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Master's Thesis on:

The Contribution of Irrigation to Food Security in Farta Woreda, South Gondar Zone, Amhara National Regional State, Ethiopia

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June, 2019

Addis Ababa, Ethiopia

STATEMENT OF DECLARATION

I, the undersigned, declare that this thesis is my own original work and has not been presented in any other University. All sources of materials used for this thesis have been duly acknowledged. I have produced it independently except for the guidance and suggestion of the Research Advisor.

Declared by

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CENTER FOR RURAL DEVELOPMENT

MA Thesis On: The Contribution of Irrigation to Food Security in Farta Woreda, South Gondar Zone, Amhara National Regional State, Ethiopia

By

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STATEMENT OF CERTIFICATIONS

This is to certify that Misekir Haileyesus Fetene has carried out his thesis work on the topic entitled The Contribution of Irrigation to Food Security in Farta Woreda, South Gondar Zone, Amhara National Regional State, Ethiopia. The work is original in nature and is suitable for submission for the award of Master's Degree in Development Studies (Rural Livelihood and Development)

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Date: ----------

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Misekir Haileyesus

ABSTRACT

Objectives of the study were to Measure the food security level of households in the study area, Identify determinants of food security and investigate the contribution of irrigation to food security. Quantitative and qualitative approach was used to generate empirical data to help address the condition. The study consisted sample of 108 households selected through cluster multistage sampling. Food Consumption Score, Household Food Insecurity Access Scale, Descriptive statistics, Econometric model and Propensity Score Matching were the analysis tools in the study and The findings showed that the research area were threatened by food insecurity even if it is in a improved condition comparing to other Woredas in addition irrigation contribution for food security was not found as expected based on Propensity Score Matching. Since, non-participants of irrigation were found to be food secure as that of the irrigation users. An inferential relationship was computed using Pearson correlation and t-test analysis to investigate the relationship between various variables and the econometric model (Tobit) result showed that among fourteen variables eight variables were significant and they affect food security at different significance level.

Based on the results obtained, the following implications are found to be of paramount importance: agricultural production activities shall be assisted with enough market information and to offer the products to market infrastructure shall be developed, agricultural activities shall focus on increase household income and reduce food insecurity, as well agricultural extension practices shall focus on the benefits of having modern livestock raring practices for the purpose of milking and irrigation practices to come up with effective results.

Key words: food security, irrigation, propensity score matching, Food Consumption Score, Determinants, Tobit Regression

Table of Contents

List of Abbreviations

ATE	Average Treatment Effect
ATT	Average Treatment on the Treated
BoARD	Bureau of Agriculture and Rural Development
CSA	Central Statistics Agency
CIA	Conditional Independence
FAO	Food and Agriculture Organization
GTPII	Growth and Transformation Plan II
HIFAS	Household Food Insecurity Access Scale
IPPC	International Plant Protection Convention
PSM	Propensity Score Matching
TOT	Treatment effect on the Treated
UNESCCA	United Nations Economic and Social Council Commission for Africa
UNICEF	United Nations Children's Fund
USAID	United States Aid for International Development
WFP	World Food Program
WFS	World Food Summit
WHO	World Health Organization
IFAD	International Fund for Agricultural Development
PSNP	Productive Safty Net Program
SARDP	Sida-Amhara Rural Development Programme
SSA	Sub Sharan Africa

List of Tables

List of Figures

CHAPTER ONE

1. Introduction

1.1 Background

Food security is a serious issue in the globe especially in the developing countries. Birara,*et al* (2015), states by indicating FAO (2014) global hunger reduction continues and about 805 million people are estimated to be chronically undernourished in 2012-14, down more than 100 million over the last decade and 209 million lower than in 1990-92. In the same period, the prevalence of undernourishment has fallen from 18.7-11.3% globally and from 23.4-13.5% for developing countries**.** However, Hilderink, *et al* (2012) in their explorative study indicate that over the last decades in sub-Saharan Africa the number of undernourished has increased with 41%, from 169 million around 1990 to 239 million in 2010. This increase is particularly remarkable since the first of the Millennium Development Goals (MDG) is to halve the 1990 level of hungry people by 2015.

Significantly 4 out of the 5 countries with the most number of people are affected by hunger/under nourishment are in the Horn/East of Africa (Ethiopia, Tanzania, Kenya and Uganda) (Birara, *et al*, 2015).

In Ethiopian food security strategy document (1996), which describes as Food insecurity is one of the defining features of rural poverty in Ethiopia, particularly in the moisture deficit northeast highland plateaus and some pastoral areas. The incidence of food poverty is higher, estimated at 50% of the population; 52% in the rural areas and 37% in the urban areas.

Ethiopia is one of the most food-insecure and famine affected countries. A large portion of the country's population has been affected by chronic and transitory food insecurity. The situation of chronically food insecure people is becoming more and more severe. Food security situation in Ethiopia is highly linked to recurring food shortage and famine in the country, which are associated to recurrent drought (Abduselam, 2017).

As majority of Ethiopian population livelihood depend on agriculture which is mainly rain fed and at the same time agriculture in Ethiopia is threatened by various climatic and manmade calamities inevitably food security will be the great problem of the country. Thus, in the region food security is a serious and long rooted problem which cannot be solved to this days and the food availability is not well grown due to the backward and rain fed agriculture practices with no effective help given for improving the situation, in the meantime the economy is dependent on agriculture and poor infrastructure that binds the progress.

The Amhara region Bureau of Agriculture and Rural Development report in 2007/8 E.C the annual product of agriculture falls in 200,000 Quintal from the preceding year which inclined as the availability of food for households in the region is in question.

This research focus on one of the region Woredas i.e. Farta Woreda which is considered as the food secure Woreda through investigating the contribution of irrigation to food security of the Woreda.

Irrigation is one of the possible means of feeding the rapidly growing population. Consequently, numerous modern and large-scale irrigation schemes have been established in the country. As a result, there is a growing interest in small-scale irrigation (SSI) development for food as well as for rural development (Dereje and Desale, 2016).

1. 2. Statement of the problem

In 2017, almost 124 million people across 51 countries and territories faced “crisis” levels of food insecurity or worse, requiring immediate emergency action to safeguard their lives and preserve their livelihoods, an increase compared to 2015 and 2016 (80 and 108 million people, respectively) (FAO, 2018). Irrigation can lead to crucial changes in the livelihood and food security of smallholders. The four food security dimensions food availability, access, utilization, and stability are likely to change as a result of increased water availability for crop production and other uses (Domènech, 2015).

In African continent the overall energy supply adequacy average for Africa is 116%, generally speaking, a sufficient level of food supply, which has significantly contributed to reducing

prevalence of malnutrition in Africa (UNESCCA, 2015). But the continent is still in a big trouble in food security since FAO (2015) states approximately one person out of four in Sub Sahara Africa is estimated to be undernourished today compared to a ratio of one out of three in 1990-92.

Food insecurity emerged as a key problem and development challenge in Ethiopia in the early 1970s and became pervasive in the subsequent decades although the issue is a century-old concern for FAO and other donating institution in the country (Kedir, 2017).

Birara, *et al* (2015) states about 10% of Ethiopia's citizens are chronically food insecure and this figure rises to more than 15% during frequent drought years and 2.7 million People require emergency food assistance in 2014 and 238,761 children require treatment for severe and acute malnutrition in 2014. As well Degefa (2002) states that depending upon the state of the natural resources and the extent of development of these resources the seriousness of food shortage problem varies from one region to another as well as from one locality to another in Ethiopia. As Mulugeta (2002) wrote among different administrative regions the highest agricultural potential is in Keffa, Illubabor, Sidamo, Welega, parts of Gojam and parts of Shewa while a low potential of arable land is found in Hararghe, Wollo and Tigray (former administrative classifications). .

As Degefa (2002) and Hussien (2006) in Furgasa and Degefa (2016) state that major causes of food insecurity in Ethiopia are closely related to environmental, demographic, economic, social, infrastructural and political factors. Hence, having such problems coupled with the country poor economy, which depends mainly on agriculture, citizens cannot be easily withdrawn from poverty and food insecurity.

Amhara region which is one of four major productive regions in Ethiopia 48 Woredas (Districts) out of 105 are considered food insecure (Dereje *et al*, 2008). Hence, the region is part of the most affected by food insecurity in the country as well as in the Globe. And the region fourth term PSNP Report in (2016) shows a total of 1,890,985 clients were targeted in 1,457 kebele which marks there are much more peoples who are vulnerable to food insecurity.

Arega (2013) states Amhara Region is prone to poverty and food insecurity and a quick recovery from chronic and transitory food insecurity is unwelcoming in the Amhara Region due to the

Current trends in population growth, poor land resource utilization, severe environmental degradation and erratic rainfall.

Mesfin (2014) wrote the vulnerability and food security condition in the region will be in problem by stating; ‘‘the average degree of vulnerability in Amhara Region is about 52.3%. With this, of the current food insecure households, about 84% are chronically food insecure or likely to remain insecure in the future’’.

Consequently, irrigation is considered the major contributing factor to ensure food security since it has a direct impact on food availability because of increased productivity, production, and changes in cropping patterns. Moreover, irrigation will likely increase the stability of the food supply because irrigation's main role is to enhance water control, thus reducing or eliminating potentially adverse impacts on production from too little rain (Domènech, 2015).Increasing yields in both rain-fed and irrigated agriculture and cropping intensity in irrigated areas through various methods and technologies are the most viable options for achieving food security in Ethiopia Mekuria (2003) cited in (Getinet, 2011).

Irrigation allows a hectare of land to produce more than rain-fed agriculture. The value of per hectare crop production under irrigated settings is about twice that under rain fed settings. So, the introduction of irrigation if water is available could be taken as a key strategy for increasing production and farm income of smallholder households (Yidnekachew, 2009).

Considering the high potential of arable land with food insecurity problem, different Five Year Strategic Plans and the Growth and Transformation Plan (2011- 2015) have given attention to the strengthening of the agricultural sector through the expansion of agricultural farming in the lowlands and irrigation infrastructures in the highlands (Woldegebrial, 2013) as well Growth and Transformation Plan II (GTP II) (2015/16-2019/20) gives due attention for irrigation practice by stating ‘‘Irrigation Development, activities will be carried out to ensure sustainable agricultural development enhancing its productivity through improved water utilization and agro ecological based irrigation schemes’’.

Therefore Farta Woreda, which resides in the region is in a problem of food security which emanates from various reasons as the other districts of the country are facing. Even though the

government immense effort has been applied on natural resource management activities and agricultural development led industrialization policy and strategy applies to the country as well in the Woreda; the living condition of the people is not too much enhanced.

Worku et al (2014) using the HFIAS scale measurement finds out that 70.7% of the households faced food insecurity in Farta Woreda. Therefore, irrigation practices will contribute much in the study area and studies shall be conducted to assess whether the irrigation practice done their have real effect on the food security situation of the population or not. And many food security studies are done to assess the level of food security situation of the population rather than studying on the contribution of irrigation on food security separately.

Furthermore Worku et al (2014) also wrote that in Farta district high proportion of household's was food insecure due to various reasons and several studies were conducted regarding food security in country.

Also, in the Woreda and kebele levels but since different Woredas have different agro-ecological, social and economic situation their stand concerning food security is not the same besides the reasons to become food secure is diverse in different Woredas.

As well Irrigation contribution to food security in Farta Woreda is not studied well in the previous food security studies and many of them focus on the status and determinants of food security in the study area.

Hence, food security which requires a multi-dimensional change shall be assisted with enough information regarding the situation which really exists in the target area. Thus, this research makes an important addition to the existing literature by assessing the contribution of irrigation to food security.

In addition, study done by Eshetu and Bohk (2017) revealed that access to small scale irrigation can significantly improve income level and food security status of beneficiary households. Hence, Investigate the contribution of irrigation to food security, Measure the food security level of households, identifying the determinants of food security in the study area as well identifying the marginal effects of the independent variables which are very important for policy and decision making are the main objectives of the research.

1.3. Objective

1.3.1. General objective

The general objective of this research is to examine the contribution of irrigation for food security in Farta Woreda.

1.3.2. Specific objectives

- Measure the food security level of households in the study area,
- Identify determinants of food security in the study area, and
- Investigate the contribution of irrigation to food security.

1.4. Scope and Limitation

In sample selection, 31 kebeles are available in the Woredahence; it is not possible to cover the whole or even half of the Woreda kebeles. However, as discussed in the statement of the problem, many of Amhara Region Woredas experience food security problems. For this reason, the research selects samples from those kebeles that almost half of residents practice irrigation. Above all, the research only focused on household heads which are found in Farta Woreda two rural kebeles i.e. Woyibila-Selamiko and Hiruyi-Abaaregay kebeles.

1.5. Significance of the study

This research is significant as it intended to empirically inform decision makers regarding food security issues and about the determinant factors that affect food security and irrigation contribution to food security in the Woreda two kebeles which are incorporated in the research. And, this enables decision makers to take remedial measures on households who are food insecure in addition results of this research will contribute for having knowledge and assist policy makers to have empirical information on the issue (Irrigation and Food Security) they are dealing with.

1.6. Organization of the Thesis

The thesis is organized in five major parts. The first part introduces the background and the reason why the study is undertaken. Objectives, significance, and limitations of the study are

also discussed in this part. The second part presents reviews on relevant literature. The third part deals with the research methodology. Results descriptive, econometric and Propensity Score Matching are presented and discussed in the fourth part. The fifth part presents conclusion on the main findings of the study and draws appropriate recommendations.

CHAPTER TWO

2. Literature review

2.1. Theoretical and Conceptual review of Food Security

The term "Food Security" was introduced after the World Food Conference in 1974 due to food crises and major famines in the world after that time the term is evolved, developed and diversified by different researchers (Birara, et al 2015).

The term "food security" is widely used in publications, articles, statements, the media, etc. Yet, the meaning one gives to it varies considerably: for many, the concepts surrounding hunger, famine and food security are blurred and these words are often used interchangeably (André, 2012). Besides Abduselam (2017) indicates Food security as a dynamic concept, which has continuously integrated new dimensions and levels of analysis over the years; this reflects the wider recognition of its complexities in research and public policy issues.

In 1983, FAO analysis focused on food access, leading to a definition based on the balance between the demand and supply side of the food security equation that, "Ensuring that all people at all times have both physical and economic access to the basic food that they need" (FAO, 2006). Earlier as specified by FAO, 2006 Policy brief document and Degefa and Furgasa (2016) World Bank gives definition for Food security as "access by all people at all times to enough food for an active and healthy life". Besides in 1950s…60s, Food security was equated with self-sufficiency in major staples.

But later on in World Food Summit, 1996 Rome Declaration on World Food Security they define the term as, Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (FAO, 1996).This widely accepted definition points to the different dimensions of food security: Food availability, Food access, Meeting nutritional requirements and Stability (Stamoulis and Zezza, 2003), As well World Food Summit, 1996 Rome Declaration on World Food Security in 1996 reaffirm food security as the right of everyone to have access to safe and nutritious food, consistent with the right to adequate food and the fundamental right of everyone to be free from hunger. This illustrates that how the

phenomenon is too much serious and how we should look at in to deeper understanding if the concept of food security at household and individual level.

Food insecurity can be transitory (when it occurs in times of crisis), seasonal or chronic (when it occurs on a continuing basis) (Stamoulis and Zezza, 2003) Chronic food insecurity means that a household runs a continually high risk of inability to meet the food needs of household members. In contrast, transitory food insecurity occurs when a household faces a temporary decline in security of its entitlement and the risk of failure to meet food needs is of a short duration (Yenesew, 2015).

Regarding the theoretical issues they were grouped into three broad categories emphasizing the causes of food insecurity by citing (Blaikie et al., 1994; Collinson, 2003; Devereux, 1993; Sen, 1981; Twigg, 2001) Arega (2013) states Political economy theory to indicate food insecurity is a political phenomenon that is not only caused by lack of food production nor by market irregularities, but due to political powerlessness, Food economy theories that mean as Degefa and Furgasa (2016) states the food security models i.e. Food Availability Decline (FAD) and Food Entitlement Decline (FED) models, in which the first deals with disruption occurred during food production will cause food insecurity and the later deals with availability and access to food as Sen (1981) cited in Fekadu and Mequanent (2010) describes individual's entitlement can be transformed via production and trade into food. Hence amount of product available in a country will not be a guarantee to make ones country food secure now and in the future.

And vulnerability theory that needs positivistic and interpretative approaches in the analysis of food security as Mesfin (2014) used it in his study he states that conceptually, vulnerability may mean different thing to different individuals. It may mean a situation where an individual feel insecure that something harmful happens in the future. In daily language, 'vulnerable' mean something likely to be harmed or wound and In his study, vulnerability is be defined as the extent and probability that household will face food insecurity in the future.

2.3. Irrigation

Irrigation can be defined as an artificial application of water to soil to create the moisture content which is suitable for the growth and development of crops and leach the salts if there is an accumulation of salts in the area that to be irrigated (Reddy RN 2010) Cited in Tesfaw, (2018).

Irrigated agriculture is considered a key element in order to reach development objectives of achieving sustainable food security especially in developing countries (Medici et al, 2016). Although Ethiopia has abundant rainfall and water resources, its agricultural system does not yet fully benefited from the technologies of water management and irrigation (Seleshi, 2010) But still One of the challenges Ethiopia facing in attaining food security and reducing poverty is high dependence on rain fed Agriculture and the country's economy which has been highly dependent on agriculture is much weakened recurrent droughts. The major problem associated with the rain fall dependent Agriculture in the country is the high degree of variability and unreliability of the rain fall patterns (Tesfaw, 2018). Thus irrigation should be given a very good concern for the government of Ethiopia since millions (80% of the country population) are dependent on agriculture.

In addition, Irrigation can improve the amount of food available to the household through two main channels. The amount and diversity of home grown food can improve as a result of having access to irrigation water, and households may be able to purchase more food as a result of having more income from the sale of irrigated products (Domènech, 2015).

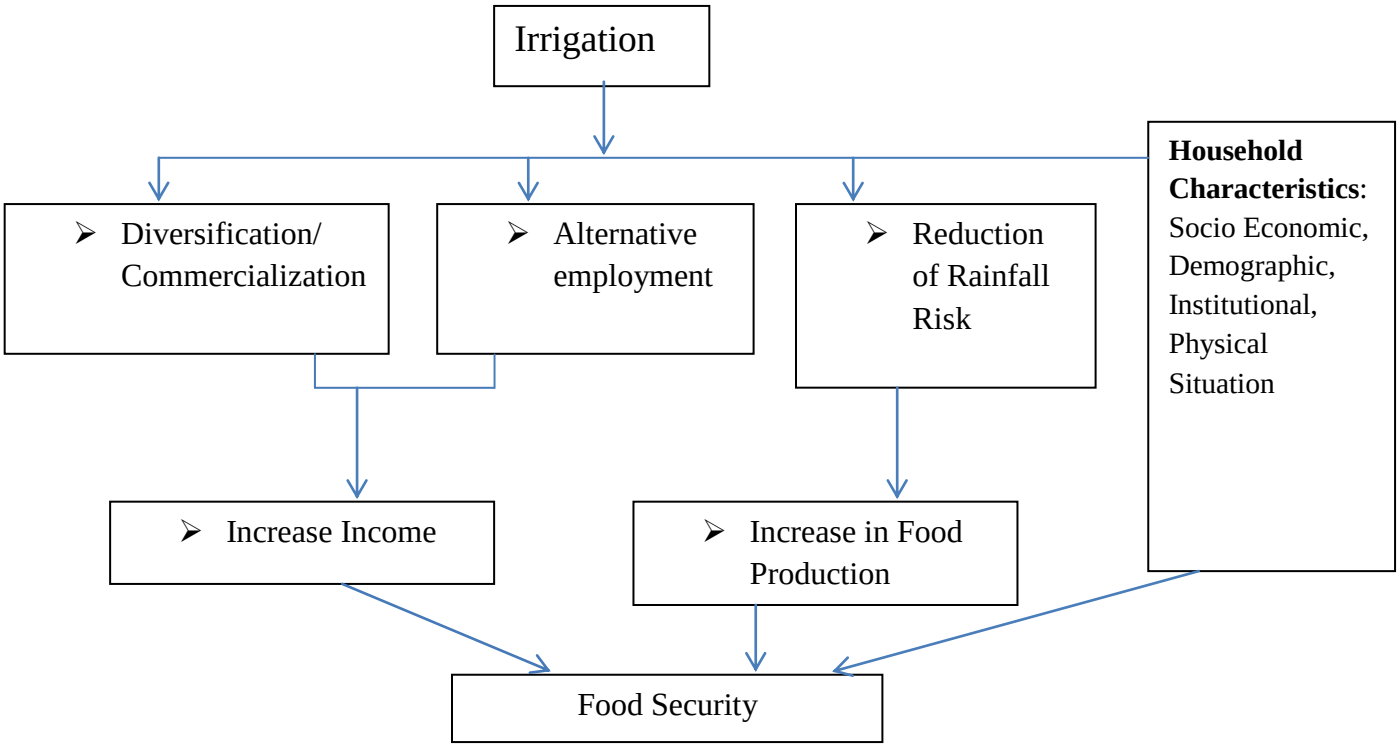
As a result since this study is concerned on the farm households which are either participant or non-participant of small scale irrigation, which is going to supplement the rain feed agriculture practice The development of small- scale irrigation scheme has led to increase cropping intensity per year and increase production by supplementing the rain fed production (Tesfaw, 2018). As well Getinet, (2011) discus smalls scall irrigation as;

> *Small-scale irrigation can be defined as irrigation, usually on small plots, in which small farmers have the controlling influence, using a level of technology, which they can operate and maintain effectively. In terms of management, there are three broad types of smallholder schemes: government-managed, farmer-managed, and jointly managed schemes. Farmer-managed schemes are developed either by community or by government but owned and managed by farmers' irrigation management committees or water users' associations with minimal government interventions.*

It is impossible to generalize that only accessing irrigation water by rural poor solves the problems of food insecurity. There are factors like, institution, policies, market situations and

rural household characteristics that affect directly or indirectly the food security and income situation of rural household (Getinet, 2011) . Thus, the conceptual framework is developed to represents the linkage between Household food security and Irrigation.

Figure 1: Schematic Representation of Irrigation and Food Security Linkage.



Source: Adopted From Tsegaye and Tamrat (2005) as cited in Getinet (2011)

2.3.1. Review of empirical literature on irrigation contribution for food security

Irrigation interventions can improve nutritional outcomes through multiple pathways, including increased productivity and availability of food supplies and improved diets (in quantity and quality) (Domènech, 2015). In Ethiopia at present some 197,000 hectares of land is under irrigation Vad VB, Solomon J, Adin DR (2005) cited in (Tesfaw, 2018). Therefore, there are potential opportunities to enormously increase the amount of irrigated land, this shows that much of the potentially irrigated land is under cultivated through irrigation even if the government of Ethiopia is said as it is planning and working on irrigation thru GTP II (2015/16);

In order to expand the contribution of medium and large scale irrigation development to the economy, guiding policy frame works will be formulated and sufficient annual budget allocated….. In addition, medium and large scale irrigation development feasibility studies and designs on 250,000 ha and construction on 280,385ha will be undertaken by the Ministry of Water, Electricity and Irrigation.

Coming to the contribution of irrigation to food security in Ethiopia The development of small-scale irrigation scheme has led to increase cropping intensity per year and increase production by supplementing the rain fed production. It also enables the farmers to produce cash crop such as coffee, sugarcane, cotton, banana and mango. Now a day the price of these cash crops grown in the area increased and competitive in the market from time to time and their livelihood improved (Tesfaw, 2018). The value of per hectare crop production under irrigated settings is about twice that of under rain-fed settings and It is estimated that in Amhara Region farmers earn up to about Birr 15,000.00 (about $1,800.00) from farm products, mainly horticultural crops from modern SSI schemes Awulachew et al (2005) as cited in (Getinet, 2011).

On the other hand studies conducted regarding the contribution of irrigation for food security on a specific study area is lacking in the region and (Getnet, 2011) states that specific empirical studies on the contribution of irrigation to household food security measured in terms of calorie acquisition is very scant or almost nil.

2.4. Empirical Literature on food security

2.4.1. Food Security situation at Global Level

Several literatures told us that Global food production is increasing but this increment is not in line with the distribution issues since we are observing considerable food insecurity around the world as the past times besides FAO, 2003 explain the condition as:

During the 1990s per capita growth of world agricultural production slowed. World cereal output, for example, fell from a peak of 342 kg per person in the mid-1980s to 311

kg per person in 1993-95, although it has since risen to 323 kg per person in 1996-98. The results of such statistics are evident in the fact that in 1995-97, 820 million were estimated by the FAO to be undernourished, with 790 million living in developing countries. Although the number of undernourished people in developing countries actually fell by 40 million between 1980/82 and 1995/97, this improvement was also uneven, being attributable to a reduction of 100 million in 37 countries, whilst in the remaining countries the numbers increased by 60 million.

In table one indicated below provided by FAO GIEWS, 2005 Depicted in FAO (2006) countries which are in need of food emergency varies from continent to continent which reviles that the problem is more prominent in Africa and the dominant variable in causing the problem is human induced even if the natural one is not much far in causing the emergency for food.

Table 1: Countries in need of food emergency

Dominant variable	Africa	Asia	Latin America	Europe	Total
Human	10	3	1	1	15
Natural	8	7	1	0	16
Combined	7	1	0	0	8
Total	25	11	2	1	39

Source: FAO GIEWS, 2005 Depicted in FAO (2006).

In 2016, the number of undernourished people in the world increased to an estimated 815 million, up from 777 million in 2015 but still down from about 900 million in the year 2000. Similarly, while the prevalence of undernourishment is projected to have increased to an estimated 11 percent in 2016, this is still well below the level of a decade ago(FAO, IFAD, UNICEF, WFP and WHO, 2017).

Table: 2, Prevalence of undernourishment in the world, 2000–2016

Percentage									
WORLD	2000	2005	2010	2011	2012	2013	2014	2015	2016
	14.7	14.2	11.5	11.2	11.0	10.8	10.7	10.6	11.0

Source: FAO Depicted in (FAO, IFAD, UNICEF, WFP and WHO, 2017).

The table illustrates that the percentage of undernourishment is declining but we can understands that the number of undernourishment is still bigger and as we observe from 2016 result it has some incremental situations from the past four years.

But within decades long at a global level the estimated total number of hungry people worldwide has declined by 218 million, from 1,011 million in 1990-92 to 792.5 million in 2014-16 (FAO, 2015).

The majority of countries already experiencing high-to-extreme food insecurity face risk factors that could worsen their food security through 2025 some countries that have low-to-moderate food insecurity today are at risk of experiencing worsening conditions during the next 10 years. The intersection of food insecurity with governance gaps will probably result in social disruption, political turmoil, or conflict (ICA, 2015).

Federal Ministry of Food and Agriculture of Germany (BMEL), (2015), states the food security condition in the globe further and describes how the situation occur in the developed countries of the world through this statement:

> *Roughly two billion people suffer from a shortage of vitamins and minerals. Another 1.4 billion are overweight or even obese as a result of unhealthy diet – not only in rich countries, but increasingly also in developing countries and emerging economies. Roughly half of the world's population does not receive an adequate diet. It is therefore not only a matter of increasing agricultural production, but of providing a balanced, healthy and sustainable diet for everyone.*

Here we can understand the issue of food security is a global concern and multifaceted since the definition (WFC, 1996, food security definition through the phrase ‘‘nutritious food’’) upholds that not only undernourishment is the phenomenon rather malnutrition which mainly exists in the developed countries is an immense problem and many of them are working on it.

On the other hand the problem of food security and its intensity and impact varies from region to region (FAO, IFAD, UNICEF, WFP and WHO 2017)

Hence the above empirical evidences told us the issue is not only confronted by the developing countries rather the developed countries too in terms of malnutrition but Africa as a continent took the bigger share of the problem as indicated in table one and three through holding 25 countries which are in need of food emergency and 333.2 million peoples affected by food insecurity in 2017 respectively and 306.7 million peoples out of the total 333.2 million peoples affected by food insecurity are found in Sub Sharan Africa.

2.4.2. Food Security situation in Africa

In Africa, the Average Dietary Energy Supply Adequacy has increased by about 8.41% since 1990-1992, though has remained stagnant since 2009-11 albeit unevenly and at below the average for all developing regions. The overall energy supply adequacy average for Africa, 116%, indicates, generally speaking, a sufficient level of food supply, which has significantly contributed to reducing prevalence of malnutrition in Africa (UNESCCA, 2015). But the continent is still in a big trouble in food security since FAO (2015) states approximately one person out of four in SSA is estimated to be undernourished today compared to a ratio of one out of three in 1990-92.

As well UNESCCA, (2015), in its report on Status of Food Security in Africa indicates from the viewpoints of food security components i.e. access, utilization and stability;

> *The physical access to food in Africa south to Sahara is complicated due to weak or inappropriate infrastructures such as poor roads, ports, communication, food storage facilities and other installations that facilitate the functioning of markets, particularly in rural areas… steady progress has been recorded in the reduction of the number of people without access to safe drinking water, improved sanitation and electricity over the past 20 years… From 2000 to 2012, there has been no improvement in the percentage of arable land equipped for irrigation, with even a slight decrease (from 6% to 5.7%); while the cereal import dependency ratio has worsen, by 24%, declining from 27.3% to 31.7%. As for the share of food imports in total merchandise exports, it has declined from 13% to 11%, though highly fluctuating, over 1990-2011.*

In addition there is a difference in encountering food security problems from region to region within the continent as FAO (2015) indicates that Compared to other sub-regions, Western

Africa has made significant progress, having reduced the number of undernourished people (WFS) by almost 13 million between 1990-92 and 2014-16….. But Since 1990-92, other sub-regions experienced an increase in the absolute number of undernourished people, approximately 20 percent and 2 percent respectively in Eastern and Southern Africa.

Table 3: Share of undernourished people by sub region (2014-16)

	Percentage	Total in million
East Africa	57	217.8
Middle Africa	27	
South Africa	2	
West Africa	14	

Source: FAO, 2015.

The above table illustrates the level of difference in terms of share in the regions with the greater share of east Africa in which Ethiopia resides. Therefore much emphasis shall be given for the region (East Africa), which can help the countries to minimize at least the situation that occurs yearly as acute food insecurity.

2.4.3. Food Security situation in Ethiopia

Ethiopia is a highly famine affected country in the world as Abduselam (2017) states by citing (Catleyet al., (2016), DFID (2014), Webb et al (1992) the Year of event and Major relative incidences of famine after 1953 were 13 famine seasons till 2016. Which indicates as the country is highly vulnerable to food insecurity.

Food insecurity situation in Ethiopia is highly linked up to severe, recurring food shortage and famine, which are associated to recurrent drought /ibid/.Thus Ethiopia is a predominantly drought prone country as history shows and following that famine were occurred, and food security problems are always the homework of every government that administers the country whether they tackle it successfully or not.Besides according to FAO, (2017) situation report 5.6 million People are food insecure in 2017... At the start of 2016, more than 10.2 million people

were in need of emergency food aid, 1.7 million household's seed insecure and 2.4 million households in need of livestock support.

The Ethiopian agriculture and livestock production are mostly traditional and heavily depends on the erratic and unpredictable rainfall. As a result, yields are low and post-harvest losses are high, creating widespread food insecurity (Fayera, 2016). Likewise about 4 to 6 million people are estimated to suffer from chronic/transitory food insecurity across the country as a result of weather related hazards. Average daily food consumption is 1880 Kcal/Capita/day compared to 2,199 for sub Saharan Africa (Derej*et al*, 2008).

Birara *et al* (2015), illustrates the causes for food insecurity in Ethiopia are mainly backward agriculture, land degradation Drought, Population Pressure, poor infrastructure facility, low level of off farm/ non-farm activity.

Recently El Niño is becoming the main reason for the livelihood problems which in turn results food insecurity in the country, FAO (2016) indicates In Ethiopia, El Niño crisis is first and foremost a livelihoods crisis. The drought has had a profound impact on the livelihoods of agriculture- and livestock-dependent households, causing thousands to rely on food aid.

The estimates reveal that: the share of people in Ethiopia who are undernourished in 2014-16 is 32 percent, a reduction from 74.8 percent in 1990-92 (FAO, IFAD and WFP, 2015). But the number is still high which shall be reduced through hard work. In addition, an estimated 7.6 million (or 11 per cent of the rural population) are currently considered chronically food insecure, meaning each year they are relying on resource transfers to meet their minimal food requirements. Over the past four years between 2.2 and 6.4 million additional people were food-insecure or not able to meet their food needs in the short term due to transitional factors. They are temporarily dependent on relief food assistance (FAO, 2015).

The country tries to minimize the food insecurity through different ways, Food Security Strategy of Ethiopia of 2002 and PSNP for instance FAO (2015) indicates PSNP in the country has grown immensely since its inception in 2005-2006 from a $ 70 million budget to 175 million in Phase II (2007-2009) and 1.3 billion in Phase III (2010-2014). Through the Household Asset Building Program (HABP), rural people can become not only food sufficient but also

sustainably food secure, enabling them to graduate from the PSNP and eventually the Food Security Programme (FSP) altogether.Yet till 2015 no additional capacity have been created in building stocks of emergency food grain reserve apart from maintaining the stock at 405,000 metric tons which is equal to the level at the beginning of the plan (2009/10) (National Planning Commission 2016).

2.4. 4. Picture of Food security in Amhara region

The Amhara region, formerly known as Region 3, has an estimated population of over 20,398,999 million, of which about 17,092,002 was rural population based on Central Statistics Agency 2007 census result (BoFED, 2015). More than 37% of the total population is living in absolute poverty (earning less than a dollar a day), which makes the region's food security situation more precarious compared to the national average 44.4 % (WFP, 2009).

In 2011 in Amhara region the headcount ratio, short-fall and severity of food insecurity were 48%, 18% and 8.7%, respectively. The results revealed that the incidence of household food insecurity was 0.48. This implies that about 48% of the sampled households were not able to meet the daily recommended caloric requirement (Mesfin, 2014).

Ethiopian public Health institute, (2016), indicates in their study of food insecurity and its association with under five children nutritional status in Amhara region sekelaworeda they state that Under five children in Amhara Region affected by under nutrition is more than other regions.

> *The Amhara region suffers from recurrent droughts and pest invasions. Of the 105 woredas in the region, forty-eight are drought-prone and chronically food insecure there has been no single year since 1950 where there was no drought in the eastern part of the region…On the other hand, much of the western half of the region has good soils and adequate rainfall and typically produce agricultural surpluses* (USAID, 2000).

Therefore the empirical literatures reveal that the region is the most Food insecure in the country since it's below the national average and almost half of the region woredas are food insecure

especially the eastern region parts i.e. South Wollo, Oromo liyu, Waghimira and half part of South Gondar zones.

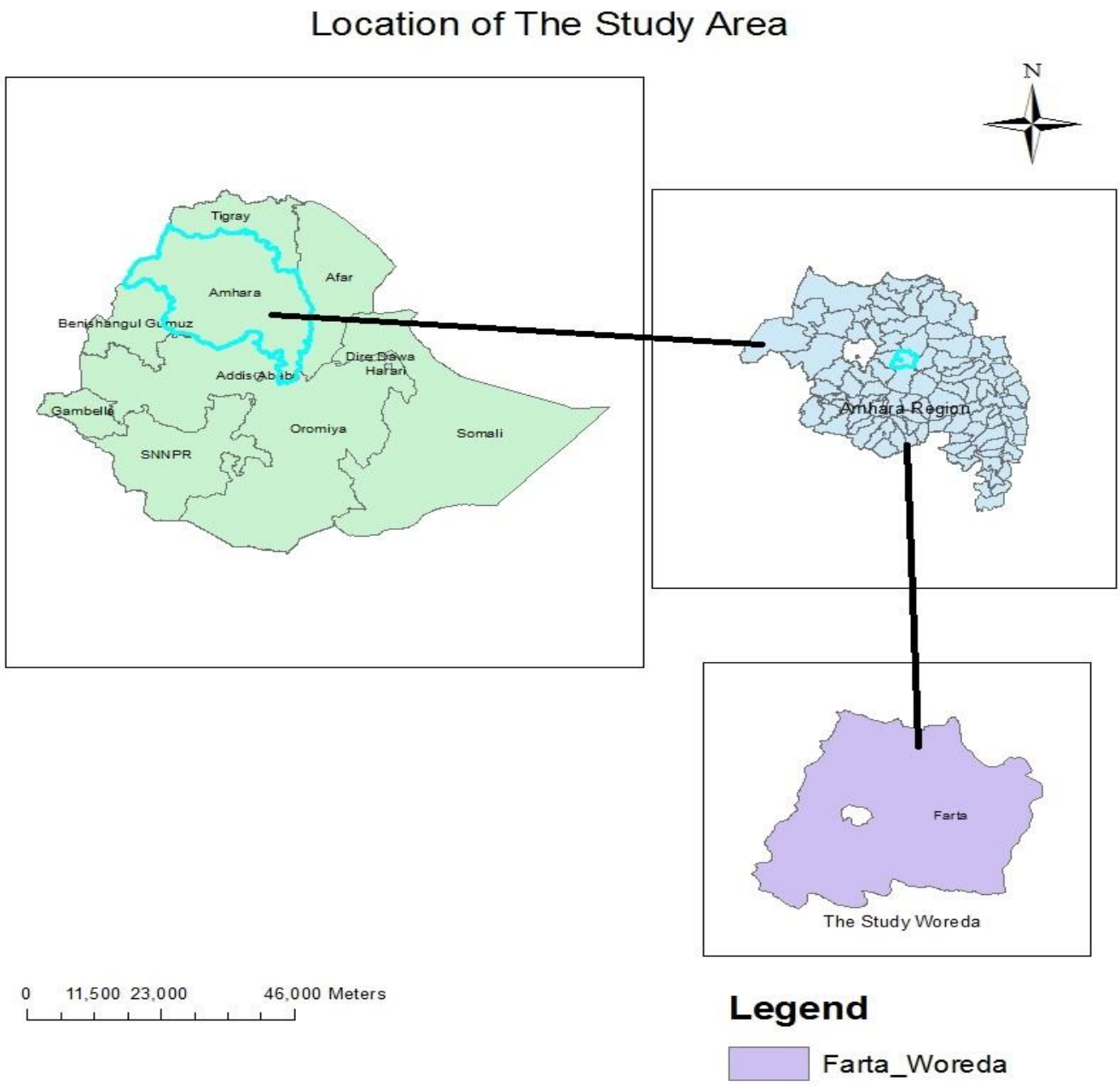
CHAPTER THREE

3. Methodology

3.1. Description of the study area

Farta Woreda is located in the North West part of Ethiopia and about 667 km from Addis Ababa. The area is situated at the altitude which ranges from 2000 to 2500 meters above sea level and it consists of four major agro ecological zones: 25% low land, 45% medium highland, 24% highland and 6% gorge. The annual temperature ranges between 9 and 25 degree Celsius and the rainfall varies from around 1250 mm in the lowlands to 1500 mm in the highland areas during the rainy season. Agriculture and pastoralism (mixed) are the main economic activities in the district. According to the 2007 Ethiopian baseline census, The Amhara National Regional State Bureau of Finance and Economic Development shows that Farta Woreda population in 2015 is 276,144.

Figure 2: Location of the study area:



NB: Scale is for Farta Woreda

Source: Own Construction via Arc GIS tools,

3.2. The Study Design

This research apply mixed research approach, To do so the dependent variable, Food Security (Food Consumption Score) and the quantitative explanatory variables i.e. Irrigation, farmland size, Household Head age, expenditure, off farm income, market access, use of improved technology, Access to extension service, education, crop diseases, number of livestock in TLU, family size, saving, remittance are incorporated to determine which one is significant variable that affect food security situation of the study areas well, it includes the contribution of irrigation on food security hence irrigation is the treatment dependent variable.

So as to apply the selected and fitted regression model which is Tobit the Food Consumption Score (FCS) is taken as a censored continuous dependent variable well for the independent variable depending on the nature of the variable it represent a specified numeric value for instance, irrigation participants are denoted by 1 and non-participants by 0. As a result, data produced are numerical and analyzed using mathematical and statistical methods.

Thus, this research applies causal research design (Cause effect) as it is concerned with cause-effect relationship. In other words, changes in the value of independent variable directly or indirectly cause changes in the value of dependent variable (Bordens and Abbott, 2011). In this research, the dependent and independent variables have such relationship, i.e. the causes are explanatory variables farmland size, off farm income, market access, use of improved technology, extension service, Education, crop diseases, number of livestock, family size, Savings, Remittance, expenditure and the effect is Food Consumption Score. So, change in the value of explanatory variable directly or indirectly affects food security. Hence, the objectives of the research demand such type of design as a result; this research relied on casual research design.

3.3. Sampling method

The sampling procedure pursued to select sample kebeles was multi stage cluster stratified sampling .The kebeles were clustered into two: two of them north east of the zonal capital (Debre-tabor) and the rest two west of it. Then the kebeles were stratified based on irrigation practice intensity based on the information accessed from the Woreda agricultural office and proximity while sample households were identified by proportional random sampling method

among irrigation users and non-irrigation users and between the two kebeles. Eventually, Woyibilaselamiko and Hiroyi aba aregay were selected.

The sampling size was determined based on the formula derived from the Binomial Theorem

Thus the minimum sample size, N for a given confidence level and precision was calculated as

$$\mathbf{N = (Z^2 X P (n\text{-}P) D)/E^2}$$

Where

- N= Minimum sample size
- Z= Z value (Z score) is derived from the anticipated confidence level for this study. The confidential level is 95 % which has Z score of 1.96.
- P = Anticipated proportion that is to be measured. This is the estimated value of what is the researcher is going to measure (The hypothesis that is going to be tested) using the sample. Since the research anticipates to study the extent of food insecurity, thus by taking a reasonable guess based on other studies, in Ethiopia, according to the 2016 CSA , the proportion of poor people(Poverty head count index) in the country is estimated to be 25.3% for rural areas. Therefore, P for this study is taken at 25%, (0.25).
- D= Design effect. This reflects the sample design with D at 1 for simple random sampling. For social rating, it is recommended that D= 1.5 for random sampling.
- E = Precision (or margin of error). E is the precision with which the researcher wants to measure something. In most statistical study E is kept at 10% particularly for poverty assessment studies it is recommended using E=10%.
- n= is the maximum sample size which is 100%
- Therefore to calculate the sample size for this study, let us use the above value

  N = (Z2 X P (n-P) D)/E2

  $N= (1.96^2 \times 0.25(1 - 0.25)1.5)/ 0.1^2$

  N= 1.08045/ 0.01

  N = 108.045

  N= 108

Source:Atinkut, (2015), by citing Levine et al (2005)

Hence through the quota sampling techniques from the list which were available two rural kebeles were selected using proportional sampling technique.

Table 4: Name of rural kebele and Sample HH Number

Name of Kebele	Sample HH Number
WoyibilaSelamiko	60
HiruyiAbaregayi	48
Sum	108

3.4. Method of Data collection

Households in the study area are used as a sampling unit and all the necessary data were drawn from the head of the household and the survey cover half December and half February seasons during the 2019 agricultural year. So as to gather data which assist to assess the food security situation of the study area FCS and HFIAS models were used as well Observation, key informant interview and structured questioner were used.

The key informant's were the food security officers of the zonal administration and Development Agents of the respective kebeles. Regarding the FCS, data collection module during the field survey, respondents were asked whether anyone in the household consumed a food item and if they respond "yes", how many days a week. As well HFIAS data collection module was used to determine the food security situation of the respondents in addition to FCS then the result of the two models (FCS and HFIAS) was contrasted.

Qualitative method were applied through data collection tools, Observation Atinkut, (2015) states as Observation of the people's way of life, their assets and resources, the ups and downs to overcome their daily struggles, their activities for living, etc., would provide valuable and supportive information. And Key informant questionnaires and qualitative data analysis approach were used through paraphrasing of the finding. Consequently through triangulation of quantitative and qualitative data analysis results better information had been gathered, analyzed and interpreted.

3.4.1. Description of variables and expected outcomes

1. Dependent Variable

Food Security (Food Consumption Score): is the dependent variable for the whole analysis, and is continuous since; it was represented by Food Consumption Score. Hence, it will have continuous result which will begin from 0 (zero) and continue till 112 (Alemseged et al, 2018), households could have an FCS of either of the extremes (0 or 112) since, respondents will be asked whether anyone in the household consumed a food item and if they respond "yes", how many days a week. But, practically, it rarely exists that a household would a have an FCS of 0 (which means no food consumed by household members for 7 days) and an FCS of 112 (which means all food groups were consumed on all 7 days by household members) in Food consumption score result and the study used FCS result for Tobit model regression as a dependent variable to determine the significance and marginal effect of explanatory variables.

As well food security situation were assessed via Household Food Insecurity Access Scale and the result score is categorized as 1,2,3,4 i.e. (1 = Food Secure, 2=Mildly Food Insecure Access, 3=Moderately Food Insecure Access, 4=Severely Food Insecure)results based on household food insecurity access scale.

2. Explanatory Variables

There are fourteen independent variables that were assumed to affect food security in the study area. These are:

Irrigation: Use of irrigation is perceived as an additional way of increasing the availability of food for the household which in turn has positive relation with food security As Getinet (2011) states at country level, irrigation with higher yields can allow countries to grow more of their own food. Irrigation is a dummy variable in this research Thus, Households that did not use irrigation or those who were living adjacent to the irrigation users and the different small-scale irrigation scheme users will be used as the comparison group, and irrigation participants are coded as 1 and 0 for non-participants.

Farm land size: Is a continuous variable and measured in terms of hectares. Farm land Size is an important determinant of household food security and it is the total area of land cultivated to

food and cash crop by households, measured in hectares (Birara et al, 2014). Farm land size plays an important role in food security as it enables the households to cultivate their land and have enough farm products that can feed the whole family members. Thus, it is expected that the value of the coefficient for household's farm land size is different from zero and food security has a significant positive relationship with farm land size.

Household head Age: Can be used as a proxy for experience of household head since he/she started farming (Alem, 2007). Younger household heads were expected to have relatively poorer experiences of the socio-physical environments and farming than older household heads. By indicating Haile et al (2005) Birara et al (2014) wrote as older people have relatively richer experiences of the social and physical environments and greater experience of farming activities. Older household heads are expected to have better access to land than younger heads, because younger men either have to wait for land redistribution, or have to share land with their families. As well age is taken as a continuous variable in the study and it is expected as age of the household head increases the household opportunity to become food secured increases.

Off farm income: Is a continuous variable since it is measured in terms of birr based on the households secured from the off farm activities. It is assumed to have a positive relationship with food security and Birra et al (2014) wrote in their study as more household head engage in gainful employment, the higher he/she earns income and the greater the chances of being food secure because higher off farm income enables households to become food secure and vice versa. Hence, it is expected the value of the coefficient will be different from zero and food security to have a significant positive relationship with off farm income.

Market access: it is having a good market access for technological inputs as well as market for farm products which can be easily accessed to sell at fair price as well Hebebrand and Wedding (2010) states that Markets are necessary to boost productivity and availability and improved access to agricultural input markets such as seed and fertilizer is crucial for productivity growth. Moreover, farmers will only increase production if they have access to viable markets for their agricultural outputs. And it has positive relation with food security since having technologies and selling farm products at fair price will enhance productivity and increase income respectively as the same time food security can be supplemented. The hypothesis is, therefore,

the value of the coefficient (β) for market access is different from zero and food security has a significant positive relationship with market access.

Use of improved technology: Here the variable holds either using technology or not thus it is a dummy variable with positive relation with food security, when we say technologies, as Alem (2007) wrote Technology adoption refers to the use of farm inputs like chemical fertilizer, pesticides, improved seeds, farm credit and access to irrigation water with improved agronomic practices. Fertilizer use pesticides post-harvest management tools etc. Thus, it is expected the value of the coefficient for use of improved technology to be different from zero and food security to have a significant positive relationship with use of improved technology.

Education; Education is first assessed to determine if the respondents are literate or illiterate based on reading and writing skills besides it is dummy variable considering as 1 for literate and 0 for illiterate respondents thus the study expected as literacy will have a positive influence on food security .

Crop diseases: Crop disease affects agricultural product and productivity negatively in the main time food security is affected negatively and Mulugeta (2002), wrote that it is an important biological factors limiting crop production and causes of food deficit. As a result, it was assumed that farmers with problem of pest infestation are more likely to be food insecure than those who don't have the problem and in the study area crop diseases is expected to influence food security negatively. Based on this, the hypothesis can be formulated as the value of the coefficient (β) for crop disease is different from zero and food security has a significant negative relationship with crop disease.

Number of livestock: It is measured in terms of total number of livestock holding of the farmer measured in livestock units in a household. Livestock possession enables the households to be food secure either through the income earned or by direct consumption. Households with no or few numbers of livestock were more likely to be food insecure (Worku et al, 2014). Therefore, TLU is a continuous variable and is assumed to have a positive association with food security. This is because there will be additional food stuff for the family. For this reason, it is

hypothesized that the value of the coefficient for number of livestock is different from zero and food security has a significant positive relationship with number of livestock.

Access to extension service: It is the provision of advice, information, and other supports to households. The advices and supports are may be provision of training on the mechanisms of disease and pest control, post-harvest product management, way of preparing quality compost. Thus, it is measured in terms of accessing extension service or not. Access to extension and veterinary services was expected to have a positive impact on household food security in the study area (Hussein and Janekarnkij, 2013). Hence, it is a dummy variable and expected to have a positive correlation with the dependent variable. Therefore, the hypothesis is that the value of the coefficient (β) for extension service is different from zero and food security has a significant positive relationship with extension service.

Family size: It is measured in terms of number of individuals in one family. In this research, it is a continuous variable and is assumed to have a positive association with food security and as Ejigayhu and Edris (2012) wrote Household size was found to be directly related with household food insecurity. Larger family households have higher probability to be food insecure. This is because there will be division of labor in a family as farm practice in the study area is labor intensive. For this reason, it is hypothesized that the value of the coefficient for household size is different from zero and food security has a significant positive relationship with family size.

Savings: Savings affect food security through its impact on access to food that is, through mechanisms that affect a household's ability to purchase and/or produce food (Shaw and Nagarajan, 2011). Saving increase the capacity of household to access food and nonfood item and increases the probability of being food secure and it has a positive effect on food security thus this study takes it as it is both dummy and continuous since households will participate in saving or not and the amount of birr that will be saved will be different in terms of birr respectively.

Remittance: As saving did remittance increase the household opportunity of being food secure citing Instraw (2008), Nigussie et al (2017) states remittances contribute to the improvement in the food security of receiving households in addition to a significant change in food

consumption patterns and the study takes it as it is both dummy and continuous since households will have an income from remittance or not and the amount of birr that will be earned will be different in terms of birr respectively.

Expenditure on Food and non-Food: Expenditure on food and nonfood items will have negative relation in relation to food security and it is a continuous variable depending on the amount of money spent for the purpose.

Table 5: Expected sign of explanatory variables

Variables	Label	Type of variable	Expected sign
Irrigation	IRR	Dummy	+
Household head Age	HHAGE	Continuous	+
Farm land size	FLS	Continuous	+
Off farm income	OFI	Continuous	+
Market access	MA	Continuous (distance in meter or kms)	+
Use of improved technology	UIT	Dummy	+
Education	EDU	Dummy (read and write?)	+
Crop diseases	CD	Dummy	_
Number of livestock (TLU)	TLU	Continuous	+
Access to extension service	ATESERV	Dummy	+
Family size	HHSIZE	Continuous	+
Savings	SAVING	Dummy and continuous	+
Remittance	REMI	Dummy and continuous	+
Expenditure on Food and non-Food	EXPENDITURE	Continuous (Birr)	_
Household Food insecurity Access Scale (Model dependent)	HFIAS	Categorical	+/_
Food consumption score (Model dependent)	FCS	Continuous	+/_

3.5. Analysis method

This research employs both descriptive statistical tools and non-linear econometric model i.e. Tobit for data analysis and use STATA software, which used to cover statistical tools and regression. The data analyzed is presented using tables. But before going to use the Tobit and Propensity Score Matching for effect measurement Food Consumption Score which is an index developed by the World Food Programme (WFP) in 1996 and Household Food Insecurity Access Scale were used as an indicator of Food Security by indicating Vatilla et al. (2013) Nigussie et al (2017), wrote as the Household Food Security Access Scale (HFIAS) captures a mix of sufficiency and physiological factors, while the food consumption score capture quality, diversity and quantity as well. By the use of these two models it was tried to compare and contrast the results obtained (Triangulate the result of both models).

1. Food Consumption Score

The World Food Program Vulnerability Analysis and Mapping (2008), and states FCS as a measure for caloric intake and diet quality at household level and the Technical guidance sheet illustrates the standard use of food consumption score for food security analysis as;

a) Using the standard Vulnerability analysis and mapping seven (7) day food frequency data and group all the food items in to specific food groups,
b) Sum all the consumption frequencies of food items of the same group and recode the value of each group based on the already prepared seven groups,
c) Multiply the value obtained for each food group by its weight and create new weight food group score,
d) Sum the weighted food group score, thus creating the food consumption score,
e) Using the appropriate threshold which is, 0-28 poor, 28.5-42, Borderline and above 42 acceptable for this study the score will be taken as it is since am going to use the Tobit model.

Thus the Score will be calculated as: FCS = (Ymainstaples× Xmain staples + Ypulses ×Xpulses +……Yoil×Xoil)

y_i= Frequencies of food consumption = number of days for which each food group was consumed during the past 7 days (7 days was designated as the maximum value of the sum of the frequencies of the different food items belonging to the same food group)
x_i= Weight of each food group

Table 6: Food Groups and Standard Weights

Food Groups	Weight
Main Staples	2
Pulses	3
Vegetables	1
Fruits	1
Meat and Fish	4
Milk	4
Sugar	0.5
Oil	0.5

Source: World Food Program Vulnerability Analysis and Mapping (2008)

2. Household Food Insecurity Access Scale (HFIAS)

The Household Food Insecurity Access Scale (HFIAS), which is an adaptation of the approach used to estimate the prevalence of food insecurity in the United States (U.S.) annually. The method is based on the idea that the experience of food insecurity (access) causes predictable reactions and responses that can be captured and quantified through a survey and summarized in a scale (Coates, et al, 2007).

The research use HFIAS, which consists of two types of questions: nine ‘occurrence’ and nine ‘frequency-of-occurrence’ questions. The respondent is first asked if a given condition was experienced (yes or no) and, if it was, then with what frequency (rarely, sometimes, or often). The resulting responses can be transformed into either a continuous or categorical indicator of food security. When calculating the HFIAS as a continuous indicator, each of the nine questions is scored between 0-3, with 3 being the highest frequency-of-occurrence, and the score for each

is added together. The total HFIAS can range from 0 to 27, indicating the degree of insecure food access. Hence the study will employ the Categories of food insecurity (access) as Food Secure, moderately food insecure, mildly food insecure, severely food secure depending on the result of a household's set of responses. And the HFIA category is calculated as the Household Food Insecurity Access category for each household. 1 = Food Secure, 2=Mildly Food Insecure Access, 3=Moderately Food Insecure Access, 4=Severely Food Insecure.

- Access HFIA category = 1 if [(Q1a=0 or Q1a=1) and Q2=0 and Q3=0 and Q4=0 and Q5=0 and Q6=0 and Q7=0 and Q8=0 and Q9=0]. Which mean HFIA Score = 1
- HFIA category = 2 if [(Q1a=2 or Q1a=3 or Q2a=1 or Q2a=2 or Q2a=3 or Q3a=1 or Q4a=1) and Q5=0 and Q6=0 and Q7=0 and Q8=0 and Q9=0]. Which mean HFIA Score = 3-8
- HFIA category = 3 if [(Q3a=2 or Q3a=3 or Q4a=2 or Q4a=3 or Q5a=1 or Q5a=2 or Q6a=1 or Q6a=2) and Q7=0 and Q8=0 and Q9=0]. Which mean HFIA Score = 16
- HFIA category = 4 if [Q5a=3 or Q6a=3 or Q7a=1 or Q7a=2 or Q7a=3 or Q8a=1 or Q8a=2 or Q8a=3 or Q9a=1 or Q9a=2 or Q9a=3]. Which mean HFIA Score = 17 and above.

A) Descriptive statistics

Descriptive statistics is used to characterize and describe univariate data (Bordens and Abbott, 2011). Thus, this research employs descriptive statistical tools (such as frequency, percentage, mean, SD and Correlation matrix i.e. chi square and T-test) to assess the food security situation of the study area and correlation between variables.

B) Econometric Analysis

Furthermore, the study uses econometric model to analyze the cause-effect relationship between the dependent and independent (explanatory) variables. According to Kothari (2004) if there is a cause-effect relationship between two or more than two variables (i.e. bivariate or multivariate), regression is the relevant technique for analysis. Thus, as food security is determined via multiple factors i.e. as Birara, *et al* (2015) write by citing (Bedeke, 2012; Eden *et al*., 2009; Regassa, 2011) Irrigation, age, farmland size, off farm income, market access, use of improved technology, education, crop diseases, number of livestock, expenditure on food and non-food, remittance and family size were expected as major determinants of household food security. As a result, the study applied regression model.

Since the dependent variable (Food Security) is qualitative in nature, Food Security situation of the sample shall be known via Food Consumption Score then the resultant score is directly taken as a dependent variable. Thus, the Food Consumption Score have continuous variable that begins from 0 to 112 and in this case the model that is employed is Tobit. But before I use the model variable inflation factor and contingency coefficient test were done as well model fitness was cheeked.

3. Tobit Model

The econometric model that has been applied for analyzing factors affecting household food security is the Tobit model explained hereafter. This model is chosen because it has advantage over other discrete models (Logistic and Probit) in that; ‘’it measures not only the probability that a household become food secure or insecure, but also the intensity of the food insecurity’’ (Ejigayhu and Edriss, 2012) as well Tobit model can be applied to censored data’s like Food Consumption Score results which are censored from both sides i.e. from left and right 17.5 and 81 respectively in this research case.

The Tobit model that was used in this research can be expressed as follows:

$FCS = \beta X_i + U_i$ ……..(1)

Where, FCS= 0 for Qi > Z, and

FCS = (Z – Qi)/Z for Qi <Z

X_i = Vector at explanatory variables

β_i= vector of respective unknown parameters

U_i = residuals that are independently and normally distributed with mean zero and a common variance, σ

FS= food security Status of Household i greater than zero

Z = Food security line (minimum FCS score).

Q_i = food consumption score of Household i

4. Effect measurement using Propensity score matching methods

Propensity score matching (PSM) constructs a statistical comparison group that is based on a model of the probability of participating in the treatment, using observed characteristics. Participants are then matched on the basis of this probability, or propensity score, to nonparticipants (Shahidur et al, 2010). Then measure the impact of irrigation on the confounding variables with the independent variable the first task would be find the propensity score by using probit.

PSM constructs a statistical comparison group that is based on a model of the probability of participating in the treatment T conditional on observed characteristics X, or the propensity score:

$P(X) = Pr(T = 1|X)$ ……1

Rosenbaum and Rubin (1983) cited in (Shahidur et al, 2010), show that, under certain assumptions, matching on P(X) is as good as matching on X. The necessary assumptions for identification of the program effect are (a) conditional independence and (b) presence of a common support. These assumptions are detailed in the following sections.

Here we can understand that so as to use the propensity score matching the conditional independence and presence of common support shall be available i.e.

Assumption of Conditional Independence and common support

Conditional independence states that given a set of observable covariates X that are not affected by treatment; potential outcomes Y are independent of treatment assignment T. If Y_1 T represents outcomes for participants and Y_0 outcomes for nonparticipants, conditional independence implies.

$$(Y_1, Y_0) \perp T|X \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

A second assumption is the common support or overlap condition: $0 < P(Ti = 1|Xi) < 1$…..3

This condition ensures that treatment observations have comparison observations "nearby" in the propensity score distribution Heckman, LaLonde, and Smith (1999) cited in (Shahidur et al, 2010).

Rosenbaum and Rubin (1983), shows that if the exposure to treatment is random within cells defined by X, it is also random within cells well-defined by the values of the mono-dimensional variablep (X). As a result, given a population of units denoted i, is the propensity score $p(X_i)$ is known the Average effect of Treatment on the Treated (ATT). In non-experimental studies, the most common approach evaluate a program effects is to calculate the average effect of the treatment on the treated [ATT]. Shahidur et al, (2010) states that the treatment effect of the program using these methods can either be represented as the average treatment effect (ATE) or the treatment effect on the treated (TOT) and the estimation of the treatment effect is as follows:

The average treatment effect (ATE): $E(\Delta_i) = E(Y1i - Y0i) = E(Y1i) - E(Y0i)$……. 3

Where $\Delta_i = Y1i - Y0i$.

This is the expected effect of the project for a randomly selected individual. The average treatment effect on the treated (ATT):

$$E(\Delta_i = 1) = E(Y1i - Y0i : Ti = 1) \text{……..4}$$

$$= E(Y1i : Ti = 1) - E(Y0i : Ti = 1)$$

Where the outer expectation is over the distribution of $(p(Xi) : Ti = 1)$and$Y1i$ and$Y0i$ are the potential outcomes in the two counterfactual situations of treatment and control respectively.

The PSM technique has been used as a non-parametric method in the impact evaluation literature. Matching methods support in creating a counter factual from the control group. The basic assumptions when using a counter factual is that the untreated samples approximate the treated samples if they had not been treated, i.e., $(Y_{0i} : \mathrm{I} = 1)$ (Heckman et.al., 1998 cited in Endeshaw, 2016).

The assumption of conditional independence (CIA) is critical and proper so as to valid the matching. This assumption argues that treatment is random and conditional on observed variables(x) specified as in the equation (2).

This assumption implies that the counter factual outcome for the treated group is the same as the observed outcome for the non-treated group given the control variables(x). In the present case, this means that the counterfactual food security situation is the same as the food security situation that would have existed if the household had no access to irrigation, specified as:

$$\mathrm{E}(\mathrm{Y}_0 \backslash \mathrm{X}, \mathrm{I} = 1) = \mathrm{E}(\mathrm{Y}_0 \backslash \mathrm{x}, \mathrm{I} = 0) = \mathrm{E}(\mathrm{Y}_0 \backslash \mathrm{x}) \quad \text{……..5}$$

The first term of equation (5) represents the counterfactual food security situation of the treated group and is equal to the observed food security of the untreated (control) group. This assumption rules of selection in to the program and gains from irrigation on the basis of run observables. The CIA requires that the set of X's contain all variables that jointly influence the outcome with no treatment, as well as the selection in to program. Under conditional independence, therefore, the ATT can be computed as:

$$ATT = E(Y_1 - Y_0 \backslash X, I = 1) = E(Y_1 \backslash x, I = 1) = E(Y_0 \backslash x, I = 1) \ldots\ldots\ldots\ldots\ldots 6$$

However, matching of households based on observables may be feasible when the dimensions of control variables are large. To overcome this problem of dimensionality, Rosenbaum and Rubin (1983) argued that one can match along a single score variable given by the propensity score, $p(x)$, which summarizes the large variables.

Propensity score matching (PSM) to be valid the balancing properties need to be satisfied as well Caliendo and Kopeinig, (2005) marked that CIA, requiring that the outcome variable(s) must be independent of treatment conditional on the propensity score. Hence, implementing matching requires choosing a set of variables X that credibly satisfy this condition**.** It is perceived that two households with access to irrigation the same probability would be placed in the treated and control samples are equal proportions. The propensity score is estimated by a binary probit model as this study done. Once the propensity score (Pscore) is estimated, the data is divide in to two equal spaced Pscore intervals, which tends to that, within each of these intervals, the mean Pscore of each conditioning variable is equal for the treated and control households, known as the balancing property. Since the P score is a continuous variable, exact matching may not be possible, in which case a certain distance between households with and without access to irrigation must be accepted. In the present research, households with and without access to irrigation would match based on their propensity score (Pscore) using matching method i.e. nearest neighbor, Kernel and stratification matching methods.

Nearest neighbor matching method

A case in which the control group is matched to a treated case based on the closest propensity score, each treated observation is matched with an observation in the control group that exhibits

the closest propensity score. In nearest neighbor matching, it is possible that the same household in the control group can neighbor more than one household in the treated group. Therefore, after matching, the difference between their food security situation is calculated as the average effect of access to irrigation (ATT).

Kernel matching method

All treated observations are matched with households in the control group based on the weighted average that is inversely proportional to the distance between the propensity scores of the treated and control groups. Using of the weighted averages of all cases in the control group to estimate counterfactual outcomes. 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.

Stratification matching method

The data set is divided in to intervals having, on average, the same propensity score. The treated and control groups within that intervals are placed under one block, and the mean difference of the outcome between the treated and control groups provides the average treatment effect of irrigation on household income(ATT). In this study the hypotheses research is described as follows.

To estimate the household's probability of participation in the irrigation scheme [Y=1 decision to participate, Y=0 otherwise], the probit model would deploy to analyze the contribution of irrigation for food secured and food in secured. The predictor variables would be related to the dependent variable Y (FCS).

After determining the irrigation participation of households' pscore, the next would be to estimate the ATT of food security. The food security situation is analyzed by using food consumption score as explained in the above.

These model identify the estimating causal effect nearest match for each treatment household (i.e., with the closest propensity score) among households that are control groups, and next compute the effect of irrigation as a mean difference of each outcome variables.

CHAPTER FOUR

4. Results and Discussions

This chapter deals with the results of descriptive statistics and econometric model and the descriptive statistics show the respondents (sample kebeles) food security status using food consumption score and household food insecurity access scale using mean, standard deviation, frequency, percentages and correlation matrix. As well, Household characteristics and irrigation practice with food security are presented via chi square and t-test analysis.

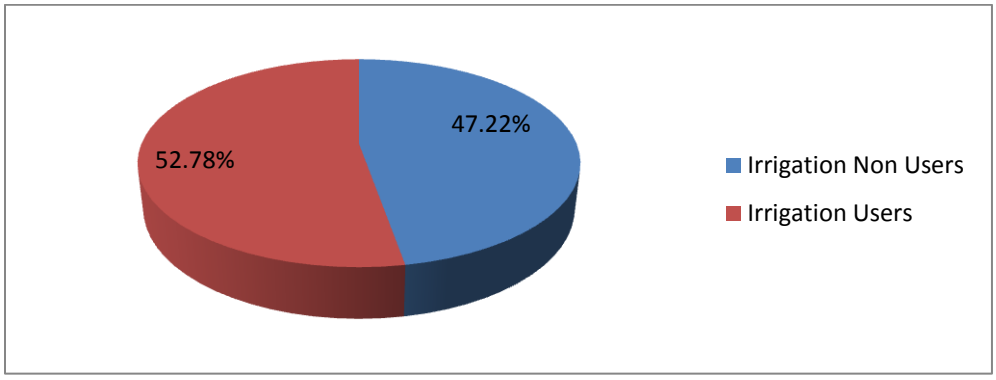
The second section presents the results of econometrics analysis used to describe the contribution irrigation to food security in the sample kebeles using propensity score matching model and determinants of food security in terms of Food Consumption Score is seen by Tobit model.

4.1. Descriptive Results and Discussions

4.1.1. Irrigation practice of the sample kebeles

Woyibila Selamiko and Hiruyi Abaaregayi were the two sample kebeles with 108 households. From figure 3 below, we can understand that the total numbers of households who are irrigation users was 52.78% and the non-irrigation user was 47.22%.

Figure 3: Sample household in irrigation users and non- users groups



Source: Computed from Survey Data (2019)

4.1.2. Demographic and Socio Economic Characteristics of the sample households

This section illustrates the demographic and Scio-economic characteristics of households including Gender, Education and total livestock.

4.1.2.1. Gender Composition and Irrigation

Respondents were analyzed with respect to irrigation users and non-irrigation users. The resulting statistics, as indicated in Table 7, shows that out of 108 respondent's household head 47.22% were male headed households in irrigation users and 5.55% were female headed. But concerning their size (number) the chi square result showed that gender composition has insignificant relation with irrigation practice as the p-value is 0.901which confirms the above statement. This could be attributed to the fact that irrigation practice in the study area did not marginalize women participation and it may resemble that irrigated land distribution has equally accessed for all family heads (Male and Female). Thus, Gender of the household was a statistically insignificant variable with 95% confidence.

Table 7: Gender Composition and Irrigation Practice

Sex	Irrigation Practice		Total
	Yes	No	
Female	6(5.55%)	5(4.63%)	11(10.2%)
Male	51(47.22%)	46(42.5%)	97(89.8%)
Total	57(52.8%)	51(47.2%)	108(100%)

Pearson chi^2 (1) = 0.0154 Pr = 0.901

4.1.2.2. Livestock Holdings

Livestock production has an numerous benefit and all of the households surveyed rear various kinds of animals in order to produce animal products as well as to generate income and access to households food. The kinds of animals reared in the sample kebeles include cattle, sheep, goats, donkeys, mule and chicken. And the T calculated result is 16.6829 with 214 degrees of freedom hence it is greater than the T tabulated, 1.973. Therefore, it is safe to reject the null hypothesis

that there is no difference between means at 0.05 level. As a result the households total livestock unit have different mean with Food Consumption Score Category mean.

4.1.2.3. Irrigation practice and Food Consumption Score Category

Irrigation has a strong land augmenting impact and the value of per hectare crop production under irrigated settings is about twice that of under rain-fed settings (Getnet, 2011). Thus, food availability will be enhanced when the same size of land is used for irrigation which in turn affects food security positively and Table 8 presents this;

Table 8: Food Consumption Score Category and Irrigation Practice

Food Consumption Score Category		Irrigation Practice	
	No	Yes	Total
Acceptable	39 (36.11)	45 (41.66%)	84 (77.78%)
Borderline	5 (4.62)	11 (10.18)	16 (14.81%)
Poor	7 (6.48)	1 (0.92)	8 (7.4%)
Total	51 (47.22)	57(52.78)	108 (100%)

Pearson chi2 (2) = 6.8664 Pr = 0.032

Source: Computed from Survey Data (2019)

Table 8 presents practice irrigation and rests on acceptable category is 41.66 Percent and respondents who practice irrigation and rests on borderline category is 10.18 percent. This shows that when respondents are able to use irrigation their food security status will be enhanced since their crop production under irrigated settings increase the food availability but the number seen on the table are not much higher than the non-participants. Hence this area may have another significant factor which affects their food security status highly than the other variables. Beside, Tesfaw (2018) wrote that there is positive relation between irrigation service, poverty alleviation and the availability of water for irrigation in community helps to enhance food security. Field observation and key informant evidence discloses that irrigation can improve households food security situation and puts them in a better state of condition than non-users, even if the non-users are food secure their condition may not above irrigation users.

As well the p value result shows that there is significant relation between food consumption score category and irrigation participation as the score shows 0.032 which means it is significance at 5 percent level and the null hypothesis is rejected.

4.1.3. Institutional Characteristics

4.1.3.1. Education level

The educational level of respondent household heads differs with respect to the households 'in irrigation user which may have a pronounced effect on irrigation practice. Then Table 9 presents that 51.28 percent of non-educated (cannot read and write) are participant of irrigation practice and the rest 48.72 percent are not participant of irrigation.

In addition 44.92 percent of educated (can read and write) are participant of irrigation practice but 55.07 percent of them are not participant of irrigation practice this shows that education (being able to read and write) could not be attributed for irrigation participation as well The chi-square test result shows that the p-value was 0.525 which is greater than 0.05 hence, education (being able to read and write) has not a significant attribution for irrigation participation that mean there is no dependence between educational status of the households and the propensity to participate in irrigation activities.

Table 9: Education level by Irrigation participation

Education (read & write)		Irrigation Practice			Total
	Irrigation users	Percentage	Non Irrigation users	Percentage	
No	20	51.28	19	48.72	39
Yes	31	44.92	38	55.07	69
Total	51	96.2	57	103.79	108

Pearson chi^2 (1) = 0.4037 Pr=0.525

Source: Computed from Survey Data (2019)

4.1.3.2. Market Access

Market access enables households to have fertilizer access and sell their produces with a better price which in turn contribute their food security situation. Poor market accessibility often leads to an increase in food insecurity either through a total lack of supplementary sources of food to

complement people's own production or through high food costs that households are unable to afford (Mukeere, 2009). Moreover, Table 8 states 84 respondents out of 108 have market access nearby their residence and they are in acceptable Food Consumption Score Category as well 16 respondents have market access and their category is on borderline. Beside in Pearson chi square test, the p-value was 0.002 at 5 percent significance level. Thus, we can reject the null hypothesis and conclude market access have a significant association with Food Consumption Score Categories.

Table 10: Market Access and Food Consumption Score

Market Access	Food Consumption Score Category			Total
	Acceptable	Borderline	Poor	
No	0	0	1	1
Yes	84	16	7	107
Total	84	16	8	108

Pearson chi^2 (1) = 12.6168 Pr=0.002

Source: Computed from Survey Data (2019)

4.1.3.3. Access to Extension services

Access to extension service in the sample kebeles reaches to 96.3 percent and when we compare the access of extension services in irrigation users and non- irrigation users, households' who participate in irrigation activity has got a little more advices and support from the development agency or extension agents when compared to non-irrigation users. According to the survey 52.88 percent irrigation-user and 50 percent non- irrigation households get advices and supports from different agricultural agents. Here, Extension service means advice on crop production, advice on soil conservation, advice on animal production so 83.18 percent of the respondents got the whole advice listed on the above the rest 16.82 percent got advice on crop production only. Irrigation practice requires close follow up to aware farmers in order to use inputs and technical efficiencies, producing high value product and to be highly commercialized. Irrigation is considered one of the most important productive assets, leading to significant increases in yields. Access to water and irrigation is a major determinant of land productivity – irrigated land is twice as productive as rain-fed land (Rapsomanikis, 2015). But in practice the ground reality result shows that the extension service is not significant at 95% confidence interval among

irrigation users and non-irrigation users as chi-square and p-value 0.910 indicated in Table 11 for this specific sample area.

Table 11: Access to extension service and Irrigation

Access to extension service	Accesses of irrigation				Total	
	Irrigation users		Non- irrigation users			
Yes	Frequency	%	Frequency.	%	Frequency	%
	55	52.88	2	50	57	52.777
No	49	47.11	2	50	51	47.222

Pearson Chi^2 (1) = 0.0129 Pr = 0.910

Source: Computed from Survey Data (2019)

4.3. Household Food Security Status

4.3.1. Household Food Security Category using Food Consumption Score and Household Food Insecurity Access Scale

Depending on the food consumption score threshold level provided by WFP, (2008) Food Consumption with Oil and Sugar is; Poor Diet 0-28, Borderline Diet 28.5-42 and Acceptable Diet above 42. Then,

The proportions of food consumption score groups of the study households are presented in Table 12 as follows.

Table 12: Frequency and Percent of households with poor, borderline and acceptable food consumption

Food Consumption Score Category	Frequency	Percent	Cumulative
Acceptable	84	77.78	77.78
Borderline	16	14.81	92.59
Poor	8	7.41	100.00
Total	108	100.00	

Source: Computed from Survey Data (2019)

Table 12 revealed that 77.78 percent of the sample household had Acceptable diet, 14.81percent of the sample household had Borderline diet and 7.41percent of the sample household had poor diet. Then, It is evident from this result that 22.22 percent of the sample households were food insecure and 77.78 percent of them were food secure. This descriptive finding shows that the sample kebeles food security situation is better.

Abaaregayikebele and woyibillaSelamiko are one of the food secure kebeles from the rest Woreda kebeles depending on the Zonal and Woreda food security officers experience and practices and this kebeles do not have serious food security problems. In addition, they conclude that as there is good food security situation in the area. The reason behind this situation based on their view is farmers who are adjacent to the nearby town can easily accept and implement technologies and they have enough livestock to produce milk and milk products to offer it for the town with better price. As well, they have enough market information since they are near to the town and this enable them to produce much depending on the market want considering higher product price they will got.

The proportion of Household Food Insecurity Access Scale of the study households are presented in Table 13 as follows.

Table 13: Frequency and Percent of households with mildly Food Insecure and Food Secure

Household Food Insecurity Access Scale Category	Frequency	Percent	Cumulative
Mildly Food Insecure	58	53.70	53.70
Food Secure	50	46.3	100.00
Total	108	100.00	

Source: Computed from Survey Data (2019)

Here high proportion 53.7 percent of the heads of the households had worries about the availability of enough food for their family and they are in a mildly food insecure category depending on the HFIAS Categorization as well 46.3 percent of them are food secure. Study

conducted by Worku et al, (2014) on Farta District founds the overall prevalence of food insecurity was 70.7% this shows that the district food security situation is improving especially based on this research finding the sample kebeles food security situation is becoming better in comparison with the adjacent Districts as Arega (2013) discloses that lay GayintWoreda which is adjacent District of Farta found out that about 74% of the households were food insecure.

4.3.2. Comparison between FCS and HHFIAS results

The results of food consumption score shows low number of food insecure households i.e. 22.22 percent comparing to the HFIAS 53. 7 percent of mildly food insecure result this may emanate from the model provided data collection module and depth of measuring food security situation in terms of the four dimension of food security i.e. availability, access, sufficiency and stability.

Since, the HFIAS data collection module starts from perception regarding the availability of food even if the access to food is in hand, well food consumption score result takes the family diet consumption frequency for the last seven days which then be calculated based on the already provided weight given earlier and it cannot see the distribution among the family members and the amount taken in terms of calorie then since the two modules indicator questioner are different the result will also be different as well HHFIAS result tells us they are mildly food insecure that mean all of them are not totally (severely) food insecure hence some respondents which rests on this category are incorporated on the food secure category of food consumption score model which is 36.11 percent as well respondents who are in acceptable FCS are incorporated in mildly food insecure category (41.67%) and 5.56 percent of households are in poor (FCS) and mildly food insecure category respectively. Thus, in total 53.7 percent of the households were mildly food insecure; which indicates majority of the households are food insecure in HFIAS model.

Table 14: Comparison between FCS and HFIAS

HFIAS	Food Consumption Score			Total
	Acceptable	**Borderline**	**Poor**	
Food Secure	**39 (36.11%)**	9 (8.33%)	2 (1.85%)	50 (46.3%)
Mildly Food Insecure	**45(41.67%)**	**7 (6.48%)**	6 (5.56%)	58 (53.7%)
Total	84 (77.78%)	16 (14.81%)	8 (7.40%)	108 (100%)

4.4. Determinants of Food Security

The econometrics result of hypothesized variables were presented using Tobit model since the dependent variable is censored from both upper and lower limit. As well, the model was used to analyze the determinants of the probability that a household food security situation is affected as indicated in the model specification stage. Robust standard error was employed. But before running the analysis it was important to check the existence of multicollinearity among the continuous variables and verify the degree of association among dummy variables through variable inflation factor and contingency coefficient respectively and table 15 and 16 presents this.

Table 15: Variable Inflation Factor test for continuous variables

Variable	VIF	1/VIF
TLU	1.14	0.875629
EXPENDITURE	1.11	0.900411
HHAGE	1.07	0.930818
HHSIZE	1.05	0.950663
FLS	1.05	0.956532
	1.08	

Source: Computed from Survey Data (2019)

The values of VIF for continuous variables were found to be small (i.e. VIF values less than 10). To avoid serious problem of multicollinearity, it is quite essential to omit the variable with value 10 and more from the Tobit analysis. Based on the VIF result, the data have no serious problem of multicollinearity. As a result, all the 5 continuous explanatory variables were retained and entered in to Tobit analysis.

Similarly, the contingency coefficients, which measure the association between various discrete variables based on the chi-square, computed in order to check the degree of association among the discrete variables.

The values of contingency coefficient ranges between 0 and 1, with zero indicating no association between the variables and values close to 1 indicating a high degree of association accordingly, the results of the computation reveal that there were no problem of association among discrete explanatory variables since the result shows as it is below 0.75. Hence, all the 9 discrete variables were entered into Tobit analysis.

Table16: Contingency Coefficient test for dummy variables

Variables	EDU	IRR	ATESERV	OFI	MA	UIT	CD	SAVING	REMI
EDU	1.0000								
IRR	0.0611	1.0000							
ATESERV	0.1588	0.0109	1.0000						
OFI	0.1669	-0.0535	-0.0000	1.0000					
MA	0.1286	0.1022	-0.0190	0.0558	1.0000				
UIT	0.0567	0.0109	-0.0385	-0.1132	-0.0190	1.0000			
CD	0.0615	0.0330	-0.0177	0.0131	0.0503	0.1020	1.0000		
SAVING	0.1911	0.3107	0.0447	0.2851	-0.0771	0.1453	0.0438	1.0000	
REMI	0.0147	0.0168	0.0591	-0.0967	0.0291	0.0591	0.0068	0.0314	1.0000

Source: Computed from Survey Data (2019)

The variable Food Security in terms of Food Consumption Score was used as a censored continuous dependent variable, with censoring at 17.5 from left and 81 from right as the collected data's are in between this values. Eventually, a set of 14 explanatory variables (5 continuous and 9 discrete) were included in the model and used in the Tobit analysis. These variables were selected on the basis of theoretical explanations and the results of various empirical studies. To determine the best subset of explanatory variables robust regression is done.

Table 17: Estimation of Tobit Regression for the Determinants of Household Food Security

Log pseudo likelihood = -413.74412 Number of Observation= 108

F (14, 94) = 217

Prob> F = 0.0000

Pseudo R^2 = 0.0478

FCS	Coefficient	Robust Std. Err	t	P>| t |	[95% Conf. Interval	
HHAGE	-.2220467	.1356958	-1.64	0.105*	-491474	.0473805
EDU	-.2995784	2.777216	-0.11	0.914	-5.813805	5.214648
HHSIZE	.4453647	.8987096	0.50	0.621	-1.339047	2.229771
IRR	-1.173439	2.210178	-0.53	0.597	-5.5648	3.214921
ATESERV	12.3717	6.953967	1.73	0.078*	-1.435863	26.17867
OFI	-.5178628	2.869455	-0.18	0.857	-6.215233	5.179508
EXPENDITURE	-.000137	.0000786	-1.74	0.085*	-.000293	.000019
FLS	.0845882	.0503338	1.68	0.096*	-.0153508	0.1845272
TLU	2.540797	.607566	4.18	0.000***	1.334461	3.747134
MA	46.51723	4.883541	9.53	0.000***	36.82084	56.21362
UIT	5.323417	4.252137	1.25	0.214	-3.119301	13.76613
CD	-5.649076	3.272402	-1.73	0.088*	-12.14651	0.8483556
SAVING	7.370835	2.428549	3.04	0.003***	2.548894	12.19278
REMI	-4.778578	4.687891	-1.02	0.311	-14.0865	4.52934
Con	-14.4171	10.95675	-1.32	0.191	-36.17198	7.337789
/ Sigma	11.71236	.8081357			10.10779	13.31694

Observation Summery 1 left censored observation at FCS<= 17.5

106 uncensored observations

1 right censored Observation at FCS>=81

Significance levels are at ***1%, **5% and *10% respectively

Source: Computed from Survey Data (2019)

The goodness of-fit measures validate that the model fits the data well. The F Value is 217 and the p value associated with this F value is very small 0.0000. Thus, the p value is compared to alpha level 0.05; the independent variables reliably predict the dependent variable (Food Security). We can say that the variable enroll can be used to reliably predict the dependent variable.

Fourteen independent variables that were hypothesized to have influence on household food Security in the study area were included in the model. Beside eight variables were significant including the 10 percent significant level and six variables, were insignificant depending on the model output.

Household Head Age (HHAGE): The result regarding the age of the household head was found to be in contrary with what was expected. The result showed that age has a negative and significant influence on household food Security at 10 percent significance level. Study conducted in WerieLeke District, Ethiopia by Alemseged et al (2014), discloses that Household Head age was affecting Food security negatively by 2.8% which is statistically significant at 5% and they state this may happened due to, Older household heads naturally could have more dependents to feed, redistribute their holdings to children and grandchildren, and may face physical incapability to work more and engage in multiple activities to support their household and ensure food security. And this research reveals that other things remaining equal food Security decrease by a factor of 22.2 percent as household head age increases by one year. The possible reason could be as the age of the person increase, one could not participate in other income generating activities. Hence, we cannot conclude it is significant based on the assumption made earlier. As well Ejigayhu and Edris (2012), using Tobit regression model found that household food security was negatively affected by household head age, keeping other factors constant, the marginal effect on the side of food insecurity increase by a factor equal to 0.6% when age of the household head increases by one year.

Access to Extension Service (ATESERV): Agricultural extension plays a crucial role in promoting agricultural productivity, increasing food security, improving rural livelihoods, and promoting agriculture as an engine of pro-poor economic growth (Saeed and Sawicka, 2017). This research found Access to Extension Service has positive impact and significant at (10 percent probability level) influence on the probability of being food secure. Besides, the result of this research supports the hypothesis that Access to Extension Service increases the probability of a household being food Secure by 37.17 percent, other things being constant. But this paper alpha value is 0.05. Hence, we cannot conclude it is significant based on the assumption made earlier.

Expenditure on Food and non-Food (EXPENDITURE): Total expenditure on food and non-food items was expected to affect food security negatively and the econometric result shows that their association is negative as anticipated before. Other things remain constant as expenditure decreases by 1 unit food security increases by 0.1 percent and significant at 10 percent probability level.

Farm Land Size (FLS): The computed result discloses that farm land size influences food security positively which is as hypothesized earlier and other things remain constant the probability of being food secure increases by 8.45 percent as farm land size increase by 1 unit at 10 percent significance level. And this finding is in line with other study findings as Tiliksew and Fekadu (2013), using binary logit model finds that as the size of farm land which is cultivated affect food security positively and food security increases by 0.171 as the size of cultivated farm land increases by 1 hectare when other variables held in their mean value. As well, Atinkut (2015) observed that 58%, of the food secure households and 38% of food insecure households hold greater than 1 hectare of land. Hence, size of land holding has a significant influence on food security status in Ebinat district, South Gondar Zone. Thus this happens were the amount production and the probability to diversify crop is higher when the size of land cultivated increases.

Crop Disease (CD): Plant pests and diseases are responsible for losses of 20 to 40% of global food production (FAO and IPPC, 2017). And this research hypothesis was Crop Disease hart's plant growth and reduces the probability of being food secure for households. Besides, the finding indicates that food security is affected negatively by crop disease and it is significance at 10 percent level, so food security reduces by 64.9 percent as crop disease increases by 1 unit, other things remain constant. Beside Degefa (2002) finds that some biological factors such as diseases, pests and weeds have been negatively affecting farmer's agricultural production. Then such condition will aggravate or create food insecurity.

Saving (SAVING): Saving is another statistically significant and positive predictor of food security in this Tobit regression model output and it is in line with the previous hypothesis, that clams as saving have a positive relationship with food security. Then, other things remain constant food security increases by 37 percent as saving increases by one unit and it is significant at 1 percent.

Market Access (MA): Market accessibility is explained by distance to the nearest road, distance to the nearest market (Tembo and Simtowe, 2009). And it enables households to access inputs for farm and has information on market which leads them to make an effective decision on when and how to sell their products. Accordingly, keeping other things constant, access to market reduces the probability of a household being food insecure by 51.7 units which is statistically significant at 1 percent. This means households that have access to market are more food secure than those who do not have and this result is consistent with the earlier seated hypothesis. Such endeavors may occur as the households can easily access market information and decide what to produce, when to produce and to whom to produce decisions for their household benefit.

Tropical Livestock Unit (TLU): Jemal and Kim (2014), finds that livestock position in TLU was positively and significantly affect food security. Indicating larger position of livestock positively contribute for household food security. Besides, this research hypostasize that total livestock unit has significant positive relation with food security at 5 percent significance level and the this research Tobit regression finding shows that total livestock unit have positive relation and significant relation with food security at 1 percent significance level, stating food security can be improved by 54 unit as total livestock unit increases by 1 unit other things remain constant, and it was in line with the earlier hypothesis.

4.5. The contribution of irrigation to Food Security

4.5.1 Balancing property of matching Estimates of the Irrigation impact

The pscore value predicted by the independent variables are HHAGE, EDU, HHSIZE,ATESERV, OFI, EXPENDITURE, FLS, TLU, UIT, CD, SAVING, REMI. The probit model was employed to calculate the pscore value. After the pscore value predication different matching methods was applied. The treatment variable is irrigation and the region of common support is those propensity scores within the range of the lowest and highest estimated values for household in the treatment group. Mostly the common support is on $0 < p(c = 1: x) < 1$ (Christopher, 2013), cited in Endeshaw, 2016). In this study the output shows that the recognized region of common support is [.17813529, .82734108] and the final number of blocks is 5, and this number of blocks ensures that the mean propensity score is not different for treated and controls in each blocks then finally the balancing property is satisfied. See annex 8.4 and 8.5.

4.5.2. Propensity Score Matching Estimates of the Irrigation impact

Propensity score matching (PSM) enables to match each participant with an identical nonparticipant and then measure the average difference in the outcome variable between the treatment and the control groups.

To examine the effect of irrigation on the outcome variable food security additional analysis was done using Propensity score matching model, econometric model (probit).The factor variables which affect the dependent variables and used to estimate the Pscore value were Head Age, Access to Extension Service, Expenditure on Food and non-Food, Farm Land Size, Crop Disease, saving, Tropical Livestock Unit, Education, Household Size, Irrigation, Off-farm Income, Use of Improved Technology and Remittance .

4.5.3. ATT Estimation of impact of Irrigation on Food Security (Food Consumption Score)

The propensity score (pscore) matching by the three methods displayed in the table 20 states that the experimental evidence on the ATT of irrigation on food security. The result is in the form of matrix as columns for number of match, ATT, SE, and T-test and the rows for the four matching algorithms. When using nearest neighbor matching method the food security situation of irrigation users was increases by 1.865 as well by Stratified and kernel matching the irrigation user groups increases their food security situation by 1.643 and 1.317respectively. All types of matching methods did not come up with significant results. In addition teffect estimation has been done via augmented inverse probability weighting and the result in table 20 shows that irrigation has not been a significant contributor for food security in the study area see annex 8.10 for covariate balance summery and sensitivity test.

This shows that irrigation was not contributing significantly for household food security situation improvement. As a result it did not acknowledge the previous hypothesis and theories which clams that irrigation has a positive impact on productivity and in turn support food security by increasing food availability.

However, Irrigation as one of the technology options available enables the farmers to diversify their production, practice multiple cropping and supplement moisture deficiency in agriculture.

In doing so, it helps the farmer to increase production and income (Agerie, 2016). Yet, the result may occurs as the area is adjacent to the nearby town Debre tabor households participate in cross breed livestock activity for milking and distribution as well better market access due to adjacency enables them to have enough market information, which assistances them to make wise decision on their product offer for market at best price. Beside livestock and market were significant variables in econometric model result, which may reduce the difference of effect of irrigation on the treated and non-treated on food security. Moreover, knowledge of effective small scale irrigation practice is lucking, which implies inappropriate use of water, either by reducing or increasing the amount of water needed for the crops.

Table 20: PSM estimate showing the impact of irrigation on Food Security (Food Consumption Score)

Type of Matching Methods	Number of Match		Average gain of FCS	Bootstrap Standard error	T-Test
	Treated (irrigation users)	Control (irrigation non-users)			
Nearest neighbor	57	22	1.865	4.889	0.381
Stratification	52	55	1.643	3.379	0.486
Kernel	57	50	1.317	3.850	0.342
Augmented ipw (teffect)			3.29	4.354 (robust Standard error)	0.449 (p-value)

Source: Computed from Survey Data (2019)

4.5.4. Sensitivity Analysis

The sensitivity analysis in an observational study was conducted by Rosenbaum; the sensitivity analysis asks how much hidden bias can be present and after ATT is found, it is vital to test whether the estimated ATT is effective or not. Additionally, sensitivity analysis in an observational study addresses this probability; it asks what the unmeasured covariate would have to be like alter the conclusion of the study. Table in the Annex 8.9 reveals that the sensitivity analysis of the outcome variable Food Consumption Score. The Gamma value from 1 to 2 has upper significance level 0.9957 and lower significance level 0.022062, this result indicates that

irrigation is significant or robust and the result was not sensitive to the confounder, which means there is no unobserved covariates that affect the outcome variable on both groups, treated and non-treated.

Also, the result shows that ATT is insensitive to external change. Therefore, the Conditional independence assumption remain to be significant and the results were not sensitive to the confounders and there are no external cofounders (variables) which affect the result calculated for ATT already in the above.

CHAPTER FIVE

5. Conclusions and Recommendations

5.1. Conclusion

The research has shown that majority 53.7 percent of households in the study area were mildly food insecure in HFIAS model and 22.22 percent household were food insecure in FCS model during the period of the survey. This difference may happen as the models measurement tool is different the result become also different. Yet the HFIAS model result reveals that the majority households in sample kebeles were food insecure. This shows that the problem of food security is threatening the research area and remedies are essential.

Market access was found to have a significant association with Food Consumption Score Categories in variable association analysis; this indicates that market access will be a significant contributor for food security status improvement.

In addition households total livestock unit have different mean with Food Consumption Score Category mean in t test analysis.

Furthermore, the research findings using Tobit model reveals Crop Disease, saving, Market Access and Tropical Livestock Unit were significant variables that affect food security at various levels, this implies that this significant variables shall be given a due attention, as they are the main factors of food security status improvement in the study area. Moreover, Market Access, Livestock and Saving found to be critical determinant of household food security in the area as they were significant at one percent. Thus, attention in agricultural extension service shall be given for these two variables.

Concerning the contribution of irrigation to food security, irrigation was not found as a significant contributor for the household food security rise. Hence, by increasing irrigation participant's food security condition was not improved significant statistically as the t-test values were below alpha value 0.05 in three used matching models i.e. nearest neighbor, stratification and Kernel matching algorithms. Then, there are variables (market access and livestock holding)

that affect food security more than irrigation participation in the area and the regression analysis showed as they are the most determinant variables.

5.2. Recommendations

- Market Access, in terms of gaining information and adjacency was found to have great significance in ensuring food security. Hence, agricultural production activities shall be assisted with enough market information and market infrastructure to offer the products to market shall be developed,
- The research also founds that Livestock holding was one of the determinant in the area as they were participating in milk production and distribution. Therefore, agricultural activities shall incorporate such doings so as to increase household income and reduce food insecurity, then agricultural extension practices shall focus on the benefits of having livestock for the purpose of milking,
- The research clearly indicated that Crop Disease is hearting households and making them vulnerable to food insecurity then mechanisms to control pest and herbs shall be developed to tackle the problem, government shall provide pesticides primarily before such disaster for crops are occurring, and Households shall regularly follow up their field,
- Household heads with older age were found to be affected by food insecurity than younger household ages so; they need to be properly targeted when planning and providing food supports to ensure acceptable food consumption of their household members.
- Finally, irrigation were found insignificant contributor of food security in research area since the irrigation non-participants were participating in livestock production activities as well as they were acquainted by market information which makes them close to irrigation participants in food security status. Thus, areas with null opportunity to practice irrigation can take this way for improving their food security situation.

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Annexes

Annex 1

Survey Questioner

Dear participants,

I am a graduate student of Addis Ababa University, College of Development Studies, and center for rural Development and currently working a research on the title "Contribution of Irrigation to Food Security in Farta Woreda, South Gondar Zone, Amhara National Regional State, Ethiopia".The purpose of the research is intended to measure the food security level of the study area in line with identify the determinants of food security in the area to come up with information regarding the food security situation of the area . To this end, I would like to invite you to participate on the study. The information you provided will be treated confidentially and will not be used for any other purpose other than academic purpose.

Part One General Information

Instruction: Circle (use tick mark) or write the answer as may be necessary to indicate your appropriate response. Thank you, Household address and interview results Address:

- Kebele _____
- Name of interviewer_____
- Date of interview _____

1. Sex [1]. Male [2]. Female

2. Age: ----------

3. Can you read and write?

   [1]. Yes [2]. No

If YOUR ANSWER IS YES FOR QUESTION NUMBER THREE ANSWER QUESTION NUMBER FOUR

4. How many times you spent in school (years)? ----------

5. Total number of Household Members.----------

Part Two: Basic research questions

Instruction: Circle (use tick mark) to indicate your appropriate response. Thank you:

6. Did you practice irrigation in 2010 E.C.?

[1]. Yes [2]. No

7. Do you have a land that has access to the source of water, which could serve for irrigation?

[1]. Yes [2], No

8. If you practice irrigation in the given year, what was the distance between your irrigated land and water source in meter? ----------

9. What amount of kilograms you produce from irrigation?

R. No	Crops	Kilograms
1	Potato	
2	Teff	
3	vegetables	
4	Maize	
5		
6		
7		

10. Do you hire additional labour for irrigation practice?

[1]. Yes [2]. No

11. Has your household received any type of extension service from any government and/ NGOs?

[1]. Yes [2]. No

12. What was the purpose of receiving extension?

[1]. To give advice on crop production [2]. To give advice on animal production

[3]. to give advice on soil conservation [4]. To collect taxes

[5]. to collect other debts [6]. Others

13. Have you participated in agricultural extension package program?

[1]. Yes [2]. No

14. If yes for how long? _____

15. Do you or any member of your family have off-farm job?

[1] Yes [2] No

16. If yes, indicate the amount of income you collect per year?----------

17. Would you please state means of annual income earning of your household----------Birr

18. Did you tell me your annual expenditure via the following categories?

No	Expense Category	Amount in Birr
1	Food	
2	Clothing	
3	Transportation	
4	Education	
5	Health	
6	Ceremony	
7		
8		
Sum		

19. Do you have your own land?

[1]. Yes [2]. No

20. If yes, what is the total size of your cultivated land holding? In "hectare if possible otherwise in timad"----------

21. Is the existing land enough to support your family?

[1]. Yes [2]. No

22. If no state your reasons

[1]. lack of fertility of the soil [2]. Small size of land

[3]. Lack of agricultural inputs to increase productivity [4]. Large family size

[5]. others

23. Do you own livestock?

[1]. Yes [2]. No

24. If yes, indicate the number of livestock owned:

No	Type	Number
1	Got	
2	Sheep	
3	Cow	
4	Oxen	
5	Mule	
6	Horse	
7	Donkey	
8	Chicken	

25. Do you have a nearby market access?

[1]. Yes [2]. No

26. Do you get reasonable selling price for your produce at this particular time?

[1]. Yes [2]. No

27. If no, what are the reasons?

[1]. No (demand) for the produce [2]. More supply of the produce

[3]. Lack of access to potential market [4]. Others (specify)

28. Do you use improved technologies provided by any means?

[1]. Yes [2]. No

29. Which kind of technologies you used?

[1]. Fertilizer (organic or/and Inorganic) [2]. Harvesting Technologies

[3]. Storage Technologies [4]. Ploughing Technologies

[5]. Improved Seed [6]. Other

30. Did any crop Disease damage your crop in 2010 E.C?

[1]. Yes [2]. No

31. If your answer is "yes" did it cause food deficit to your household?

[1]. Yes [2]. No

32. Do you have saving?

[1]. Yes [2]. No

33. If you have saving what amount of birr you save in a year?----------

34. Do you have an income in remittance?

[1]. Yes [2]. No

35. If you have an income in remittance what amount of birr you earn in a year?----------

Part Three: Food Consumption Score Data collection module

S. No	Food Items	Days eaten in past week (1-7 days)	Weight
1	Main staples		2
2	Pulses		3
3	Vegetables		1
5	Fruit		1
6	Meat/fish		4
7	Milk		4
8	Sugar		0.5
9	Oil		0.5

Part Four: Household Food Insecurity Access Scale (HFIAS) Measurement Tool

No	Questions	Rarely (once or twice)	Sometimes (three to ten times)	Often (more than ten times)	Code
1	In the past four weeks, did you worry that your household would not have enough food? [1] Yes [0] No				
1a	How often did this happen?				
2	In the past four weeks, were you or any household member not able to eat the kinds of foods you preferred because of a lack of resources? [1] Yes [0] No				
2a	How often did this happen?				
3	In the past four weeks, did you or any household member have to eat a limited variety of foods due to a lack of resources? [1] Yes [0] No				
3a	How often did this happen?				
4	In the past four weeks, did you or any household member have to eat some foods that you really did not want to eat because of a lack of resources to obtain other types of food? 1] Yes [0] No				
4a	How often did this happen?				
5	In the past four weeks, did you or any household member have to eat a smaller meal than you felt you needed because there was not enough food? [1] Yes [0] No				
5a	How often did this happen?				

6	In the past four weeks, did you or any other household member have to eat fewer meals in a day because there was not enough food? [1] Yes [0] No				
6a	How often did this happen?				
7	In the past four weeks, was there ever no food to eat of any kind in your household because of lack of resources to get food? [1] Yes [0] No				
7a	How often did this happen?				
8	In the past four weeks, did you or any household member go to sleep at night hungry because there was not enough food? [1] Yes [0] No				
8a	How often did this happen?				
9	In the past four weeks, did you or any household member go a whole day and night without eating anything because there was not enough food? [1] Yes [0] No				
9a	How often did this happen?				
Score					

Key Informant Questions

1. Are communities in your locality exposed to food insecurity?

   ---

2. What are the major causes of food insecurity in the area?

   ---

3. Does irrigation contribute for food security?

   ----

4. What measures are taken by the government to increase production and productivity in the agricultural sector in general?

   ---

5. What possible solutions you recommend to alleviate food insecurity in general?

Annex 2

Summary Statistics of Continuous Variables

Variable	Obs	Mean	Std. Dev.	Min	Max
HHAGE	108	52.33333	9.665431	30	71
HHSIZE	108	5.555556	1.560813	2	10
EXPENDITURE	108	19675.05	16967.53	590	65000
FLS	108	2.390361	9.427996	.1	99
TLUTOTAL	108	4.708472	2.039111	.03	12.62

Annex 2

Summary Statistics of Discrete Variables

Variable	Obs	Mean	Std. Dev.	Min	Max
EDU	108	.6388889	.482562	0	1
IRR	108	.5277778	.5015552	0	1
ATESERV	108	.962963	.189733	0	1
OFI	108	.25	.4350314	0	1
MA	108	.9907407	.096225	0	1
UIT	108	.962963	.189733	0	1
CD	108	.212963	.4113103	0	1
SAVING	108	.6111111	.4897708	0	1
REMI	108	.0833333	.2776739	0	1

Annex 3

Food Consumption Score (FCS)

Food Consumption Score Category	Freq.	Percent	Cum.
ACCEPTABLE	84	77.78	77.78
BORDERLINE	16	14.81	92.59
POOR	8	7.41	100.00
Total	108	100.00	

Annex 4

Household Food Insecurity Access Scale (HHFIAS)

Household food insecurity access scale category	Freq.	Percent	Cum.
MIDDLY FOOD INSECURE	58	53.70	53.70
FOOD SECURE	50	46.30	100.00
Total	108	100.00	

Annex 5

Determinants of Household Food security Model Out put

```
. tobit FCS HHAGE EDU HHSIZE IRR ATESERV OFI EXPENDITURE FLS TLUTOTAL MA UIT CD SAVING  REMI, ll ul vce(robust)

Tobit regression                                Number of obs   =        108
                                                F(  14,     94) =     217.15
                                                Prob > F        =     0.0000
Log pseudolikelihood = -413.74412               Pseudo R2       =     0.0478
```

FCS	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
HHAGE	-.2220467	.1356958	-1.64	0.105	-.491474	.0473805
EDU	-.2995784	2.777216	-0.11	0.914	-5.813805	5.214648
HHSIZE	.4453617	.8987096	0.50	0.621	-1.339047	2.229771
IRR	-1.173439	2.210178	-0.53	0.597	-5.5618	3.214921
ATESERV	12.3714	6.953967	1.78	0.078	-1.435863	26.17867
OFI	-.5178628	2.869455	-0.18	0.857	-6.215233	5.179508
EXPENDITURE	-.000137	.0000786	-1.74	0.085	-.000293	.000019
FLS	.0845882	.0503338	1.68	0.096	-.0153508	.1845272
TLUTOTAL	2.540797	.607566	4.18	0.000	1.334461	3.747134
MA	46.51723	4.883541	9.53	0.000	36.82084	56.21362
UIT	5.323417	4.252137	1.25	0.214	-3.119301	13.76613
CD	-5.649076	3.272402	-1.73	0.088	-12.14651	.8483556
SAVING	7.370835	2.428549	3.04	0.003	2.548894	12.19278
REMI	-4.778578	4.687891	-1.02	0.311	-14.0865	4.52934
_cons	-14.4171	10.95675	-1.32	0.191	-36.17198	7.337789
/sigma	11.71236	.8081357			10.10779	13.31694

```
  Obs. summary:          1  left-censored observation  at FCS<=17.5
                       106     uncensored observations
                         1 right-censored observation  at FCS>=81
```

Annex 6

Variable inflation factor result

```
. vif
```

Variable	VIF	1/VIF
SAVING	1.47	0.679196
EDU	1.44	0.693594
TLUTOTAL	1.36	0.735311
EXPENDITURE	1.35	0.738053
HHAGE	1.32	0.759268
OFI	1.24	0.808091
HHSIZE	1.21	0.829509
IRR	1.20	0.833322
MA	1.18	0.845441
CD	1.12	0.893294
UIT	1.12	0.896130
FLS	1.11	0.899995
REMI	1.08	0.924043
ATESERV	1.07	0.934871
Mean VIF	1.23	

Annex 7

Contingency coefficient for dummy variables

```
. pwcorr EDU IRR ATESERV OFI MA UIT CD SAVING REMI
```

	EDU	IRR	ATESERV	OFI	MA	UIT	CD
EDU	1.0000						
IRR	0.0611	1.0000					
ATESERV	0.1588	0.0109	1.0000				
OFI	0.1669	-0.0535	-0.0000	1.0000			
MA	0.1286	0.1022	-0.0190	0.0558	1.0000		
UIT	0.0567	0.0109	-0.0385	-0.1132	-0.0190	1.0000	
CD	0.0615	0.0390	-0.0177	0.0131	0.0503	0.1020	1.0000
SAVING	0.1911	0.3107	0.0447	0.2851	-0.0771	0.1453	0.0438
REMI	0.0174	0.0168	0.0591	-0.0967	0.0291	0.0591	0.0068

	SAVING	REMI
SAVING	1.0000	
REMI	0.0344	1.0000

Annex 8

Propensity Score Matching Tables

Annex 8.1. Probit model to predict propensity score

```
Iteration 0:   log likelihood = -74.693143
Iteration 1:   log likelihood = -66.564553
Iteration 2:   log likelihood = -66.505239
Iteration 3:   log likelihood = -66.503799
Iteration 4:   log likelihood = -66.503793

Probit regression                                 Number of obs   =        108
                                                  LR chi2(12)     =      16.38
                                                  Prob > chi2     =     0.1745
Log likelihood = -66.503793                       Pseudo R2       =     0.1096
```

IRR	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
HHAGE	.0143728	.0148424	0.97	0.333	-.0147179	.0434634
EDU	.146828	.3111525	0.47	0.637	-.4630197	.7566756
HHSIZE	.0242088	.0873154	0.28	0.782	-.1469262	.1953438
ATESERV	-.1322653	.6700969	-0.20	0.844	-1.445631	1.181101
OFI	-.422794	.3168447	-1.33	0.182	-1.043798	.1982103
EXPENDITURE	-2.05e-06	8.68e-06	-0.24	0.814	-.0000191	.000015
FLS	-.0160847	.022664	-0.71	0.478	-.0605053	.028336
TLUTOTAL	.0307635	.0696143	0.44	0.659	-.1056781	.167205
UIT	-.5330998	.6784236	-0.79	0.432	-1.862786	.7965861
CD	.1609541	.3245843	0.50	0.620	-.4752194	.7971276
SAVING	.9301088	.2958028	3.14	0.002	.3503459	1.509872
REMI	-.123001	.4582289	-0.27	0.788	-1.021113	.7751111
_cons	-.8128642	1.193701	-0.68	0.496	-3.152474	1.526746

Annex 8.2. T-stat values of the outcome variables

Variable	Sample	Treated	Controls	Difference	S.E.	T-stat
FCS	Unmatched	51.8824561	50.0392157	1.84324044	2.70862115	0.68
	ATT	49.4107143	52.9464286	-3.53571429	3.83198672	-0.92

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

psmatch2: Treatment assignment	psmatch2: Common support		
	Off suppo	On suppor	Total
Untreated	0	51	51
Treated	29	28	57
Total	29	79	108

Annex 8.3.pstest for unmatched and matched covariates mean bias and graph

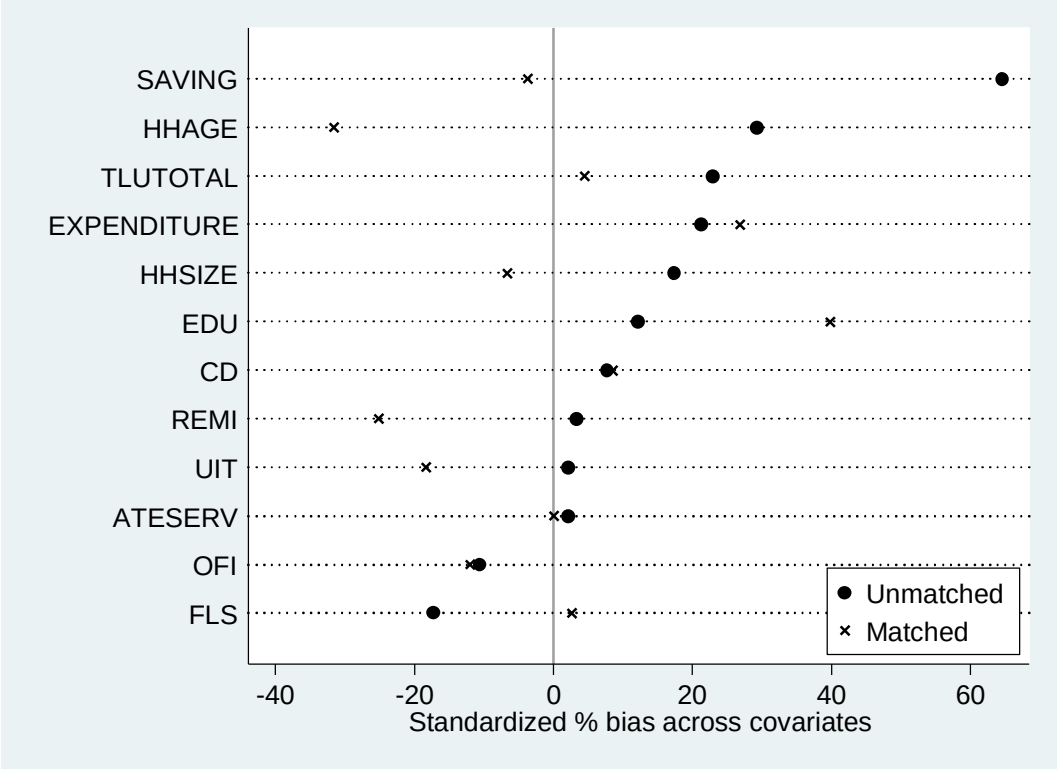
```
. pstest, graph both
```

Variable	Unmatched / Matched	Mean Treated	Mean Control	%bias	%reduct |bias|	t-test t	t-test p>|t|	V(T)/ V(C)
HHAGE	U	53.667	50.843	29.3		1.52	0.130	0.73
	M	53.667	56.719	-31.6	-8.1	-1.70	0.093	0.74
EDU	U	.66667	.60784	12.1		0.63	0.530	.
	M	.66667	.47368	39.8	-228.1	2.10	0.038	.
HHSIZE	U	5.6842	5.4118	17.4		0.90	0.368	0.75
	M	5.6842	5.7895	-6.7	61.4	-0.36	0.719	0.77
ATESERV	U	.96491	.96078	2.2		0.11	0.911	.
	M	.96491	.96491	0.0	100.0	0.00	1.000	.
OFI	U	.22807	.27451	-10.6		-0.55	0.582	.
	M	.22807	.2807	-12.0	-13.3	-0.64	0.523	.
EXPENDITURE	U	21368	17783	21.3		1.10	0.275	1.62
	M	21368	16849	26.8	-26.0	1.40	0.163	1.46
FLS	U	1.597	3.277	-17.3		-0.92	0.358	0.01*
	M	1.597	1.3458	2.6	85.0	1.66	0.099	2.87*
TLUTOTAL	U	4.9292	4.4618	22.9		1.19	0.236	0.81
	M	4.9292	4.8378	4.5	80.4	0.23	0.817	0.73
UIT	U	.96491	.96078	2.2		0.11	0.911	.
	M	.96491	1	-18.4	-750.0	-1.43	0.156	.
CD	U	.22807	.19608	7.8		0.40	0.689	.
	M	.22807	.19298	8.5	-9.7	0.46	0.649	.
SAVING	U	.75439	.45098	64.6		3.37	0.001	.
	M	.75439	.77193	-3.7	94.2	-0.22	0.828	.
REMI	U	.08772	.07843	3.3		0.17	0.863	.
	M	.08772	.15789	-25.2	-655.6	-1.14	0.258	.

* if variance ratio outside [0.59; 1.70] for U and [0.59; 1.70] for M

Sample	Ps R2	LR chi2	p>chi2	MeanBias	MedBias	B	R	%Var
Unmatched	0.110	16.38	0.174	17.6	14.7	81.6*	1.12	20
Matched	0.102	15.84	0.147	15.0	10.3	77.2*	1.02	20

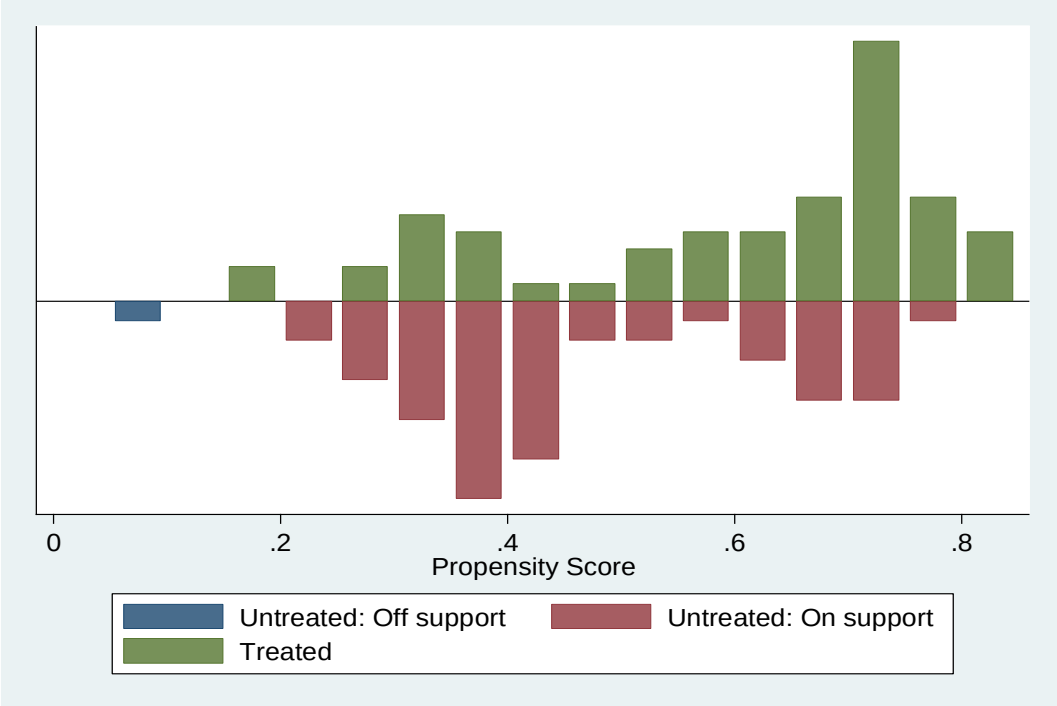
* if B>25%, R outside [0.5; 2]


SAVING
HHAGE
TLUTOTAL
EXPENDITURE
HHSIZE
EDU
CD
REMI
UIT
ATESERV
OFI
FLS
Unmatched
Matched
-40
-20
0
20
40
60
Standardized % bias across covariates

Annex 8.4.Balancing propensity

```
. pscore $treatment $xlist_full, pscore(myscore) blockid(myblock) comsup


*******************************************************
Algorithm to estimate the propensity score
*******************************************************


The treatment is IRR

    Did you
   practice
 Irrigation
   in 2011? |      Freq.     Percent        Cum.
------------+-----------------------------------
         NO |         51       47.22       47.22
        YES |         57       52.78      100.00
------------+-----------------------------------
      Total |        108      100.00


Estimation of the propensity score

Iteration 0:   log likelihood = -74.693143
Iteration 1:   log likelihood = -66.564553
Iteration 2:   log likelihood = -66.505239
Iteration 3:   log likelihood = -66.503799
Iteration 4:   log likelihood = -66.503793

Probit regression                                 Number of obs   =        108
                                                  LR chi2(12)     =      16.38
                                                  Prob > chi2     =     0.1745
Log likelihood = -66.503793                       Pseudo R2       =     0.1096

------------------------------------------------------------------------------
         IRR |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       HHAGE |   .0143728   .0148424     0.97   0.333    -.0147179    .0434634
         EDU |    .146828   .3111525     0.47   0.637    -.4630197    .7566756
      HHSIZE |   .0242088   .0873154     0.28   0.782    -.1469262    .1953438
    ATESERV |  -.1322653   .6700969    -0.20   0.844    -1.445631    1.181101
         OFI |   -.422794   .3168447    -1.33   0.182    -1.043798    .1982103
 EXPENDITURE |  -2.05e-06   8.68e-06    -0.24   0.814    -.0000191     .000015
         FLS |  -.0160847    .022664    -0.71   0.478    -.0605053    .0283336
    TLUTOTAL |   .0307635   .0696143     0.44   0.659    -.1056781     .167205
         UIT |  -.5330998   .6784236    -0.79   0.432    -1.862786    .7965861
          CD |   .1609541   .3245843     0.50   0.620    -.4752194    .7971276
      SAVING |   .9301088   .2958028     3.14   0.002     .3503459    1.509872
        REMI |   -.123001   .4582289    -0.27   0.788    -1.021113    .7751111
       _cons |  -.8128642   1.193701    -0.68   0.496    -3.152474    1.526746
------------------------------------------------------------------------------


Note: the common support option has been selected
The region of common support is [.17813529, .82734108]


Description of the estimated propensity score
in region of common support

                    Estimated propensity score
-------------------------------------------------------------
      Percentiles      Smallest
 1%     .1885458       .1781353
 5%     .2687105       .1885458
10%      .299427       .2136943       Obs                 107
25%     .3555582       .2397114       Sum of Wgt.         107

50%     .5695743                      Mean           .5347154
                       Largest        Std. Dev.      .1853691
75%     .7114697       .7974467
90%      .756557       .8066933       Variance       .0343617
95%     .7663856       .8179085       Skewness      -.1490563
99%     .8179085       .8273411       Kurtosis       1.534875


*******************************************************
Step 1: Identification of the optimal number of blocks
Use option detail if you want more detailed output
*******************************************************


The final number of blocks is 5

This number of blocks ensures that the mean propensity score
is not different for treated and controls in each blocks


*******************************************************
Step 2: Test of balancing property of the propensity score
Use option detail if you want more detailed output
*******************************************************


The balancing property is satisfied


This table shows the inferior bound, the number of treated
and the number of controls for each block

  Inferior |   Did you practice
  of block |  Irrigation in 2011?
of pscore |        NO        YES |     Total
----------+----------------------+----------
  .1781353 |         0          2 |         2
        .2 |        26         11 |        37
        .4 |        10          9 |        19
        .6 |        14         32 |        46
        .8 |         0          3 |         3
----------+----------------------+----------
     Total |        50         57 |       107

Note: the common support option has been selected


*****************************************
End of the algorithm to estimate the pscore
*****************************************
```

Annex 8.5: Graph before matching and after matching



Annex 8.6: Matching by different PSM algorithms

Annex 8.7.1: Matching for the outcome variable Food Security (FCS)

Annex 8.8.2: All matching methods

ATT estimation with the Kernel Matching method

n. treat.	n. contr.	ATT	Std. Err.	t
57	50	1.317	.	.

Note: Analytical standard errors cannot be computed. Use
the bootstrap option to get bootstrapped standard errors.

Bootstrapping of standard errors

command: attk FCS IRR , pscore(ps09) comsup bwidth(.06)
statistic: attk = r(attk)

Bootstrap statistics — Number of obs = 108; Replications = 50

Variable	Reps	Observed	Bias	Std. Err.	[95% Conf.	Interval]	
attk	50	1.316931	-.389059	3.850158	-6.420251	9.054113	(N)
					-6.576811	8.614317	(P)
					-6.576811	8.751103	(BC)

Note: N = normal
P = percentile
BC = bias-corrected

ATT estimation with the Kernel Matching method
Bootstrapped standard errors

n. treat.	n. contr.	ATT	Std. Err.	t
57	50	1.317	3.850	0.342

ATT estimation with the Stratification method
Analytical standard errors

n. treat.	n. contr.	ATT	Std. Err.	t
52	55	1.643	3.242	0.507

Bootstrapping of standard errors

command: atts FCS IRR , pscore(ps09) blockid(blockf1) comsup
statistic: atts = r(atts)

Bootstrap statistics — Number of obs = 108; Replications = 50

Variable	Reps	Observed	Bias	Std. Err.	[95% Conf.	Interval]	
atts	50	1.642762	-.1087797	3.379487	-5.148572	8.434096	(N)
					-4.474612	9.452525	(P)
					-4.331923	11.53058	(BC)

Note: N = normal
P = percentile
BC = bias-corrected

ATT estimation with the Stratification method
Bootstrapped standard errors

n. treat.	n. contr.	ATT	Std. Err.	t
52	55	1.643	3.379	0.486

ATT estimation with Nearest Neighbor Matching method
(random draw version)
Bootstrapped standard errors

n. treat.	n. contr.	ATT	Std. Err.	t
57	22	1.865	4.889	0.381

Note: the numbers of treated and controls refer to actual nearest neighbour matches

8.9. Rosenbaum sensitivity analysis test

```
. gen rho = FCS - _FCS if _treated==1 & _support==1
(51 missing values generated)

.
. rbounds rho, gamma(1(0.05)2)

Rosenbaum bounds for rho (N = 57 matched pairs)

Gamma           sig+      sig-    t-hat+    t-hat-       CI+       CI-
-------------------------------------------------------------------------
    1         .614105   .614105        -1        -1     -6.75      6.25
 1.05         .673736   .551712      -1.5  -.499999        -7         7
  1.1         .726834   .491009        -2   4.4e-07      -7.5      7.75
 1.15         .773306   .433176      -2.5        .5      -7.5      8.65
  1.2         .813375   .379071     -2.75         1        -8      9.25
 1.25         .847474   .329252     -3.25      1.25     -8.25      9.75
  1.3         .876163   .284016      -3.5      1.75      -8.5     10.25
 1.35         .900056   .243445        -4         2        -9        11
  1.4         .919778   .207454     -4.25       2.5     -9.25      11.5
 1.45         .935927   .175836      -4.5      3.15      -9.6        12
  1.5         .949057     .1483     -4.75      3.75     -9.85      12.5
 1.55         .959664   .124506        -5         4    -10.25        13
  1.6         .968184   .104089     -5.25       4.5    -10.25     13.75
 1.65         .974991   .086682      -5.5      4.75    -10.75     14.25
  1.7         .980405   .071927     -5.75      5.25       -11      14.5
 1.75         .984692   .059485        -6       5.5    -11.25     15.25
  1.8         .988074   .049043     -6.25         6     -11.5      15.5
 1.85         .990732   .040318     -6.75      6.25    -11.75        16
  1.9         .992814   .033057     -6.75       6.5       -12     16.25
 1.95         .994441   .027037        -7         7       -12      16.5
    2         .995708   .022062     -7.25       7.5    -12.25     17.25

* 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)

.
```

8.10. teffect estimation in Augmented ipw, covariate balance summery and sensitivity test

```
Iteration 0:   EE criterion =  6.865e-18
Iteration 1:   EE criterion =  6.087e-30

Treatment-effects estimation                    Number of obs     =        108
Estimator      : augmented IPW
Outcome model  : linear by ML
Treatment model: logit
```

FCS	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
ATE						
IRR						
(YES vs NO)	3.295094	4.354715	0.76	0.449	-5.239991	11.83018
POmean						
IRR						
NO	50.41648	2.402555	20.98	0.000	45.70756	55.1254

Covariate balance summary

	Raw	Weighted
Number of obs =	108	108.0
Treated obs =	57	55.4
Control obs =	51	52.6

.

	Standardized differences		Variance ratio	
	Raw	Weighted	Raw	Weighted
HHAGE	.2926439	-.0276161	.732644	.8051359
HHSIZE	.1737079	.0032894	.7526675	.712089
ATESERV	.0216227	-.0147851	.8966933	1.069186
OFI	-.106214	-.0068031	.8821523	.9914155
FLS	-.1730128	-.0983585	.0051332	.0094185
TLUTOTAL	.2289865	.0099537	.8050834	.7398934
UIT	.0216227	-.000189	.8966933	.9998844
CD	.0775934	-.0019138	1.114524	.9961738
SAVING	.6460225	-.0282803	.7467718	1.008413
REMI	.033344	-.0152189	1.104823	.95834