186	0.000	-3.38084***
Farmers' cooperative membership	.404488	.0824043	0.115	.404488
Access to credit services	-.0318311	.0661015	0.920	-.0318311
Frequency of extension contact	.1422057	.0257914	0.113	.1422057
Distance to nearest market	-.0015187	.0013679	0.769	-.0015187
Participation in training	.5391878	.0764708	0.031	.5391878**
Marital status	.5953935	.0947332	0.137	.5953935
Orthodox	-9.226726	.0742893	0.000	-9.273888***
Muslim	-8.700011	.0609635	0.000	-9.878221***
Protestant	.5065908	.2929498	0.085	.5065908*
Location	-.0965235	.0813516	0.706	-.0965235
_cons	6.352016	.1023038	0.000	
/sigma	1.8342	.0249594		

196 left-censored observations at landalloted to teff <= 0

131 uncensored observations

Note: ***. **.* indicates significance level at 1%, 5%, 10% respectively.

Source: Author result of survey data, 2020.

Age: Age of the households head found to be positively and significantly affecting use intensity of improved teff variety (quncho) adoption at 1 % of significance level. The Tobit model result indicates that other factors remains constant, a year increases in the age of the respondent increases probability of adoption and use intensity of improved teff variety (quncho) adoption by 4percent. The reason could be the possibility for capitalization of information and knowledge about the technology packages through time is increasing as their age is getting older. This result is congruent with the study by Kebede *et al.* (2017); Hailu (2008) and Asfaw *et al.* (2012) found a positive influence of age on agricultural technology adoption in general. However, this may diminish, as the household head gets older (Beshir *et al.*, 2012). and in other hand (Jaleta *et al.* (2015) ; Melesse, 2018 ; Milkias and Abdulahi, 2018).

Education Level: is found to be positively and significantly affecting use intensity of improved teff variety (quncho) adoption at 10% significance level. The Tobit model result indicates that other factors remains constant, one unit increases in years of schooling of the respondents increases probability of adoption and use intensity of improved teff variety (quncho) adoption by 6percent. This means that as years of schooling of farm households' increase the probability to devote significant amount of land to improved teff variety was increased, because the more educated farmers have more perception on adoption of new technologies. More educated farm households may make a farmer more receptive to advice from an extension agency or more able to deal wit h technical recommendations that require a certain level of numeracy or literacy. This in line with Admassie and Ayele, (2010)

Off/non-farm income: It is positively and significantly affecting use intensity of improved teff variety (quncho) adoption at 1% of significance level. The Tobit model result indicates that other factors remains constant, a unit increases of farmers who participate on off/non-farm income activities increases the probability of adoption and use intensity of improved teff variety (quncho) adoption by 80 percent than who didn't participate on off/non-farm income. It hypothesized that households who participated on off/non-farm are more likely to allocate significant amount of land to improved teff variety (quncho) than households who didn't participated in off/non-farm income, because of money that they earn from non-farm leads the households to engage in the participation as well as adoption of new varieties. This is in line with the study of Alene *et al.* (2000); off-farm income has a positive but insignificant effect on the adoption and intensity of use of improved maize seed. Kassa (2014) Participating in off-farm activities can solve liquidity problem while intending to purchase chemical fertilizer and HYV.

Livestock Size: The livestock sizes of the respondent households have a positively and significantly affecting use intensity of improved teff variety (quncho) adoption at 1% significance level. The Tobit model result indicates that other factors keeping constant, unit increases in TLU increases probability of adoption and use intensity of improved teff variety (quncho) adoption by 12 percent. This is probably due to livestock ownership is considered as an asset that could be used either in the production process or it could be exchanged for cash (particularly small ruminants) for the purchase of land whenever the need to produce and diversify new varieties. Moreover, livestock is considered as a sign of wealth and increases availability of cash for adopting technologies. This is in line with the Beshir *et al*. (2012) and Tesfaye *et al*. (2016).

Land certificate: The households who have land certificate were positively and significantly affecting use intensity of improved teff (quncho) variety adoption at 1% of significance level. The Tobit model result indicates that other factors keeping constant, a unit increases of farmers who have land certificate increases the probability of adoption and use intensity of improved teff variety (quncho) adoption by 89 percent than who haven't land certificate. This hypothesis indicated that farmer households who have land certificates are more likely to devote significant amount of land to improved teff variety (quncho) than farmers who didn't have land certificate, because they allocate more land for improved varieties. This is in line with the findings of Admassu and Workneh (2016); they found that land use certificate has a positively associated with farmers field. Land tenure security is a key pathway for the development of the poor and contributes to achieving sustainable development goals (SDGs) since land is a basic socio-economic asset of agricultural based economics in developing countries (Mengesh *et al.*, 2019).

Dependency Ratio: Is the ratio of dependent family members to the active working age of family members. It is negatively and significantly affecting use intensity of improved teff variety (quncho) adoption at 1% of significance level. The Tobit model result indicates that other factors keeping constant, a unit increases in Dependency ratio decreases probability of adoption and use intensity of improved teff variety (quncho) adoption by 38 percent. This indicates that households who have more dependent family members are likely to devote less amount of land to improved teff variety(quncho) than households who have less dependent family members. Because of burden of supporting family members fall in active labor within the households. This congruent with Dibaba et *al*. (2018); Adem (2016), and (Abera, 2015) founds that household members of holdings with high dependency ratios might not be able to participate in programs due to time, labor and financial constraints. but contrary to the results of Kebede *et al.* (2017) by two-limit Tobit model indicated that some respondents save labor, while others significantly demand it, and wheat technologies, unlike other crop technologies do not require intensive labor.

Participation in Training: is positively and significantly affecting use intensity of improved teff (quncho) variety adoption at 5% of significance level. The Tobit model result indicates that other factors keeping constant, unit increases of farmers who participated in training increases probability of adoption and use intensity of improved teff variety (quncho) adoption by 53 percent than who didn't participated in training. It means that farm households who are accessed in training on technology adoption are more likely to devote significant amount of land to improved teff variety (quncho) than households who didn't participate in training. It is congruent with the Shiferaw *et al.* (2014). Milkias and Abdulahi (2018) studied on determinants of agricultural technology adoption: the case of improved highland maize varieties in Toke Kutaye District, Oromia Regional State, Ethiopia, revealed that participation in training positively affect adoption of improved highland maize varieties.

Religion: In study area religions like Orthodox and Muslems are significantly and negatively affecting use intensity of improved teff variety (quncho) adoption at 1% significance level. While, protestant Christian is positively and significantly affecting use intensity of improved teff variety (quncho) adoption at 10% significance level.

The result suggests that both Moslems and Orthodox Christians are less likely to devote significant amount of land to improved teff variety (quncho) than ther religions. One may argue that orthodox Christians and Moslems are relatively more conservative than other types of reli gious practices and thus resists change or changes are slow (Admassie and Ayele, 2010)**.**

4.2.4 Impact of improved teff(quncho) variety adoption on productivity

4.2.4.1 Estimated Propensity Score Matching

Adoption of improved teff variety (quncho) is significantly affect teff productivity of the farm households. The impact of adoption of improved teff variety (quncho) on productivity is mentioned as the follows. Propensity Score Matching (PSM) is used for approximating a randomized experiment and reducing the selection bias in observation studies. On average, individual respondents with same propensity score are balanced on covariates and the counterfactual (the result for the treated observations if they were instead not treated) can be estimated within that group. The propensity score is the conditional (predicted) probability of receiving treatment given the relevant controls X (Rosenbaum and Rubin, 1983). To know the impact of this adoption on productivity, the treated and controlled variable needs to match each other's. Thus, the process of matching creates a high degree of covariate balance between the treatment and control samples that were used in the estimation procedures.

Table 9: Performance of different matching estimators

Matching estimators	Balancing test	Pseudo R2 after matching	Matched sample size
Nearest Neighbor(NN)			
Neighbor (1)	14	0.141	326
Neighbor (2)	17	0.046	326
Neighbor (3)	18	0.035	326
Neighbor (4)	18	0.031	326
Caliper			
Caliper(0.01)	15	0.129	293
Caliper(0.1)	14	0.141	326
Caliper(0.25)	14	0.141	326
Caliper(0.5)	14	0.141	326
Kernel			
With band width of (0.08)	19	0.026	293
With band width of (0.1)	18	0.034	326
With band width of (0.25)	19	0.032	326
With band width of (0.5)	15	0.069	326
Radius			
With band width of (0.01)	8	0.299	326
With band width of (0.1)	8	0.299	326
With band width of (0.25)	8	0.299	326
With band width of (0.5)	8	0.299	326

Source: own calculation from survey result, 2020

4.2.4.2 Choice of Matching Algorithm

Matching estimators like Nearest Neighbor (NN), Kernel Matching (KM) Caliper Matching (CM), and Radius Matching were used to match the treatment and control households in the common support region. The final choice of a matching estimator guided by different criteria such as equal means test(balancing test), low pseudo-R2 and greater number of matched sample size are some of the criteria to select matching algorithm (Dehejia and Wahba, 2002). Balancing test refers number of explanatory variables with no statistically significant mean differences between the matched groups of treatment and control households. The table below shows after looking into the results, guided by the indicators; it was found that Nearest Neighbor (4) was the best estimator for the data at hand. Therefore, the following estimation results and discussion are the direct outcomes of the Nearest Neighbor (4) algorithms. As the estimation results follows and discussions are the direct outcomes of Nearest Neighbor (4) are the best matching algorithm. This study used to estimate the average treatment effect on the treated (ATT) of outcome variable or objective of this study based on the results obtained from the Nearest Neighbor (4).

4.2.4.3 Matching of Treated and Control Groups

The propensity scores vary between 0.0730863 - 0.9860736 for adopter of improved teff variety (quncho) with mean score of 0.6180169 . Whereas the score vary between 2.41e-06 – 0.983041 for non-adopter households with mean score of 0.2552962 . The common support then lies between 0.0730863 - 0.983041. This means that households whose propensity score less than minimum (0.0730863) and larger than maximum (0.983041) are not considered for matching purpose. Based on this procedure, 1 households discarded from adopters of improved teff(quncho) variety.

Table 10: Summary of propensity scores of improved quncho teff variety adoption

Variable	Observation	Mean	Std. Dev.	Min	Max
Adopters	131	.6180169	.2495226	.0730863	.9860736
Non adopters	196	.2552962	.2215982	2.41e-06	.983041
Total respondents	327	.4006063	.2930702	2.41e-06	.9860736

Source: own calculation from survey data, 2020

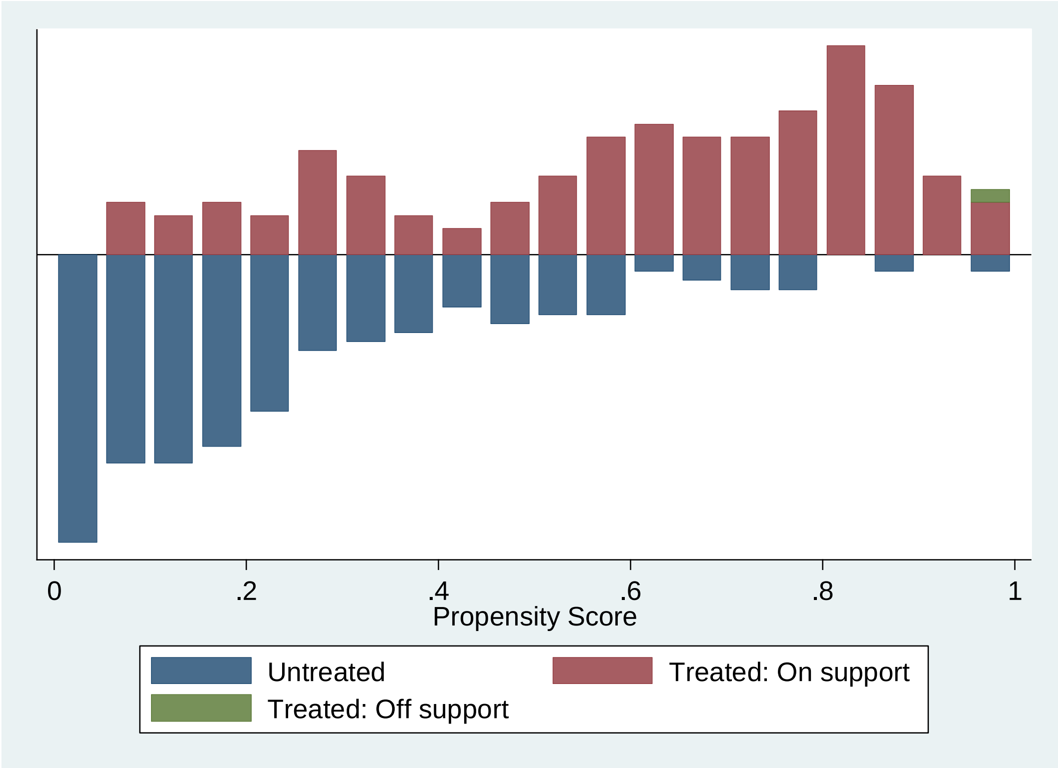

Figure 5: Propensity Score Distributions and Common Support for the Propensity Score

Source: Author calculation using survey data, 2020

4.2.4.4 Testing Propensity Score and Covariates balance

After selecting best performing matching algorism which satisfies prior identified performance criteria, balance of propensity score and explanatory variables was checked by the selected matching algorism of Nearest Neighbor(4) the table below shows that the standard bias difference between explanatory variables before matching was in the range of 4.8% - 73.8% in absolute value and after matching was 0.1 % - 19.4 % in absolute value which is below the critical level of 20% suggested by Rosenbaum and Rubin (1985). It is clear that the main intention of estimating propensity score is not to get a precise prediction of selection into treatment. Rather, to balance the distributions of relevant variables in both groups (Caliendo and Kopeinig, 2008).

The t-test suggests that differences in household characteristics between the treatment and control groups are jointly insignificant both before and after matching. The main purpose of the estimation of propensity score is to balance the distributions of relevant variables in both treatment and control groups, but not to obtain a precise prediction of selection into treatment.

Therefore, the selected matching algorism, Nearest Neighbor(4) has created a covariate balance between adopters of improved teff(quncho) variety and non-adopter households, which is important to conduct impact analysis.

Table 11: Propensity score and covariate balance

Variables	Before matching				After Matching			
	Mean		%reduct	t-test	Mean		%redu	t-test
	Treated	Control	%bias	T	Treated	Control	%bias	T
Pscore	.61802	.2553	153.7	12.88	.61519	.60961	2.4	0.18
Sex of HH head	.75573	.73469	4.8	0.43	.75385	.68462	15.8	1.24
Age of HH head	40.176	33.888	71.3	6.36	40.085	40.696	-6.9	-0.49
Educational level of HH head	6.2214	6.0408	5.5	0.49	6.2692	6.3231	-1.6	-0.12
Marital status (1=married)	.8855	.77551	29.5	2.55	.88462	.87692	2.1	0.19
Orthodox	.31298	.41327	-20.9	-1.84	.31538	.26154	11.2	0.96
Protestant	.61069	.42857	37.0	3.27	.60769	.67885	-14.4	-1.20
Muslim	.07634	.16327	-26.9	-2.31	.07692	.05962	5.4	0.55
Location(1=midland)	.67176	.60714	13.4	1.19	.66923	.67115	-0.4	-0.03
Productive family members	2.9597	2.5459	30.4	2.66	2.9615	3.1208	-11.7	-1.00
Off/ non-farm income	.38931	.17347	49.3	4.48	.38462	.43462	-11.4	-0.82
TLU	11.592	8.4016	73.8	6.65	11.477	11.527	-1.2	-0.09
Land allotted to teff production	2.1014	1.7795	7.6	0.62	2.0868	1.7954	6.9	0.87
Land certificate(1=yes)	.69466	.43878	53.3	4.69	.69231	.65962	6.8	0.56
Dependency ratio	.50267	.69934	-62.5	-5.22	.50323	.50283	0.1	0.02
Farmers' Cooperative membership	.69466	.61224	17.3	1.53	.69231	.675	3.6	0.30
Access to credit services	.30534	.27551	6.6	0.58	.30769	.22115	19.0	1.58
Frequency of extension contact	2.374	2.0357	22.7	2.00	2.3923	2.3058	5.8	0.49
Distance to the nearest (Km)	57.595	60.485	-12.4	-1.07	57.577	57.625	-0.2	-0.02
Access to training	.58779	.45408	26.9	2.38	.58462	.48846	19.4	1.56

Source: Author calculation from survey result, 2020

4.2.4.5 Propensity score matching and quality test

On quality test, the percentage bias reduction indicates that after matching the covariates have been balanced and there is not much difference between adopters and non-adopters of improved teff variety (quncho). Another test employed to check the matching quality is the value of pseudo R^2 before and after matching. The value of pseudo R^2 should be quite high before matching and should be quite low after matching; the value of pseudo R^2 was very low. The low pseudo R^2, low mean standardized bias, high total bias reduction, and the insignificant p-values of the likelihood ratio test after matching suggest that the proposed specification of the propensity score is fairly successful in terms of balancing the distribution of covariates between the two groups (Caliendo and Kopeinig, 2008).

This low pseudo-R^2 value and the insignificant likelihood ratio test indicated that adopters of improved teff variety (quncho) and non-adopter households had the same distribution in the covariates after matching. These results indicated that the matching procedure is able to balance the characteristics in the treated and the matched comparison groups. Hence, these results can be used to assess the impacts of adoption of improved teff variety (quncho) on households' productivity by having similar observed characteristics. This enables to compare observed outcomes for adopter households with those of a non-adopter households group sharing a common support. After matching the value of pseudo R^2 close to zero indicating that after matching the covariates have been balanced and there is no systematic differences between adopters and non-adopters of improved teff variety (quncho).

From the table11 below the standardized mean bias for over all covariates used in the propensity score was 36.3% before matching and it was reduced to 7.3% after matching. As well as there was 30 % pseudo R2 before matching and it was dropped to 3.1 % after matching. This low pseudo R2, low standardized bias, the pseudo R was high total bias reduction and the insignificant p-values of the likelihood ratio test after matching suggest that the specification of the propensity is successful in terms of balancing the distribution of covariates between the treated and control groups.

Table 12: Propensity score matching: quality test

Sample respondents	Pseudo R2	LRchi2	p>chi2	MeanBias	MedBias	B	R	%Var
Unmatched	0.307	135.09	0.000	36.3	26.9	150.5*	0.96	33
Matched	0.031	13.15	0.831	7.3	6.3	45.9*	1.48	33

Source: Author calculation from survey result, 2020

All of the above tests suggest that the matching algorithm chosen was relatively best for the data of this study. Therefore, it was possible to proceed to estimate the average treatment effect on the treated (ATT) for the sample households.

4.2.4.6 Treatment Effect on the Treated (ATT)

The estimated average treatment effect (ATT) of sample households showed that adoption of improved teff variety (quncho) has strong significant effect on teff productivity of treated farm households. As the table below result showed ATT estimation using Nearest Neighbor (4) which summarized as the outcome variables that is teff productivity of adopter households and non-adopter households. After controlling for differences in socio-economic characteristics of the adopter and non-adopter households, it has been found that, the average involvement in adoption of improved teff variety (quncho) has impact on teff productivity of the adopter households in adoption of improved teff variety (quncho) by 859.24Kg/ha.

Here from the table below the average treatment effect on the treated (ATT) of teff productivity of treated groups earned 1851.56 Kg/ha, while controls (untreated) groups earned 992.31Kg/ha which indicated 859.24Kg/ha difference of teff productivity and t- value of 15.09 that the adopter households gained than non-adopter households. Tesfaye and Bedada (2016) emphasized that the income gains from improved wheat varieties was higher for those households who endowed with larger land size.

Generally, this treatment effect on the treated indicates that the adopter households could generate about 859.24Kg/Ha of teff yield than non-adopter households. The result indicates that the propensity of adoption decision of improved teff variety (quncho) has resulted in a positive and statistically significant difference between adopters and non-adopters in terms of teff productivity of farm households.

Table 13: Treatment Effect on the Treated (ATT) .

Outcome Variable	Sample	Treated	Controls	Difference	S.E.	T-stat
Teff productivity	Unmatched	1853.14	857.40	995.73	32.92	30.24
	ATT	1851.56	992.31	859.24	56.94	15.09***

The bootstrapped SE obtained after 100 replications. Note: *** significant at 1% probability level

Source: Author calculation, 2020.

4.2.4.7 Sensitivity Analysis

Propensity score matching is a methods that evaluates the robustness impact of selection bias of only observed characteristics; It cannot account for unobserved factors affecting adoption status; the basic idea behind PSM is to match each adopter with an identical non-adopter and then measure the average difference in the outcome variable between the two (Dehejia and Wahba, 2002) . Since it is not possible to estimate the magnitude of selection bias with non-experimental data, the problem can be addressed by sensitivity analysis. Rosenbaum (2002) proposes using Rosenbaum bounding approach in order to check the sensitivity of the estimated ATT. In order to check for unobservable biases, sensitivity analysis was performed on the computed outcome variables using Rosenbaum bounding approach with respect to deviation from the conditional independence assumption. The result showed that the inference for the effect of the adoption is not changing adopter and non-adopter households has been allowed to differ in their odds of being treated up to 100% at critical sigma 2 in terms of unobserved covariates. That means for all outcome variables estimated, at various level of critical values, thus the study conclude that my impact estimates (ATT) are insensitive to unobserved selection bias and are a pure effect due to the households' participation on adoption.

The first column of the table shows those outcome variables which bear statistical differences between improved teff variety (quncho) and non-adopter households in impact estimate. The results show that inference for the impact of adoption does not change, even though the adopter and non-adopter households were allowed to differ in their odds of being treated up to 200% ($e\gamma=2$) in terms of unobserved covariates. That means for all outcome variables estimated, at various level of critical value of $e\gamma$, the p- critical values are significant which further indicate that the study has considered important covariates that affected both adoption and outcome variables. Thus, it is possible to conclude that impact estimates (ATT) of this study for each outcome variables was insensitive to unobserved selection bias

4.3 Constraints of improved teff variety (quncho) adoption

According to the discussion held by FGD and survey result, the participant of FGD and respondent households faces different constraints which hinder their adoption status of improved teff variety (quncho) in study area. Those constraints are lack of improved seed varieties & unavailable supply of improved seed on time of planting and Crop diseases & pests are the most constraints that affect the teff productivity of the farm households.

Table 14: Constraints of improved teff variety (quncho) adoption

Constraints for adoption of ITVs	Adopters (n=131)		Non adopters (n=196)		Total	
	N	% age	N	% age	N	% age
Lack of improved seed variety	13	9.92	51	26.02	64	19.57
Unavailability supply of improved seed during planting	26	19.85	42	21.43	68	20.80
Lack of fertilizer	1	0.76	3	1.53	4	1.22
Crop diseases & pests	31	23.66	27	13.78	58	17.74
Lack of training	17	12.98	21	10.71	38	11.62
Lack of improved & unviability of improved seed on time of planting	27	20.61	33	16.84	60	18.35
All constraints mentioned above	16	12.21	19	9.69	35	10.70
Total HHs	131	100.00	196	100.00	327	100.00

Source: Author calculation using survey data, 2020

The other problem that FGD results revealed was lack of effective marketing system or market structure in the study area. That means there is no market for grain crops which benefit farmers as their effort. Here they said that due to the increment of input price with in time period, the farmers unable to afford input factors to adopt improved varieties on their small plotted land. They warmly respond that farmer households didn't return his/ her effort, rather its tedious work for farm households. Still they were waiting governments' response on their output price.

5. SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 Summary

Increasing agricultural productivity is the core agenda to enhance food security of the households in Ethiopia. To increase the productivity of smallholder farmers, adoption of modern agricultural technologies is an important means, and is believed to improve the income of the smallholder farmers through enhancing agricultural productivity. As well as developing and achieving agricultural productivity is possible if and only if disseminating yield increasing technologies in for rural farmers.

Even though increasing agricultural productivity is not enough for food sustenance to meet human needs in the study area and also in Ethiopia. This inefficient productivity is affected by demographic factors, social factors and institutional factors and soon. So, this study was conducted to identify those factors/determinants/ on adoption of improved teff variety (quncho) to enhance teff growers productivity. This study was to analyze the determinants of use intensity of improved teff variety (quncho) adoption and its impact on productivity.

The empirical analysis utilizes cross-sectional farm household level data collected from a randomly selected 327 farm households, 131 producers of improved teff variety (quncho) and 196 from non-producer of improved teff(quncho) during the survey time in Kiramu district. Structured questioner was designed for the survey data collection. Both descriptive and inferential statistics was used to analysis the result of the study. Descriptive statistics such as mean, percentage and standard deviation of the two groups was analyzed. Inferential statistics like chi-square and t-test also applied to show dummy and continuous independent variables. Also econometrics models like Tobit model and propensity score matching were applied to analyze the final result of the study.

The result of Tobit model showed that: Age of the households head, off-farm income, livestock size, land certificate, protestant Christian followers, and access to training have positive influence on use intensity of improved teff variety(quncho) adoption. But, dependency ratio and Orthodox and Muslim followers have a negative influence on the improved teff variety (quncho) adoption in the study area. Additionally, unavailability of improved technologies on time of planting, lack of supply of technologies, unable to visited by extension workers, woreda experts and there is no agricultural research institute around their woredas for the deliverance of improved technologies. Due to termites and pests on time of harvesting their productivity becomes decline are the main problems of farm households in the study district. The result of propensity score matching (PSM) was showed that the average treatment effect on the treated (ATT) of improved teff variety (quncho) adopter got 859.24kg/ha of teff yield than non-adopters. This indicated that on adopter households get 859.24kg/ha more teff productivity than non-adopter households due to involvement in adoption of improved teff variety (quncho) in the study area.

5.2 Conclusion

This study focused on the determinants of use intensity of improved teff variety (quncho) adoption and its impact on productivity in Kiramu district, Oromia regional state, Ethiopia. The empirical analysis of this study used cross sectional type of data. The determinants of use intensity of adoption are analyzed based on Tobit model. The impact of adopting improved teff variety (quncho) adoption on productivity is based on Propensity score matching. This helps in estimating the true effect on an improved quncho variety by controlling for selection problem on production and adoption decisions.

The result from the study shows that in the determinants of use intensity of improved teff variety (quncho) adoption emphasized that: Age of farmer households significantly and positively affecting use intensity of improved teff variety (quncho) adoption. Older farmers devoted more amount of land to improved teff variety (quncho) adoption than younger farmers. This is due to accumulated knowledge gained through experience.

Off/non-farm income has positively and significantly affecting use intensity of improved teff variety (quncho) adoption. This means, because of the money that they earn from non-farm leads the households to engage in the participation to devote more amount of land to improved teff variety (quncho) adoption than households who didn't participated.

Livestock sizes have also positively and significantly affecting use intensity of improved teff variety (quncho) adoption. The largest amount of livestock is considered as a sign of wealth and increases availability of cash for purchasing land for the sake of adopting improved teff variety (quncho).

Land certificate was positively significant on the probability of use intensity of improved teff variety (quncho) adoption. It means HHs who has a land certificate have more probability to allocate improved teff variety (quncho) than households who haven't land certificate, because they considered as their own farm land.

Frequency of extension contact was significantly and positively affecting use intensity of improved teff variety (quncho) adoption. The study found access and availability of extension service to be more powerful than other factors in explaining adoption. This is due to technical support and some advice from experts; farm households are more likely to devote land to improved teff variety (quncho) adoption.

Participation in training has positively and significantly affecting use intensity of improved teff variety (quncho) adoption. It means that farm households who are accessed in training on technology adoption are more likely to devote significant amount of land to improved teff variety (quncho) than households who didn't participated in training. Because of households who have participated in training have more experience on adopting improved technologies than households who didn't participated in the same training.

Dependency ratio was negatively and significantly affecting use intensity of improved teff variety (quncho) adoption. It implies that farmers with high number of dependent family members are likely to devote less amount of land to improved teff variety (quncho) adoption. Because of the lack of labor force which involve in adopting improved teff variety (quncho) cultivation and prefer not to adopt the new technologies.

The results from the propensity score matching (PSM) model show that the households that use improved teff variety (quncho) tend to be different from those that do not. In addition, the households that use this variety tend to have higher teff productivity even after controlling for observed and unobserved factors. The average treatment effect on treated (ATT) indicates adopter households got 859.24Kg/Ha of teff yield per a hectare of land than non-adopters. This result shows the potential of improved seeds varieties in helping households in especially in rural areas increasing their productivity.

5.3 Recommendation:

Based on the result of empirical model analysis the study recommend on the following demographic and socio economic related factors affecting use intensity of improved teff variety (quncho) adoptions and its impact on farm productivity as follows:

Age of household heads was positively and significantly affecting use intensity of improved teff variety (quncho) adoption on teff productivity. Therefore, Capacity building, experience sharing with model farmer and experience sharing from elders is solution for boosting productivity.

Off/non-farm income: Has positively and significantly influencing use intensity of improved teff variety (quncho) adoption. To increase the rural farmers' productivity, farmers need to diversify their income by participating on different income generated jobs next to their farm income. Therefore, government agents better to facilitate additional work for rural farmers by expanding rural infrastructures, and also establish agricultural development project by giving per time work for rural farmers. NGOs, Government bodies and other fund rising bodies better to award and give recognition for model farmers, as well as to promote model farmer to entrepreneurs and investors could invite other small holder farmers initiate to hard work habit.

Livestock size was affecting use intensity of improved teff variety (quncho) adoption positively and significantly. Farm households who have large livestock size are likely to devote more amount of land to improved teff variety (quncho) adoption. Therefore, farmers, animal veterinary experts, international and national livestock research institute have to strengthening the existing livestock production system through providing improved health services, better livestock feed (forage), adopting agro-ecologically based high-yielding breeds and disseminating artificial insemination in the study areas.

Land certificate was also affecting use intensity of improved teff variety (quncho) adoption positively and significantly. So, the farmer care to improve his/ her productivity by compromising to improve his/her land fertility. In the study area all farm households haven't got land certificate, so, the Government have to give a land certificate for all households to protect it as their own property.

Frequency of extension contact was positively and significantly affecting use intensity of improved teff variety (quncho) adoption. To sustain productivity of farm households, development agents and experts increase the frequency of extension contacts by identifying the farmers' situation and giving advice, demonstration, and reporting the problems that face farmers' productivity. The district's agricultural and rural development office and other stakeholders' have to work together to fasten the frequency of extension visits with farmers on agricultural technologies particularly on improved teff variety (quncho) adoption.

Participation in training is positively and significantly affecting use intensity improved teff variety (quncho) adoption. To increase the intensity of land to improved teff variety (quncho) adoption: NGOs, Government agents, and experts' needs to give information about the new varieties and it's important by multimedia, mini media and other information dissemination tools. As well as training and demonstration give experience on how to use improved technologies and expand through farm communities. So, government agents, experts and NGOs better to give emphasis on training farm households on technology adoption.

Dependency ratio has negatively and significantly influencing use intensity of improved teff variety (quncho) adoption. It reveals that dependent family members of the households indicate that households with large dependent family members had lower rates on devotion of land to improved teff variety (quncho) adoption. So, governments and NGOs better to supply improved farm machinery like tractors, combinors to less labor intensive farmers to encourage their initiation to adopt improved teff varieties by allocating more land.

Generally, it is recommended that agricultural research institutions and extension agents are vital for the development and dissemination of new technologies and these services need to be strengthened. So, it's better if they combine together to disseminate information for the rural farm households in all area of the countries by using social medias, radios and other information dissemination instruments. This suggests that there is a continuing need to link research and extension agents.

Governments also increase budgetary support for extension services; strengthening these services may also involve private sector and NGO participation. Policies better to support the development and expansion of efficient markets for inputs and outputs. Seed providers supply the varieties early planting and supply according to farmers need and governments, experts and NGOs find the solution for the termites and pests which damage their productivity

6. REFERENCES

Abera, H.B., 2008. Adoption of improved tef and wheat production technologies in crop-livestock mixed systems in northern and western Shewa zones of Ethiopia (Doctoral dissertation, University of Pretoria).

Abewa, A., Yitaferu, B., Selassie, Y.G. and Amare, T., 2014. The role of biochar on acid soil reclamation and yield of Teff (Eragrostis tef [Zucc] Trotter) in Northwestern Ethiopia. *Journal of Agricultural Science*, *6*(1), p.1.

Adem, K. H. 2016. Impact of Small Scale Irrigation on Household's Food Security In Fentale District East Showa Zone of Oromia National Regional State, Ethiopia (Msc thesis Presented to the School of Graduate Studies of Haramaya University, Haramaya, Ethiopia

Ademe, A., Gurmis, N. & Tegegne, B. 2018. Market chain analysis of teff: The case of merhabete district, north shewa zone, amhara national regional state of ethiopia (doctoral dissertation).

Adesina, A.A. and Zinnah, M.M., 1993. Technology characteristics, farmers' perceptions and adoption decisions: A Tobit model application in Sierra Leone. *Agricultural economics*, *9*(4), pp.297-311.

Adimassu, Z., Langan, S., Johnston, R., Mekuria, W. and Amede, T., 2017. Impacts of soil and water conservation practices on crop yield, run-off, soil loss and nutrient loss in Ethiopia: review and synthesis. *Environmental Management*, *59*(1), pp.87-101.

Admassie, A. and Ayele, G., 2004. Adoption of improved technology in Ethiopia.

Admassie, A. and Ayele, G., 2010. Adoption of improved technology in Ethiopia. *Ethiopian Journal of Economics*, *19*(1), pp.155-179.

Ahmed, M.H., Geleta, K.M., Tazeze, A. and Andualem, E., 2017. The Impact of improved maize varieties on farm productivity and wellbeing: evidence from the East Hararghe Zone of Ethiopia. *Development Studies Research*, *4*(1), pp.9-21.

Ahmed, M.M., Mugerwa, E.B. and Edaku, C., Adoption Of Modern Farming Technology And Poverty Reduction In Nigeria: A Case Of Cooperative Societies In Kano State, Nigeria.

Alene, A.D., Poonyth, D. and Hassan, R.M., 2000. Determinants of adoption and intensity of use of improved maize varieties in the central highlands of Ethiopia: A tobit analysis. *Agrekon*, *39*(4), pp.633-643.

Amare, M., Asfaw, S. and Shiferaw, B., 2012. Welfare impacts of maize–pigeonpea intensification in Tanzania. *Agricultural Economics*, *43*(1), pp.27-43.

Alemaw, A.T., 2014. *Impact of improved maize varieties adoption on smallholder farmers' marketed maize surplus in Oromia regional state, Ethiopia* (Doctoral dissertation, Sokoine University of Agriculture).

Arega, M., 2009. *Determinants of intensity of adoption of old coffee stumping technology in Dale Wereda, SNNPRS, Ethiopia* (Doctoral dissertation, Haramaya University).

Arpino, B. and Fabrizia, M., 2009. The specification of the propensity score in multilevel studies. In *Seventh scientific meeting of the Classification and Data Analysis Group (CLADAG) of the Italian Statistical Society*. Salvatore Ingrassia and Roberto Rocci.

Asfaw, A. and Admassie, A., 2004. The role of education on the adoption of chemical fertiliser under different socioeconomic environments in Ethiopia. *Agricultural economics*, *30*(3), pp.215-228.

Asfaw, S., Shiferaw, B., Simtowe, F. and Lipper, L., 2012. Impact of modern agricultural technologies on smallholder welfare: Evidence from Tanzania and Ethiopia. *Food policy*, *37*(3), pp.283-295.

Asfaw, S., Kassie, M., Simtowe, F. and Lipper, L., 2012. Poverty reduction effects of agricultural technology adoption: a micro-evidence from rural Tanzania. *Journal of Development Studies*, *48*(9), pp.1288-1305.

Asfaw, S., Shiferaw, B., Simtowe, F. and Haile, M., 2011. Agricultural technology adoption, seed access constraints and commercialization in Ethiopia. *Journal of Development and Agricultural Economics*, *3*(9), pp.436-477.

Assefa, K., Chanyalew, S. and Tadele, Z., 2013. *Achievements and Prospects of Tef Improvement-Proceedings of the Second International Workshop, November 7-9, 2011, Debre Zeit, Ethiopia*. Ethiopian Institute of Agricultural Research, Addis Ababa, Ethiopia; Institute of Plant Sciences, University of Bern, Switzerland.

ATA (Agricultural Transformation Agency) "Transforming agriculture in Ethiopia", Annual Report 2015/2016.

ATA 2018. (Agricultural Transformation Agency),Annual Report 2017/2018.

Ayenew, M.M. and Kopainsky, B., 2014, July. Food insecurity in Ethiopia: Population, food production and market. In *32nd International Conference of the System Dynamics Society, Delft, The Netherlands*.

Barrett, C.B., 2001. Does food aid stabilize food availability?. *Economic development and cultural change*, *49*(2), pp.335-349.

Baum, C.F., 2013. Propensity Score Matching Regression Discontinuity Limited Dependent Variables. *Applied Econometrics*.

Bayissa, G.W., 2014. A double-hurdle approach to modeling of improved tef technologies adoption and intensity use in case of Diga District of East Wollega zone. *Global Journal of Environmental Research, 8*(3), pp.41-49.

Becerril, J. and Abdulai, A., 2010. The impact of improved maize varieties on poverty in Mexico: a propensity score-matching approach. *World development*, *38*(7), pp.1024-1035.

Beegle, K., Coudouel, A. and Monsalve, E. eds., 2018. *Realizing the full potential of social safety nets in Africa*. The World Bank.

Becker, S.O. and Ichino, A., 2002. Estimation of average treatment effects based on propensity scores. *The stata journal*, *2*(4), pp.358-377.

Behailu, G., 2014. *Assessment of Factors Affecting Farmers' Adoption level of Row Planting Technology and Yield Improvement on the Production of Eragrostis Teff [ZUCC.]: The Case of Minjar Shenkora Woreda, Amhara Region, Ethiopia* (Doctoral dissertation, Addis Ababa University).

Bekele, A. and Lakew, Y., 2014. Projecting Ethiopian Demographics from 2012–2050 Using the Spectrum Suite of Models. *Ethiopian Public Health Association (EPHA), Addis Ababa, Ethiopia*.

Bekele, E., Fido, R.J., Tatham, A.S. and Shewry, P.R., 1995. Heterogeneity and polymorphism of seed proteins in tef (Eragrotis tef). *Hereditas*, *122*(1), pp.67-72.

Berehe Dagnaw, H., 2018. *Influence of Nitrogen Fertilizer Rates and Varieties on Grain yield, Grain Nutrition and Injera Sensory Quality of Tef [Eragrostis tef (Zucc.) Trotter] Varieties* (Doctoral dissertation, Addis Ababa University).

Berhe, T., Gebretsadik, Z., Edwards, S. and Araya, H., 2011, November. Boosting tef productivity using improved agronomic practices and appropriate fertilizer. In *Achievements and prospects of Tef improvement. Proceedings of the second International Workshop* (pp. 133-140).

Beshir, H., Emana, B., Kassa, B. and Haji, J., 2012. Determinants of chemical fertilizer technology adoption in North eastern highlands of Ethiopia: the double hurdle approach. *Journal of Research in Economics and International Finance*, *1*(2), pp.39-49.

Besley, T. and Case, A., 1993. Modeling technology adoption in developing countries. *The American economic review*, *83*(2), pp.396-402.

Beyene, H. and Yirga, C., 1992. *Vertisol farming systems of North Shewa. Research with Farmers: Lessons from Ethiopia* (No. 338.162 FRA. CIMMYT.).

Beyene, H., 2008. *Adoption of improved tef and wheat production technologies in crop-livestock mixed systems in northern and western Shewa zones of Ethiopia* (Doctoral dissertation, University of Pretoria).

Bryson, A., Dorsett, R. and Purdon, S., 2002. The use of propensity score matching in the evaluation of active labour market policies.

Bultosa, G., 2007. Physicochemical characteristics of grain and flour in 13 tef [Eragrostis tef (Zucc.) Trotter] grain varieties. *Journal of Applied Sciences Research*, *3*(12), pp.2042-2050.

Caliendo, M. and Kopeinig, S., 2008. Some practical guidance for the implementation of propensity score matching. *Journal of economic surveys*, *22*(1), pp.31-72.

Centeral Statistical Agency 2016. Agricultural statistics abstract: Agriculture". Addis Ababa, Ethiopia.

Chala, G. and Usmael, A.T.K.L.A., Oromia Agricultural Research Institute (IQQO), Mechara Agricultural Research Center (McARC), PO Box: 19, Mechara, Ethiopia.

Chandio, A.A. and Yuansheng, J.I.A.N.G., 2018. Determinants of adoption of improved rice varieties in northern Sindh, Pakistan. *Rice Science*, *25*(2), pp.103-110.

Chipeta, M., Emana, B. and Chanyalew, D., 2015. Ethiopia's Agriculture Sector Policy and Investment Framework (2010–2020) External Mid-term Review.

Colman, D. and Young, T., 1989. *Principles of agricultural economics: markets and prices in less developed countries*. Cambridge University Press.

CSA 2015. Centeral statistical agency. Agricultural sample survey report on area and production of major crops. Addis Ababa.

CSA 2017. Report on area under production of major crops volume i, agricultural sample survey, statistical bulletin 584, the federal democratic republic of Ethiopia, Addis Ababa.

CSA 2016. Agricultural statistics abstract: Agriculture". Addis ababa, Ethiopia.

CSA 2017. The Federal Democratic Republic of Ethiopia Central Statistical Agency, Agricultural Sample Survey. Report on area and production of major crops. Addis ababa: Ethiopia.

CSA2018. The Federal Democratic Republic of Ethiopia Central Statistical Agency. Key Findings Of The 2017/2018 (2010 E.C).

CSA2019.The Federal Democratic Republic of Ethiopia Central Statistical Agency Agricultural Sample Survey. Report on Area And Production of Major Crops.

Debelo D. (2015). Does Adoption of Quncho Tef Increases Farmers' Crops Income? Evidence from Small Holder Farmers in Wayu Tuqa District, Oromia Regional State, Ethiopia. Journal of Economics and Sustainable Development www.iiste.org,Vol.6, No.17, 20-32

Degife, A.W., 2020. *Impacts of land use cover change, cropland expansion and climate change on the potential of yield and production in Ethiopia, Gambella Region* (Doctoral dissertation, lmu).

Degu, G., Mwangi, W.M., Verkuijl, H. and Wondimu, A., 2000. *An assessment of the adoption of seed and fertilizer packages and the role of credit in smallholder maize production in Sidama and North Omo Zones, Ethiopia*. CIMMYT.

Dehejia, R.H. and Wahba, S., 2002. Propensity score-matching methods for nonexperimental causal studies. *Review of Economics and statistics*, *84*(1), pp.151-161.

Delbiso, T.D., Rodriguez-Llanes, J.M., Donneau, A.F., Speybroeck, N. and Guha-Sapir, D., 2017. Drought, conflict and children's undernutrition in Ethiopia 2000–2013: a meta-analysis. *Bulletin of the World Health Organization*, *95*(2), p.94.

DiMarcantonio, F. and Demeke, M., 2013. Analysis of incentives and disincentives for teff in Ethiopia.

Demeke, M., Guta, F., Ferede, T., and Ababa, A., 2004. Agricultural development in Ethiopia: are there alternatives to food aid?. *Department of Economics, Addis Ababa University. www. sarpn. org. za/documents/d0001583/FAO2005_Casestudies_Ethiopia. pdf*.

Diao, X. and Pratt, A.N., 2007. Growth options and poverty reduction in Ethiopia–An economy-wide model analysis. *Food Policy*, *32*(2), pp.205-228.

Dibaba, R.,Hagos,A., Yirga, C. & Habte, E. 2018. Determinants of Improved Teff Varieties Adoption and Its Impact on Productivity: The Case of Non-Traditional Teff Growing Areas of Western Ethiopia.Journal of Natural Sciences Research Vol.8, No.22)

Dibaba, R., Hagos, A., Yirga, C. and Habte, E., 2019. Adoption and Perception of Farmers towards Attributes of Improved Teff (Quncho) Varieties: Evidence from Benishangul-Gumuz Region of Ethiopia. *Current Research in Agricultural Sciences*, *6*(2), pp.68-82.

Doss, C.R., Mwangi, W.M., Verkuijl, H. and De Groote, H., 2003. *Adoption of maize and wheat technologies in eastern Africa: a synthesis of the findings of 22 case studies* (pp. iv-32). CIMMYT.

Drinkwater, M., McEwan, M. and Samuels, F., 2006. The effects of HIV/AIDS on agricultural production systems in Zambia: a restudy 1993–2005', IFPRI RENEWAL report.

Etsehiwot, S. 2018. *The Determinants of Agricultural Technology Adoption and Its' Impact On Teff Productivity in the Case of Amhara and Oromia National Regional State* (Doctoral dissertation, AAU).

Faltermeier, L. and Abdulai, A., 2009. The impact of water conservation and intensification technologies: empirical evidence for rice farmers in Ghana. *Agricultural Economics*, *40*(3), pp.365-379.

FAO 2002.The state of food insecurity in theworld 2001(food and agriculture organization, Rome).

FAO 2013. Economic growth is necessary but not sufficient to accelerate reduction of hunger and malnutrition. FAO's annual State of Food Insecurity in the World report.

FAO 2015. The state of food insecurity in the world 2014: Strengthening the enabling environment for food security and nutrition. FAO, Rome.

FAO 2018. The State of World Fisheries and Aquaculture 2018- Meeting the sustainable development goals.

FAO 2019. The state of food security and nutrition in the world 2019. Safeguarding against economic slowdowns and downturns. Rome, . Fao.Licence: Cc by-nc-sa 3.0 igo.

FAO 2020. Food and Agricultural Organization in Ethiopia, Programmes and projects

Feder, G., Just, R.E. and Zilberman, D., 1985. Adoption of agricultural innovations in developing countries: A survey. *Economic development and cultural change*, *33*(2), pp.255-298.

Feder, G., Just, R.E. and Zilberman, D., 1982. Adoption of agricultural innovation in developing countries: a survey.

Feleke, S. and Zegeye, T., 2006. Adoption of improved maize varieties in Southern Ethiopia: Factors and strategy options. *Food policy*, *31*(5), pp.442-457.

Gari, A.G., 2017. Determinants of Smallholders Wheat Commercialization: The Case of Gololcha District Of Bale Zone, Ethiopia.

Gebremariam, K., 2001. Factors influencing the adoption of new wheat and maize varieties in Tigray, Ethiopia: The Case of Hawzien Woreda. *Unpublished M. Sc. Thesis, Alemaya University, Alemaya*.

Ghimire, R., Wen-Chi, H.U.A.N.G. and Shrestha, R.B., 2015. Factors affecting adoption of improved rice varieties among rural farm households in Central Nepal. *Rice Science*, *22*(1), pp.35-43.

Global Harvest Initiative, 2018. Global Agricultural Productivity Report®(GAP Report®).

Godfray, H.C.J., Beddington, J.R., Crute, I.R., Haddad, L., Lawrence, D., Muir, J.F., Pretty, J., Robinson, S., Thomas, S.M. and Toulmin, C., 2010. Food security: the challenge of feeding 9 billion people. *science*, *327*(5967), pp.812-818.

Guerre, E. and Moon, H.R., 2006. A study of a semiparametric binary choice model with integrated covariates. *Econometric Theory*, *22*(4), pp.721-742.

Gujarati, D.N., 1995. Basic Econometrics, 3-rd ed.

Hagos, F., Jayasinghe, G., Awulachew, S.B., Loulseged, M. and Yilma, A.D., 2012. Agricultural water management and poverty in Ethiopia. *Agricultural Economics*, *43*, pp.99-111.

Hahn, E.D. and Soyer, R., 2005. Probit and logit models: Differences in the multivariate realm. *The Journal of the Royal Statistical Society*, *Series B*, pp.1-12.

Hailu, B.K., Abrha, B.K. and Weldegiorgis, K.A., 2014. Adoption and impact of agricultural technologies on farm income: Evidence from Southern Tigray, Northern Ethiopia. *International Journal of Food and Agricultural Economics (IJFAEC)*, *2*(1128-2016-92058), pp.91-106.

Hallahan, C., 1997. „The Tobit model: an example of maximum likelihood estimation with SAS/IML”. *SAS Users Group International*, *22*, pp.1379-1384.

Headey, D., Dereje, M. and Taffesse, A.S., 2014. Land constraints and agricultural intensification in Ethiopia: A village-level analysis of high-potential areas. *Food Policy*, *48*, pp.129-141.

Healey, J.F., 2014. *Statistics: A tool for social research*. Cengage Learning.

Heinrich, C., Maffioli, A. and Vazquez, G., 2010. A primer for applying propensity-score matching. *Inter-American Development Bank*.

http://www.fao.org/traditional-crops/teff/en/

Huluka, A.T. and Negatu, W., 2016. The Impacts of farmer field school training on knowledge and farm technology adoption: evidence from smallholder maize farmers in Oromia, Ethiopia. *Journal of Economics and Public Finance*, *2*(1), pp.1-21.

Husen, N.A., Loos, T.K. and Siddig, K.H., 2017. Social capital and agricultural technology adoption among Ethiopian farmers. *American Journal of Rural Development*, *5*(3), pp.65-72.

Isman, A., 2012. Technology and Technique: An Educational Perspective. *Turkish Online Journal of Educational Technology-TOJET*, *11*(2), pp.207-213.

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

Jaleta, M., Kassie, M. and Marenya, P., 2015. *Impact of improved maize variety adoption on household food security in Ethiopia: an endogenous switching regression approach* (No. 1008-2016-80248).

Karki, L.B. and Bauer, S., 2004. Technology adoption and household food security. Analyzing factors determining technology adoption and impact of project intervention: A case of smallholder peasants in Nepal. In *Proceedings of Deutscher Tropentag Workshop* (pp. 5-7).

Kebebew, A., Sherif, A., Getachew, B., Gizaw, M., Tefera, H. and Sorrells, M.E., 2011. Quncho: the first popular tef variety in Ethiopia. *International Journal of Agricultural Sustainability*, *9*(1), pp.25-34.

Kebede, D., Ketema, M., Dechassa, N. and Hundessa, F., 2017. Determinants of adoption of wheat production technology package by smallholder farmers: Evidences from eastern Ethiopia. *Turkish Journal of Agriculture-Food Science and Technology*, *5*(3), pp.267-274.

Kebede, B. and Korji, D., 2017. Demonstration of improved teff varieties at selected midland districts of Guji zone, Oromia regional state, Ethiopia. *Asian Journal of Agriculture and Rural Development*, *7*(7), p.131.

Kinati, W., Bekele, A. and Chinnan, K.P., 2014. Impact of farmer research group interventions on maize farmers in Central Rift Valley of Oromia: An empirical study. *Journal of Agricultural Extension and Rural Development*, *6*(3), pp.94-107.

Klieštik, T., Kočišová, K. and Mišanková, M., 2015. Logit and probit model used for prediction of financial health of company. *Procedia Economics and finance*, *23,* pp.850-855.

Krugman, P., 1994. Defining and measuring productivity. *The Age of diminishing Expectations*.

Larsen, A.F., 2015. *Agricultural technology adoption, food security, poverty and child health: Assessments of an agricultural intervention in Tanzania*. Department of Economics, University of Copenhagen.

Lechner, M., 2002. Program heterogeneity and propensity score matching: An application to the evaluation of active labor market policies. *Review of Economics and Statistics*, *84*(2), pp.205-220.

Lee, H., 2018. Teff, a rising global crop: Current status of teff production and value chain. *The Open Agriculture Journal*, *12*(1).

Lefort, R., 2012. Free market economy,'developmental state'and party-state hegemony in Ethiopia: the case of the 'model farmers'. *The Journal of Modern African Studies*, *50*(4), pp.681-706.

Maddala, G.S. and Lahiri, K., 1992. *Introduction to econometrics* (Vol. 2). New York: Macmillan.

Mansingh, J.P. and Bayissa, D.D., 2017. Knowledge on Improved Practices of Teff by Smallholder Farmers in Ethiopia. *Journal of Extension*, *29*(4).

Matunhu, J., 2011. A critique of modernization and dependency theories in Africa: Critical assessment. *African journal of History and Culture*, *3*(5), pp.65-72.

McDonald, J.F. and Moffitt, R.A., 1980. The uses of Tobit analysis. *The review of economics and statistics*, pp.318-321.

Mekuria, W., 2018. The link between agricultural production and population dynamics in Ethiopia: a review. *Advances in Plants & Agriculture Research*, *8*(4), pp.348-353.

Melesse, B., 2018. Journal of Agricultural Science and Food Research.

Mendola, M., 2007. Agricultural technology adoption and poverty reduction: A propensity-score matching analysis for rural Bangladesh. *Food policy*, *32*(3), pp.372-393.

Mesfin, H.M., Ahmed, M.H. and Abady, S., 2016. Determinants Of Multiple Groundnut Technology Adoption In Eastern Ethiopia. *Review of Agricultural and Applied Economics (RAAE)*, *19*(395-2016-24363), pp.51-60.

Milkias, D. and Abdulahi, A., 2018. Determinants of agricultural technology adoption: the case of improved highland maize varieties in Toke Kutaye District, Oromia Regional State, Ethiopia. *Journal of Investment and Management*, *7*(4), pp.125-132.

Minten, B. and Barrett, C.B., 2008. Agricultural technology, productivity, and poverty in Madagascar. *World Development*, *36*(5), pp.797-822.

Minten, B. and Barrett, C.B., 2008. Agricultural technology, productivity, and poverty in Madagascar. *World Development*, *36*(5), pp.797-822.

Minten, B., Taffesse, A.S. and Brown, P. eds., 2018. *The economics of teff: Exploring Ethiopia's biggest cash crop*. Intl Food Policy Res Inst.

Mishra, K., Abdoul, S.G., Miranda, M.J. and Diiro, G.M., 2015. *Gender and Dynamics of Technology Adoption: Evidence from Uganda* (No. 330-2016-13685).

Mulatua, A., 2019. *Impact Of Teff Row Planting On Rural Household Income: Evidence From Merhabete Woreda, Amahara Region, Ethiopia* (Doctoral dissertation).

Mulatu, E., Ibrahim, O.E. and Bekele, E., 2005. Policy changes to improve vegetable production and seed supply in Hararghe, Eastern Ethiopia. *Journal of vegetable science*, *11*(2), pp.81-106.

Mulugeta, A., 2011. *Factors affecting adoption of improved Haricot bean varieties and associated agronomic practices in Dale woreda, SNNPRS* (Doctoral dissertation, Hawassa University).

Mulugeta, T. and Hundie, B., 2012. *Impacts of adoption of improved wheat technologies on households' food consumption in southeastern Ethiopia* (No. 1007-2016-79620).

Negasa, A., Gunjal, K., Mwangi, W. and Seboka, B., 1997. Factors affecting the adoption of maize production technologies in Bako Area, Ethiopia. *Ethiopian Journal of Agricultural Economics (Ethiopia).*

Negese,T. M., Jemal, A. A., & Endeg, T. W.,2016. Adoption and Impact of Row Planting of Wheat Crop on HouseholdLivelihood:-A Case Study of Duna Woreda in Hadiya Zone, Ethiopia.

Nyangena, W. and Juma, O.M., 2014. *Impact of improved farm technologies on yields: the case of improved maize varieties and inorganic fertilizer in Kenya*. Environment for Development Initiative.

Nyman, M., Björck, I., Siljeström, M. and Asp, N.G., 1989. Dietary fibre in cereals-composition, fermentation and effect of processing. *Styrelsen foer Teknisk Utveckling*.
O'Connor, A., 2016. Is teff the new super grain. *The New York Times*.

Olayide, S.O., Eweka, J.A. and Bello-Osagie, V.E., 1980. Nigerian small farmers: problems and prospects in integrated rural development. *Nigerian small farmers: problems and prospects in integrated rural development.*

Ouma, J., Bett, E. and Mbataru, P., 2014. Does adoption of improved maize varieties enhance household food security in maize growing zones of Eastern Kenya. *Developing Country Studies*, *3*(23), pp.157-165.

Pallant, J. and Manual, S.S., 2007. A step by step guide to data analysis using SPSS for windows version 15.

Piesse, J. and Thirtle, C., 2010. Agricultural R&D, technology and productivity. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *365*(1554), pp.3035-3047.

Rogers, E.M., 2010. *Diffusion of innovations*. Simon and Schuster.

Rosenbaum, P.R. and Rubin, D.B., 1983. The central role of the propensity score in observational studies for causal effects. *Biometrika*, *70*(1), pp.41-55.

Saka, J.O. and Lawal, B.O., 2009. Determinants of adoption and productivity of improved rice varieties in southwestern Nigeria. *African Journal of Biotechnology*, *8*(19).

Shiferaw, B.A., Okello, J. and Reddy, R.V., 2009. Adoption and adaptation of natural resource management innovations in smallholder agriculture: reflections on key lessons and best practices. *Environment, development and sustainability*, *11*(3), pp.601-619.

Shiyani, R. J. (2000). “Adoption of Improved Chickpea Varieties: Evidences from Tribal Region of Gujarat.”. Indian Journal of Agricultural Economics , 55:179-170.

Storck, H., Emana, B., Adnew, B., Borowiccki, A. and Woldehawariat, S., 1991. Farming systems and resource economics in the tropics: farming system and farm management practices of smallholders in the Hararghe Highland. *Vol. II, Wissenschaftsverlag Vauk, Kiel, Germany*.

Tatham, A.S., Fido, R.J., Moore, C.M., Kasarda, D.D., Kuzmicky, D.D., Keen, J.N. and Shewry, P.R., 1996. Characterisation of the major prolamins of tef (Eragrostis tef) and finger millet (Eleusine coracana). *Journal of Cereal Science*, *24*(1), pp.65-71.

Teklewold, H., Kassie, M. and Shiferaw, B., 2013. Adoption of multiple sustainable agricultural practices in rural Ethiopia. *Journal of agricultural economics*, *64*(3), pp.597-623.

Tesfaye, S., Bedada, B. and Mesay, Y., 2016. Impact of improved wheat technology adoption on productivity and income in Ethiopia. *African Crop Science Journal*, *24*(s1), pp.127-135.

Tsegaye, A.; Adgo, E.; Selassie,Y.G. Impact of Land Certification on Sustainable Land Resource Management in Dryland Areas of Eastern Amhara Region, Ethiopia. J. Agric. Sci. 2012, 4, 261–268.

Tura, M., Aredo, D., Tsegaye, T., La Rovere, R., Kassie, G.T., Mwangi, W.M. and Mwabu, G., 2010. Adoption and continued use of improved maize seeds: Case study of Central Ethiopia. *African Journal of Agricultural Research*, *5*(17), pp.2350-2358.

UNDP 2018. Toward building resilience and supporting transformation in Ethiopia, United Nation Development Program ,Annual Report.

Vandercasteelen, J., Dereje, M., Minten, B. and Taffesse, A.S., 2013. Scaling-up adoption of improved technologies: The impact of the promotion of row planting on farmers' teff yields in Ethiopia. LICOS-Discussion paper series 344/2013, pp.1-25.

Verbeek, M. Using linear regression to establish empirical relationships. IZA World of Labor 2017: 336 doi: 10.15185/izawol.336

White, H. and Sabarwal, S., 2014. *Quasi-Experimental Design and Methods: Methodological Briefs-Impact Evaluation No. 8* (No. innpub753).

World Bank 2010. Handbook on impact evaluation: Quantitative methods and practices (public disclosure authorized). Washington, DC

World Bank 2018. Realizing the full potential of social safety nets in Africa.

WorldBank 2016. Over view of the World Bank in Ethiopia.

Wubeneh, N. G. & Sanders, J. H. 2006. Farm-level adoption of sorghum technologies in Tigray, Ethiopia. Agricultural systems, 91(1-2), pp.122-134.

Yihun, K., Adugna, A., Tirfesa, A. and Gebrekidan, B.,2019. The State of Science and Technology in Cereals Production in Ethiopia.

7. APPENDICES

Appendix Table 1: Adult-equivalent conversion factors for estimated calorie requirements according to age and gender

Age (years)	Calories * (kcal)	Adult-equivalent conversion factor
Newborns		
0-1	750	0.29
Children		
1-3	1,300	0.51
4-6	1,800	0.71
7-10	2,000	0.78
Men		
11-14	2,500	0.98
15-18	3,000	1.18
19-24 **	2,900	1.14
25-50 **	2,900	1.14
51+	2,300	0.90
Women		
11-14	2,200	0.86
15-18	2,200	0.86
19-24 **	2,200	0.86
25-50 **	2,200	0.86
51+	1,900	0.75
Breastfeeding women (+500kcal) ***		
11-14	2,700	1.06
15-18	2,700	1.06
19-24	2,700	1.06
25-50	2,700	1.06
51+	2,400	0.94
Pregnant women (+300kcal) #		
11-14	2,500	0.98
15-18	2,500	0.98
19-24	2,500	0.98
25-50	2,500	0.98
51+	2,100	0.82

* According to Recommended Dietary Allowances (RDA) for 1989 [12];

** Age brackets used as the reference for establishing an adult's mean calorie requirements; *** Additional 500kcal for breastfeeding, according to the RDA [12];

Additional 300kcal for pregnancy, according to the RDA [12].

Source: Claro RM *et al*, 2010

Appendix Table 2: Conversion factor for tropical livestock unit (TLU)

Livestock	TLU
Oxen	1
Cow	1
Calves	0.25
Heifer	0.75
Bull	1
Sheep	0.6
Goat	0.6
Donkey	0.7
Horse	1.1
Mule	0.7
Chickens	0.013

Source: Storck, *et al.*, 1991

Appendix Table 3: Multicollinearity test for continuous explanatory variables

Variable	**VIF**	**1/VIF**
Age	1.16	0.864305
Education level	1.01	0.990794
Productive family member	2.10	0.476535
Dependency ratio	2.10	0.475212
TLU	1.12	0.889392
Frequency of extension contact	1.02	0.984518
Distance to the nearest market	1.01	0.990440
Land allotted to teff	1.00	0.996151
Mean VIF	1.36	

Source: Author calculation using survey data, 2020

Appendix Table 4: Multicollinearity test for dummy explanatory variables

	adoption	Sex	offar m~e	landce ~e	Farm coop	access ~t	Access~o	marsta tus	Religi on	Locati on
Adoption	1.0000									
Sex	0.0236	1.0000								
offarm~e	0.2411	0.0133	1.0000							
landce~e	0.2516	0.0628	0.2098	1.0000						
farmcoop	0.0844	-0.0117	-0.0561	-0.0284	1.0000					
access~t	0.0323	0.0023	-0.0067	0.1237	0.0614	1.0000				

Access~o	0.1236	0.0654	-0.0026	-0.0371	0.0295	0.0153	1.0000			
marstatus	0.1402	0.5068	0.0242	0.0469	0.1175	0.0169	0.0107	1.0000		
Religion	0.0679	-0.0253	0.1122	0.1023	0.0736	0.0646	0.0258	0.0538	1.0000	
Location	0.0657	0.1768	0.0462	0.0885	0.0190	0.0350	0.0811	0.1213	0.1493	1.0000

Source: Author calculation using survey data, 2020

Appendix Table 5: Results of Sensitivity Analysis

rbounds teffproductivity , gamma(1(.25)2)

Rosenbaum bounds for teff productivity (N = 327 matched pairs)

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	0	0	1217.5	1217.5	1178.33	1301.67
1.25	0	0	1181.67	1292.5	1145	1360
1.5	0	0	1156.67	1341.71	1112.5	1406.67
1.75	0	0	1131.67	1379.17	1061.33	1452.5
2	0	0	1107.5	1413.33	1010.83	1485.83

* gamma - log odds of differential assignment due to unobserved factors

sig+ - upper bound significance level

sig- - lower bound significance level

t-hat+ - upper bound Hodges-Lehmann point estimate

t-hat- - lower bound Hodges-Lehmann point estimate

CI+ - upper bound confidence interval (a= .95)

CI- - lower bound confidence interval (a= .95)

Household Interview Schedule

Dear respondents! The aim of this questionnaire is to collect data for the final thesis of MSc which is entitled on "**Determinants of improved teff varieties adoption and its impact on Households productivity: The Case of Kiramu District".** The study is one of the requirements for the completion of Masters of Science in Agricultural Economics from Jimma University. These study will indispensable in appraising the factors which affect improved teff (quncho) variety adoption and the impact of adopting those improved teff(quncho)variety on farm house holds teff productivity in Kiramu District which will have a paramount relevance in suggesting key recommendations. Relevant questions raised in this material will enable the researcher to get information that pertaining to the factors which influence improved teff(quncho) variety adoption, intensity and the implication of improving teff productivity by adopting modern teff(quncho) variety on Kiramu District farm house holds.

Dear respondents! The information what you will give me is very important for accomplishment of my academic findings and thus your genuine response to this questions is very important in achieving the goal of the study. So, i ask your kindly response for all my questions.

Note: The respondent to this interview should be the HH head or his/her partner

Date of interview __/___ /2012

Part I. Household Characteristics, Demographic, Socioeconomic and Institutional Data

Kebele name **______________village ______ Enumerator name_______________sign____**

1. Full name of the respondent: ______________________Respondents Id _____ Phone no_________
2. Gender of household head 1. Male 0. Female
3. Age of household head _________ years
4. Have you married : 1 yes 0 no
5. Religion: 1 protestant, 0 others
6. Educational level of Households _______ grade
7. How many family members do you have? Male _____ Female _______ Total ______

Family members' who are enough for crop production activities (Labor availability):

Age Category	Male		Female		Total	
	Full time	Part time	Full time	Part time	Full time	Part time
< 8 years						
8 to 16 years						

16 to 32 years						
32 to 60 years						
Above 60						

***Code:** 1) Land preparation 2) sowing 3) Weeding 4) Cultivation 5) Harvest 6) Transportation 7) Storage 8) Marketing 9) others (specify)

8. Do you have livestock? 1. Yes 0. No

#if **yes**, indicate current number of livestock you have:

No	Livestock holding	(Number)	Equivalent in ETB
1	Oxen		
2	Cow		
3	Calves		
4	Heifer		
5	Bull		
6	Sheep		
7	Goats		
8	Donkeys		
9	Horses		
10	Mule		
11	Chickens		
12	Beehives		

9. Have you participated on other activities in addition to farm activity? 1. Yes 0. No

#If **yes** please fill your activities in the ff table.

No	Operations involved	Total number of working hours/day	Total income received in Birr/day
1	Daily laborer		
2	Petty trading		
3	Handicraft		
4	Firewood /charcoal selling		
5	Homemade drinks		
6	Selling grass and straw		
7	Selling stone & sand for construction		
8	Government employee		
9	Other, specify		

10. Are you a member of farmers' cooperatives? 1. Yes 0. No

If **yes**, what service did you got from the cooperative members related to improved teff (quncho) variety? i. training ii. Input supply iii. Marketing services iii. Other specify_______________

11. Have you ever acquired any credit in the last three (3) years? 1: Yes 0: No

12. If **Yes** How often you got Credit services in the last of three (3) years? ____ Times

13. Have you met extension agents for the sake of adopting improved quncho teff variety in the last three years? 1: Yes 0: No

#if **yes** how often you met in the last three (3) years? ______ Times

#what the information you got from the expert?

1. Practical assistance at farm 2.Training on how to use 3. If other specify _____

14. Have you ever participated in training on the using of improved teff (Quncho) variety in the last three years?

1. Yes 0. No

#if yes**,** from which institution you have got training?

1) Woreda Agriculture office 2) Model farmers 3) Research center 4) NGOs 5) Relatives 6) other (specify) ___________

#on what topics you have got training?

I, Improved quncho teff variety selection II. Quncho teff pest management practices

III. How to store quncho teff variety VI. If other specify _____________________

15. How far the nearest market from your residence? ____________ (kilometers)

16. Do you have land certificate? 1: yes, 0: no

17. How far the nearest extension & credit agent(s) office from your residence? _______Kms

Part-2: Teff Production

1. What is the size of your total farm land? _________________hectares
2. Have you planted teff varieties in the last three years? Yes ____ No ___

#if **yes** what types of teff varieties you planted?

1. Quncho variety 2.Other improved varieties 3. Local teff 3. Both local and improved

3. If you have grown improved teff(quncho) variety when did you start growing? ________ Years

4. How much land did you allocated for improved Quncho teff variety for the last three years?

No	Name of teff varieties		
		land allocated	Amount
	Quncho vareity		
	Other improved varieties		
	Local teff		
Code* **1 Hectare** **2. Sangaa**			

5. Did you apply modern agricultural inputs in your teff farm products in the last three years?

If yes, answer the following questions

6. Do you think that the improved teff (quncho) variety is better than local varieties in terms of the following characteristics/ traits?

1. Yield 1. Yes 0. No 2. Colour 1. Yes 0. No

3. Taste 1. Yes 0. No 4. Drought resistance 1. Yes 0. No

5. Maturity period 1. Yes 0. No 6. Storability 1. Yes 0. No

7. Resistance to diseases/pests/weeds 1. Yes 2. No

7. How much quncho teff you sold in 2010 ______, in 2011 ______, 2012______ in quintals

8. What are the major challenges during using improved teff (quncho) variety?

1. Lack of improved seed availability 2. In adequate supply of seed on time

3. Lack of fertilizer 4. Crop Disease and pests

5. Lack of training on way of using these technologies

6. Specify if others____________________________________

9. What planting method did you used during sowing your improved quncho teff variety?

1. Broadcasting 2. Raw-Spacing 3. Others ______________

10. How did you control weed problem from your improved quncho teff?

1. Hand weeding 2. Chemical fertilizers 3.traditional method

#if you used chemicals for weed control, what was the type of chemical you applied? ____

11. Was any insect or pest problem happened in your quncho teff production? Yes ____ No______

#if **yes,** what prevention /control measure did you applied?

a. Cultural method 2. Insecticides and pesticides 3. Others _________________

12. Did you apply fertilizer in teff crop production in 2011/2012 Ec ? 1) Yes 0) No

#if your answer is **yes,** to which variety you applied fertilizer?

1. Local 2.Quncho 3.Other improved 4.For all

#if your answer is **yes,** which kind of fertilizer you used? 1) DAP 2) Urea 3) NPS 4) NPSB

5.All 6. If other specify__________

#If you did not applied fertilizer in Teff crop production, what is your reason? Reason ____________________________

		Land size(**code*** 1.Ha 2.Sangaa)			Quantity of seed (**code***: 1.ku 2.KG 3. Qunnaa			Fertilizer use 1)Yes 0) No			Applied raw spacing 1)Yes 0) No			Herbicides and pesticides (**code*:** number of litres inNumber)			Yield obtained (code*: 1.Ku 2.KG 3.Qunnaa		
Quncho variety																			
Local seed																			
Other improved varieties																			

Part 3: Households' farm productivity

1. **Productivity gained by 2011/2012 main seasons in EC.**

No	Items produced during 2011/2012 Main season	Quantity of land allocated	Source			Income gained			
			Home produced	Tenure (siso)	Gifts/remittances/	Amount gained (Kg)		Amount consumed	Amount soled(Kg
						Total gained	Productivity(Kg/Ha)		
1	Sorghum								
2	Maize								
3	Wheat								
4	Barley								
5	Finger millet								
6	Suf(sunflower)								
7	Teff		Xx						
8	Nug								
9	Rapeseed (gomenzer)								
10	Coffee								
11	Banana								
12	Chat								
13	Redpeper (barbere)								
14	Sugarcane (shenkora)								
15	Linseed(talba)								
16	Beans								
17	Peas								
18	Chick pea								
19	Soybean (akureater)								
20	Sesame								
21	Haricot bean								
22	Orange								
23	Pappaya								
24	Avocado								
25	Tiringo								
26	Mango								
27	Irish Potato								
28	Sweet potato								
29	Onion								
30	Cucumber (Dabaaqula)								
31	Carrot								

Part 4: Check List for Focus Group Discussion

As you probably know, agricultural office is trying to popularize an improved technology, which should significantly increase yields. The office is also providing best practices from other areas who adopt improved teff varieties; especially quncho variety because it is more popularized than other varieties in rural farm house holds. Even Agricultural agents are also supporting the farmers in different dimensions.

However,

1. Most of the farmers are not adopting improved teff(quncho) variety why?
2. Which one of the varieties (local or improved) teff has more yields?
3. Have you got improved teff(quncho) seed timely?
4. How the extension services deliver information to you about importance of improved teff(quncho) variety?
5. What are the challenging factors which affect adoption of improved teff(quncho) variety in your area?
6. Is there any type of training and Demonstrations provided to you on the way how you improve teff(quncho) Variety?
7. Do you think that adopting improved teff (quncho) variety has an impact on your teff productivity?
8. What is your recommended implication on adopting improved teff(quncho) variety?

Part 5: Questions for the Key Informants

1. Do you think that the teff production and productivity is enough to enhance productivity and food security status of households in the district?
2. What methods did you apply for transferring knowledge and practice about improved teff (quncho) variety?
3. What type of planting methods that producer of improved teff variety (quncho) use? What you advised them?
4. Is the farm inputs are accessible to farmers in time? If yes, how? If no, why?
5. What do you think that major challenges which face rural farm households to adopt improved teff (quncho) variety?
6. What is your recommended implication for farm house holds and for government organization about improved teff(quncho) variety adoption?