Factors determining adoption of irrigation: the Case of Adami Tulu Jidokombolcha District of Oromia Regional State, Ethiopia

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Factors determining adoption of irrigation: the Case of Adami Tulu Jidokombolcha District of Oromia Regional State, Ethiopia

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Acronyms and Abbreviations

ATJK	Adami Tulu Jido Konbolcha
GDP	Gross Domestic Product
MOFED	Ministry of Finance and Economic Development
ADBGCEC	African Development Bank Group Chief Economist Complex
FDRE	Federal Democratic Republic of Ethiopia
FAO	Food and Agriculture Organization
CRVoE	Central Rift Valley of Ethiopia
m.a.s.l	Meter Above Sea Level
NGO	Non-governmental organization
MoWR	Ministry of Water Resources
RHSIT	Rainwater Harvesting and Supplementary Irrigation
G.C.	Gregorian Calendar
SWC	Soil and Water Conservation
ETB	Ethiopian Birr
PA	Peasant Association
OoARD	Office of Agriculture and Rural Development
WUA	Water User Association
MoFED	Ministry of Finance and Economic Development
GO	Governmental Organization

Abstracts

Ethiopia has been a food deficit country since the early 1970s, in spite of the importance of agriculture in its economy. It has been unable to produce sufficient quantities to feed the country's rapidly growing human population. Among other factors dependence on rain fed agriculture is the cause for vulnerability of Ethiopia's economy especially in Central Rift Valley of Ethiopia due to the spatial and temporal distribution of rainfall is uneven. Therefore, diversification of irrigation is an option to ensure food security especially in draught prone areas (Central Rift Valley of Ethiopia). This study was conducted with the objective of investigating determinants of adoption and intensity of adoption of irrigation in Adami Tulu Jidokombolcha district. In order to achieve this objective, primary data was collected from 130 randomly selected individual irrigation adopters and non-adopters households by using structured interview. For the data analysis, descriptive statistics including mean and percentages were used to describe the characteristics of individual adopters and non-adopters of irrigation. Moreover, t-test and chi-square analyses were employed to compare the individual irrigation adopter and non-adopter group. The paper employed binary probit econometric model for the analysis of determinants of adoption of irrigation and Truncation regression for the analysis of the determinants of intensity of the irrigation technology separately. A total of 10 explanatory variables under four factors (Household demographic characteristics, Capacity to invest, Physical factors, Institutional factors) were included in the probit regression. Among four variables under household demographic characteristics, Education and Age of household head significantly influence the adoption of irrigation. Three explanatory variables under Capacity to invest factor (estimated wealth of household, numbers of active family labor and total irrigable land) were significantly influence the adoption of irrigation. Among two variables included under Physical factor, distance of plots from irrigation water source play significant role in adoption of irrigation. Pump support under institutional factor also influence the adoption. Likewise, a total of 12 explanatory variables under four factors (Household demographic characteristics, Capacity to invest, Physical factors, Institutional factors) were included in the truncated regression. Only experience in irrigation play significant role among other four independent variables included under household demographic characteristics factor. Numbers of active family labor and total irrigable land under capacity to invest factors and soil fertility under physical factors significantly influences the intensity of adoption of irrigation. Access to credit, pump support and extension agent contact (Institutional factors) were significantly influence the intensity of adoption of irrigation. Therefore, these factors need to be taken into account in any planning of irrigation activities by policy makers to tackle the rainfall variability and moisture deficit and thereby to ensure food security.

Keywords: Irrigation technology, Adoption, probit model, truncated model, Ethiopia

1. Introduction

Ethiopia is one of the poorest nations in the world. It covers an area of 1,127,000 km^2 and is the second most populous country in Africa with a population of 82.8 million in 2010. The proportion of urban and rural dwellers nationally is 16.1% and 83.9% respectively. Population growth is currently 2.7% per annum (Abebe, 2011).

Agriculture is the backbone of Ethiopia's economy and basis of livelihood for the majority of the population. It accounts for about 41% of GDP in 2009/2010 (Abebe, Z., 2011) and 90% of the country foreign exchange earnings (MOFED, 2002a). It provides raw materials for more than 70% of the countries industry (MEDAC, 1999). Although Ethiopia has achieved strong economic growth since 2007, yet it remains one of the world's poorest countries. About 29% of the population lives below the national poverty line (IFAD, 2012). Poverty incidence is much higher in rural than urban areas (FDRE, 2002 as cited in Belayneh, 2003).

Ethiopia has been a food deficit country since the early 1970s, in spite of the importance of agriculture in its economy (Belay and Degnet, 2004). A close look at the performance of the Ethiopian agriculture reveals that over the last three decades it has been unable to produce sufficient quantities to feed the country's rapidly growing human population (Belay and Degnet, 2004). Among other factors dependence on primary commodities and rain fed agriculture are the cause for vulnerability of Ethiopia's economy (ADBGCEC, 2010). According to the African Development Bank Group (2010), during the past five to seven years Ethiopia has experienced droughts and adverse terms of trade shocks. As a result of this, per capita food production is very low and has led to repeated occurrence of food shortage and famine. In order to leak from the food insecurity problem, the country needs to improve its agricultural sector in sustainable manner. Diversification of irrigation is an option to ensure food security.

The spatial and temporal distribution of rainfall in Ethiopia is uneven. Thus, reliable food supply is difficult especially due to this temporal imbalance in the distribution of the rainfall and resulting non-availability of required moisture at required period. Hence, diversification of irrigation plays important role in contributing to household food security. Most Ethiopian farmers depend on rain fed agriculture which made the country's agricultural economy extremely brittle and vulnerable to the influence of weather and climatic variability. The dry spells at critical times of crop growing season owing to shortage of rainfall lead to failure of crop, which in turn results in food shortages.

To tackle the rainfall variability and moisture deficit and thereby the problem of food insecurity, special attention has been given to supplementary irrigation. One of the major intervention areas to reduce the rainfall variability and moisture deficit is the development of small scale irrigation in rural parts of the country (FAO 2003). According to FAO 2003, by insuring adequate and reliable water supply, irrigation boosts yields of most crops while decreasing hunger and poverty.

The study area, Adami Tulu Jiddo Konbolcha (ATJK) District in of the Central Rift Valley of Ethiopia (CRVoE), is one of the potential small scale irrigation users' areas in the East Shoa Zone of Oromia regional state. The CRVoE includes Lake Ziway, Lake Abjata, Lake Langano and Lake Shala. Meki River and Ketar River are the main tributaries of Lake Ziway and this Lake is connected with Lake Abjata through the Bulbula River. Hora Kela is a river that connects Lake Langano with Lake Abjata.The East Shoa Zone has several lakes and some rivers and also there are several small scale irrigation schemes. This study focus on irrigation using Lake Ziway among other Lakes found in the CRVoE. Lake Ziway is one of the freshwater Rift Valley lakes of Ethiopia. It is located about 121.18 Km south of Addis Ababa; the woredas holding the lake's shoreline are Adami Tulu Jidokonbolcha and Dugda Bora. It is 31 kilometers long and 20 kilometers wide, with a surface area of 434 Km^2, average depth of 4 meter and maximum depth of 9 meter and is at an elevation of 1636 m.a.s.l. The Ziway watershed falls in between 7^o 15'N to 8^o30'N latitude and 38^oE to 39^o30'E longitude covering a total area of about 7300 Km^2.

There are several small scale irrigation scheme, large water pump and small water pump developed on Lake Ziway by different NGOs and government in ATJK district. In addition to Lake Ziway, ground water is also used as source of water for irrigation practice in the study area. The ground water is very shallow around the lake which in turn easily used for irrigation purpose.

Field crop (maize, Haricot bean, wheat and teff) and Horticultural crops are the major crops grown in the study area. Field crops are dominantly rain fed and occasionally irrigated to supplement rain in case of shortage or absence of rainfall. However, majority of horticultural crops are grown by small water pump, large water pump and small scale irrigation scheme. Onion and tomatoes are the dominant horticultural crops grown in the study area while green bean, sweet potato and pepper are horticultural crops grown next to onion and tomato.

In drought prone areas, development of irrigation, provision of sufficient water and sustainable water for agricultural function is a viable option to secure food production. Although the study area is drought prone, the surrounding farmers are not using the irrigation as per expected and also there is a variation between farmers in adoption of irrigation practice. Such diversity among farmers can be related to various constraints categorized under different factors; personal and demographic, economical, social, or institutional. Understanding factors behind such diversity and farmers current level of adoption of irrigation is of paramount importance in providing critical input to the appropriate design of future programs and projects. Therefore, this study was aimed at assessing the status of adoption and factors contributing to adoption of irrigation and its intensity.

1.1. Statement of the problem

Achieving national food security is one of the main challenges currently facing developing countries like Ethiopia. Irrigation can play significant role in improving households' income via increased yields, increased cropping areas and in producing higher value crops which in turn play role in reducing poverty (FAO, 2003). These all favoring initially farmers, including poor small deficit and surplus farmers; thereby raises employment directly of farm workers, indirectly of other workers if wage increase) and maybe decrease prices in an imperfectly open economy or if there are high transport costs" (FAO, 2003).

Food supplies, higher calorie intakes and better nutrition levels can be increased by increased mean yields. There are also stability effects by reducing the dependency on rainfall-hence irrigation reduces the variance of output and employment and yields, and helps to minimize the adverse consequences of drought (Dhawan, 1988 as sited in FAO, 2003)

Despite importance of irrigation in mitigating drought and drought consequences, increase food supplies, improve household income and poverty reduction; production and productivity as well as income of particularly small scale farmers is still very low. The low productivity and income of famers is mainly attributed among other factors to poor adoption of irrigation.

Adoption of irrigation and its intensity by farm household is determined by several factors which in most cases vary from place to place and among household famers themselves implying the need to undertake area specific studies as to investigate relevant factors. Several adoption studies have been conducted in different country so far and have reported various factors influencing farmer adoption behavior. However, studies on adoption of irrigation are insufficient in the study area specifically and in the country as a whole implying probably the low attention have been given to subsector. Therefore, there is no adequate information on the status of adoption of irrigation and factors influencing it and specially study conducted on the intensity is scanty.

In the study area of ATJK district, farmers mainly depend on agriculture (crop production) and they have no promising activity option to secure their food except irrigation activities owing to rain fall is unpredictable. Despite the existence of big water resource (big lake) which can be used for irrigation widely, most of the surrounding famers are waiting for rain fed. However, there is a shortage of rainfall availability and even if the rainfall is available, it is uneven and the time at which it stopped is unknown. Consequently most of the surrounding farmers are hungry and some of them need food help. In the study area, there are off- farm and non-farm activities which are not promising to combat famine (food shortage). This is because the amount of income achieved from non-farm and off farm in this study area may not enough to cover their food requirement. However, most farmers among adopters are used these activities as supplement for irrigation activities (financing income from these activities to irrigation) (Upadhyay *et al.,* 2002). The only promising activity to guarantee to reduce famine in this drought prone area is adoption of irrigation. Some small investors of urban dwellers have been investing in small scale irrigation in the study area while majority of surrounding farmers have not adopted this promising irrigation practice. Moreover, there is also variation among farmers in their intensity of adoption of farm irrigation practice. Such diversity among farmers could be associated to many factors: economic, location (physical), social, personal or institutional which needs to be investigated and planning necessary intervention.

Thus, it is very interesting to investigate why farmers not adopting irrigation although the area is drought prone and they are not food self-sufficient (hunger). This can help policy maker to plan appropriate design of future programs and projects.

Therefore, this study is intended to assess determinants of adoption of irrigation. Furthermore, it will try to investigate factors contributing to the diversity among adopter farmers in their intensity of adoption of irrigation practice in the study area.

1.2. Objective of the Study

The general objective of the study is to generate information on the status of irrigation adoption and investigate determinants of adoption and intensity of adoption of irrigation.

1.3. Research Question

- ❖ What is the status of irrigation adoption by farmers in the study area?

- ❖ What are the factors determining adoptions and intensity of irrigation in the study area?

1.4. Significance of the study

This study will generate information on status of adoption and determinants of adoption of irrigation by farmers. Famers' adoption behavior can be constrained by several factors. Thus, understanding the factors affecting adoption of irrigation is important to bring future change in Agricultural sector thereby the livelihood of farmers.

Hence, the study will help policy makers in order to design appropriate policy interventions. It further helps them to be aware of the indispensability of detailed study of deep causes of adoption and non-adoption of irrigation by smallholder farmers and also help different stakeholders to design appropriate technologies and intervention based on elicited information.

1.5. Scope and limitation of study

This study is only a piece of a huge effort to elicit realities regarding adoption and factors determining the adoption of irrigation by farmers. Therefore, its scope is limited in terms of coverage and depth owing to limited time and financial resource available. It is limited to Adami Tulu Jidokonbolcha district in terms of area coverage. However, the results of the study can be used as a reference for other similar drought prone areas.

2. Literature Review

2.1. The Irrigation Concept

Water not only helps in survival of human beings but also serve in making life comfy and luxurious. In addition to an assortment of other service of water, the main service of water in the world is for irrigation purpose. The definition of irrigation is nothing more than uninterrupted and consistent water delivery to several crops according to their water demand. Crops fade away when there is no enough water and not timely available to them which results small yields (Garg, 1989).

In the world, the temporal and spatial differences that exist in the supply and demand of water is the basic problem of water distribution. Amending water supply and demand is the general solution of this problem so that the need of water will always be greater than or equal to supply (Desta 2004).

Providing the amount needed and quality water that the plants need throughout a season is the primary goal of irrigation from farmer's perspective. This is to optimize plant growth and crop production (Wichelns, 2000). According to Wilchelns, (2000) the definition of irrigation is the intervention by human to amend the spatial or temporal delivery of water and to maneuver the entire or part of this water for the production of crops. According to Chambers (1988), good irrigation service from famers' perspective involves the deliverance of an enough, suitable, predictable and on time water supply for preferred farming activities.

These points of view of irrigation targets and function are used to explain the notion of irrigation from farmers' perspective. Success of irrigation indicates the extent at which volume of water and its quality, and irrigation time go with the needs of plant right through the season. Faultless success takes place when it is possible to produce and achieve utmost yield of crop by applying appropriate volume of water, quality and correctly apply the time of watering provided that inputs other than irrigation are not limiting (Wichelns, 2000). Farmers try to take advantage of net revenue conditional on different resource constraints and will opt for irrigation inputs to attain success from irrigation at desired level. (Wichelns, 2000).

Hence, if facilities of irrigation not fully developed, the achieved crop output shall be deceased and if enough grains are not obtained, almost the humanity integral progress shall be vulnerable. In view of this reality; it can be simply accentuated that at least in dry tropical or dry subtropical area, irrigation is must be practiced.

Therefore irrigation may be defined as the science of artificial application of water to the land according to the crop condition and needs all through the crop period for full-grown nourishment of the crops (Garg 1989).

2.2. World Status of Development of Irrigation

Irrigation activity is an old human doing in several developed and underdeveloped country of the world for many thousand years. India and Far East countries have grown rice under the irrigation

activity for almost 5000 years while the Nile valley in Egypt and the plain of Tigris and Euphrates in Iraq were under irrigation for 4000 years (peter, 1979).
Irrigation has shaped the basis of current civilization in several countries for millennia. To give some examples, the back bone of Egyptians is Nile's flooding of the delta for many years. To add some, the land between the Tigris and Euphrates which is called Mesopotamia was the principal source of grains for the Sumerian Empire. In that same period of time, irrigation in fact developed modernized in present day china and Indus basin (Schilfgaarde, 1994).

Evidence also shows that there were reservoirs in Sri Lanka more than 2000 years old. As far back as 2300 BC, the Babylonian Code of Khammurabi provided that 'If anyone opens his irrigation canals to let in water, but is careless and the water floods the fields of his neighbor, he shall measure out grain to the latter in proportion to the yield of the neighboring field.' The stony-gravel limestone desert of the Negev area in Israel is also other indicator of irrigation development. The ancient farmers developed 'runoff' farm systems that used sporadic flash floods for irrigating in the case of lack of permanent water source (Shanan, 1987)

Traditional surface irrigation methods are yet prevailing in enormous areas of the world, like in Mediterranean zone. These irrigation methods are founded on short blocked shallow trench and small basin on ungraded level of lands, with manual delivery of water at the upper zone of the field (Sousa et al., 1999). In addition to surface irrigation there are several methods in which water for irrigation is able to apply in to crop plots. Flooding, furrow irrigation, sprinkler irrigation and drip irrigation are some of these methods (Desta, 2004).

For major population of the rural poor of the third world, canal irrigation is a direct source of livelihood. Canal irrigation is covers main part of the rural and national economy especially in China, Egypt, Indonesia, Mexico, Philippines, Sudan and Thailand. In various ways, increased agricultural production by irrigation activities can reduce rural poverty. This is due to increased agricultural production by irrigation activities can replace for imports and generate exports at the level of national economy. It also reduces the cost of food grain. Thus, irrigation can be considered as an effort to boost agricultural production and it usually decreases food price. This favors particularly urban poor to attain food for consumption. Moreover, irrigation creates additional employment opportunity and earnings for the poor. This can be directly through employment in agriculture and indirectly through multiplier effect as incomes are spent, creating more employment and incomes (Chamber, 1988).

Thus, irrigation plays a key role in providing food for larger population and is certainly intended to play high role in future also. It not only increases the output of particular crops, but also extends the successful crop-growing period and allows multiple cropping especially in drought prone areas where only single crop could be grown. Moreover, where the irrigation activities provide more food secure, it is also important to increase the level of inputs used in irrigation to intensify agricultural production to become more economically feasible (economies of scale). Hence irrigation reduces the risk of these expensive inputs being exhausted by crop failure resulting from lack of precipitation or water (FAO, 1997).
FAO (2001) also reports that the role of irrigation in addressing food insecurity problem and in achieving agricultural growth at global level is well established. Clearly irrigation can and should play an important role in raising and stabilizing food production especially in the less developed parts south of the Sahara of Africa.

2.3. Irrigation Status in Africa

African continent is dry and suffers the most uneven rainfall regime (FAO, 1997). Thus, every year many people's are at risk due to drought is repeatedly happening in several African countries. Also, water resources of Africa are comparatively less developed compared to other continents.

The performance of agriculture in sub-Saharan Africa has been characterized over the decades by ups and downs and it has not been up to expectation. But annual growth has averaged around 3.9 percent in recent years (FAO 2006). Extra food in Africa in the past came from raise in the land area cultivated, but as a high quality land happen to less available, the continental region will be coerced to enhance yields through adoption and continued use of irrigation and other modern technologies. Irrigated agriculture has a higher potential for intensification than rain-fed agriculture (FAO, 1997).

Global estimate shows that 40 percent of food and agricultural commodities produced by irrigation activities while in Africa irrigation accounts for 38 percent (IFPRI, 2009). According to this study; from the overall cultivated land area, irrigation in Africa equipped only 5.8 percent while it equipped 36.6 percent and 17.7 percent in Asia and on world as a whole respectively.

According to the tendency in the irrigated land development over thirty years, irrigation in Africa increased on the average at a rate of 1.2 percent per year. However, this rate starts to fall down in the mid 1980s and is now less than 1% per year, but it is different from country to country (Desta 2004). Although there is still substantial potential for the future development of irrigation, water is growing scarcely in those area where the demand for irrigation is high. In the Northern dry part of Africa, more than half of the total extraction of water takes place.

Africa's total annual water resource potential from precipitation is 20,360 KM^3/year and from renewable source is 3930 KM^3/year (FAO, 2005). The whole continent water resource extraction is estimated to be 215$km^{3/}$year, which is distributed to agricultural sector, societies and industry. From extracted water, (86%) is disseminated to agriculture but this figure is differing from one to another regions (FAO, 2005).. Dry region has the highest level of water extraction for agriculture purpose where irrigation plays an important role in agriculture. Contrary, the moist region shows lowest water extraction.

2.4. Irrigation History and Its importance in the Future in Ethiopia

In Ethiopia, irrigation is traditional and it is a small-scale scheme which is diverted from river. The diversion structure is also simple and exposed to frequent damage by flood. At the beginning of 1960s, modern irrigation was launched to produce large quantity of sugar cane, fruit and cotton by private investors in the middle Awash valley. However, with the 1975 rural land proclamation, huge irrigated farms were taken to responsibility of ministry of State Farms and all small-scale irrigation schemes constructed after 1975 were almost organized in to producers' cooperatives (FAO, 1995c).

According to the Ethiopian water resource management proclamation No. 197/2000, water uses defined as "*the use of water for drinking, irrigation, industry, power generation, transport, animal husbandry, fishing mining and uses of water for other purposes*". Total water extractions in 2002 were estimated to be 5.6 km^3 of which 5.2 km^3 (93.6%) was used for the purpose of agricultural activities like irrigation and livestock. Even so, almost all the food production in Ethiopia achieved from rain-fed agriculture; about 3 percent of food production derived from irrigated land. According to Abebe, Z., (2011), fresh water extractions for the water supply and sanitation 'sub-sector' account for 0.3 km^3 (6%) of annual fresh water withdrawals nationally. In rural areas, per capita domestic freshwater withdrawals are commonly between 5 and 10 liters per day (2 to 4 $m^3 \cdot$ year-1). Annual, freshwater withdrawals for industry are estimated to be 0.02 km3 (~0.4% of total fresh water withdrawals) in 2002 (FAO, 2005 and WB, 2006 as cited in Abebe, Z., 2011).

Ethiopia is endowed with abundant water resources like lakes, rivers and other water bodies which are anticipated to supply widespread potentials for farming of fish and irrigation purpose (Mengistu, 2000).
According to a recent estimate, the total irrigated land area covers around 197,225 ha in Ethiopia. This much of expansion of the irrigated land area comes from the development of small scale scheme for irrigation. However, when compared to the resources the country has; the existing irrigation expansion in Ethiopia is extremely small (MoWR, 2001).

Although, in Ethiopia water resource is said to be very rich, it is obvious that even by the low standard of African countries, the water resource use of Ethiopia is very limited. From total irrigable lands of Ethiopia, only less than five percent is under irrigation (Awulachew *et al.* 2007).
In contrast to this literature finding, almost all cropped land in Egypt is under irrigation. When irrigation in Ethiopia compared with Sudan, Madagascar, Egypt and Nigeria country's irrigation, it covers only less than three percent of the Ethiopian total cropped land. When compared to the area under rain-fed, the contribution of irrigation to the production of food would not be significant assuming all the irrigated land is utilized to produce food crops. (Desalegn, 1999). Therefore, to effectively and efficiently utilize water resource to attain food self-sufficiency and food security, a rational management and development of water resources is required.

According to Desalegn (1999), irrigation development in Ethiopia did not try to engage the farming population both in planning and construction phases. Modern irrigation was entrusted a small technical and managerial elite working for large scale investors' interests in the past and later for state enterprises but it bypassed the peasant. On the other hand, there is a long tradition among peasant famers of water management for small-scale agricultural use. In Ethiopia traditional scheme is served for more than forty percent of irrigated land (Desalegn, 1999).

Through rain-fed agricultural production alone, Ethiopia cannot achieve its food requirements. Thus, the government has taken a plan towards developing irrigation schemes of several scales. This will continue and be further reinforced during the coming years. However, currently the maximum area cited to be under irrigation is estimated at only five percent of the potential which is accounting for only three percent of the country's total food production. Irrigation programme intends to develop a total of 29,043 ha of new land which brings the total area under irrigation to 226,293 ha that can benefit 114390 households (UK Trade and Investment, 2003).

The expansion of irrigation play key role in sustainable and reliable agricultural development which is very important for overall economic development of the country. So as to realize food security at household level of Ethiopian’s highly and rapidly increasing population; small, medium and large scale irrigation infrastructural facility required to be developed. Thereby, this kind of developments could even secure externally marketable surplus that would earn foreign exchange and contribute in local industries by providing required raw material (MoWR, 2001).

2.5. Technology Adoption

The terms of “technology” is defined by various authors in different ways. Rogers (1995) explain the word “technology” and “innovation” as they are synonymous and defines technology as the design for instrumental action that reduce the uncertainty in the cause-effect relationship involved in attaining a desired outcome.

A more meaningful definition may be that a technology is a set of “new ideas” which is linked with some extent of uncertainty and hence a lack of predictability on their outcome. Blending into the normal routine of the planned economic system without upsetting the system’s state of affairs is required for a technology to impact on economic system. This entails overcoming the uncertain linked with the new technologies. It therefore comes as no surprise that several studies set out to establish what these factors are, and how they can be eliminated (if constraints) or promoted (if enhancers) to achieve technology adoption.

From the work of Enos and Park (1988) the term technology is defined as “the general knowledge or information that permits some tasks to be accomplished, some service rendered, or some products manufactured”.

The term adoption on the other article defined as “a mental process an individual passes from first hearing about an innovation to final utilization” (Roger’s 1962 as cited in Feder, *et al*. 1985).

According to Rogers, 1995 a technology that is being adopted has an edge over conventional practices. According to this article a technological innovation cover at least some degree of benefits for its potential adopters.

The dynamic process of adoption involves learning a technology gradually (Cameron, 1999). From the time several innovations available to the time they are widely adopted, certainly it require a long period of time (Rogers, 1995). Depending on the characteristics of individuals, place and practice the time needed between the initial information and final adoption can be differ.

In the process of technology adoption initially from hearing information up to maximum adoption by producers involves many variables which influence adoption and its intensity positively or negatively. In this literature review part, those variables which will support or contradict this study were investigated as follows.

2.6. Empirical Studies on Determinants of adoption and Intensity of Adoption

A number of empirical studies have been conducted by different people and institutions on the adoption of agricultural innovations both inside and outside of Ethiopia. The studies are mainly carried out around soil and water conservation, cereals and horticultural crops adoption technologies. However, the studies conducted in the area of adoption of irrigation as a general is scanty.

There is wide-raging body of literature on the economic theory of technology adoption as a general. Numerous factors have been found to affect adoption of agricultural technology in developing countries. Studies on the determinants of adoption of irrigation technology and its intensity have focused on several factors that play role in hindering or positively influencing the famers' irrigation adoption (e.g. Adeoti, A. I., 2009; Kulshreshthal, S.N. and Brown, W.J., 1994; Abdulai *et al*., 2011; He *et al*., 2007; Mushtaq *et al*., 2006). These studies previously conducted on irrigation adoption widely used estimation models such as logit, probit, tobit and Heckman two stage to assess the probability of using or not using irrigation technology. Moreover, several highly similar studies with adoption of irrigation technology were conducted on soil and water conservation adoption (e.g. Jara-Rojas *et al*., 2012; Amsalu, A. and J.de Graaf, 2007; J. de Graaf *et al*., 2008; Jara-Rojas *et al*., 2013: Pender, J.L. and Kerr, J.M., 1998; Gebremedhin, B. and Swinton, S.M., 2003; ANLE *et al*., 2007; Baidu-Forson, 1999; Mazvimavi, K. and Twomlow, S, 2009; Davey, K.A. and Furtan, W.H., 2008; Mutune et al. 2011; Chiputwa *et al*., 2011; Norris, P.E. and Batie, S.S., 1987; Bayard et al., 2006).

Study on cereals and horticultural crops adoption technologies also conducted by different people (e.g. Awotide *et al*., 2012; Tiamiyu *et al*., 2009; Faturoti, *et al*., 2009; Noorhosseini-Niyaki, S.A. and Allahyari, M.S., 2012; Mariano *et al*., 2012; Mafuru *et al*., 1999). The results of these articles were summarized in the table 2.1.

A decisive study in the area of irrigation adoption is He *et al*. (2007). They classified the determinants of adoption of irrigation under different factors that include perception variables, institutional variables, farmer variables, agro-ecological location variables and farming variables. They employed the binary logistic regression in modeling of Rain water harvesting and supplementary Irrigation Technology (RHSIT) adoption in China. According to this study result, age of household head is usually considered with the assumption that the probability of adoption of technology is higher among younger farmers than older farmers. Similarly Kulshreshthal, S.N. and Brown, W.J. (1994); Amsalu, A. and J. de Graaf, (2007); J. de Graaf *et al*., 2008); Chiputwa *et al*. (2011); Norris, P.E. and Batie, S.S. (1987); Gebremedhin and Swinton (2003) and Awotide *et al*. (2012) were reported that age of household has significant influence on adoption of technologies.

With regards to education, there is a general agreement that education level of household head is associated with adoption of technologies due to education is believed to increase farmers' ability to obtain and analyze information that helps him to make appropriate decision. Several studies for example the one conducted by He *et al*. (2007); Abdulai *et al*., (2011); (J. de Graaf *et al*., 2008); Chiputwa *et al*. (2011); and Tiamiyu *et al*.(2009) have reported that education level of household positively associated with adoption and intensity of adoption. According to different literature illustrated above, the influence of other variables on adoption of technologies were summarized in the table 2.1.

Table 2.1. Summary of article results conducted on adoption of technology

Article author	List of variables	Significant?	Direction of significance	Estimation model used
Adeoti, A. I., 2009	Extension service contact	Yes	Positive	Heckman two step technique
	dependency ration	Yes	Negative	
He *et al*. (2007)	Family labor	Yes	Positive	Binary logistic regression
	Extension contact	Yes	Positive	
	Land tenure status	No	_	
Kulshreshthal, S.N. and Brown, W.J. (1994)	Membership in agricultural organization	Yes	Positive	Probit model
	size of farm	No	_	
Abdulai *et al*., (2011)	Extension contact	Yes	Positive	Probit model
	family labor,	Yes	Positive	
	Member of farmers organization, land quality	Yes	Positive	
	Access to credit service	Yes	Positive	
	Plot distance from irrigation water source	Yes	Negative	
Jara-Rojas, *et al*. (2012)	Farm size	Yes	Positive	Multinomial logit
	Livestock number	Yes	Positive	
	Family size	Yes	Positive	
	Access credit	Yes	Positive	
Jara-Rojas, *et al*. (2013)	Land area	Yes	Positive	Seemingly unrelated Bivariate probit
	Quality of soil,	Yes	Positive	
	Family labor	Yes	Positive	
	Access to credit	Yes	Positive	
	off-farm activities	No	_	
Amsalu, A. and J. de Graaf, (2007)	Farm size,	Yes	Positive	Probit
	Livestock size,	Yes	Positive	
	Soil fertility	Yes	Positive	
	Family size	Yes	Negative	
Mutune *et al*. (2011)	off-farm activity	Yes	Positive	Logit
	extension service	Yes	Positive	

	Farming experience	Yes	Positive	
	Family labor	Yes	Positive	
	Membership of organization	Yes	Positive	
Chiputwa *et al.* (2011)	Family labor,	Yes	Positive	Tobit
	Extension visit	Yes	Positive	
	Land quality	Yes	Positive	
	Disposable income	Yes	Positive	
Norris, P.E. and Batie, S.S. (1987)	Farm size	Yes	Positive	Tobit
	income	Yes	Positive	
	off-farm work ,	Yes	Negative	
	Land tenure	Yes	Negative	
Mazvimavi, K. and S. Twomlow (2009)	Sex (male)	Yes	Positive	Tobit
	Extension contact	Yes	Positive	
	Plot size	Yes	Positive	
	Rain fall pattern	Yes	Positive	
	Faming experience	Yes	Positive	
	Household labor availability	No	_	
	Impacts of HIV/AIDS	No	_	
Tiamiyu *et al.*(2009)	Farming experience	Yes	Positive	Tobit
	Extension visits	Yes	Positive	
	Land ownership,	Yes	Positive	
	credit use	Yes	Positive	
	Level of rice commercialization	Yes	Positive	
	Family labor	No	_	
	Family size	No	_	
Noorhosseini-Niyaki, S.A. and Allahyari, M.S., (2012)	Extension contact	Yes	Positive	Logit
	Membership in social institutions	Yes	Negative	
	family members' participation in farm activities	Yes	Positive	
	Family size	Yes	Positive	
Awotide *et al.* (2012)	Household size,	Yes		Logit
	Access to credit	Yes	Positive	
	Membership of organization	Yes		
	Degree of extension contact	Yes	Positive	
	Wealth index	Yes	Positive	
Mariano *et al.* (2012)	Household size	Yes	Negative	Logit
	Area cultivated owned	Yes	Negative	
	Non-rice income	Yes	Positive	

	farm size	Yes	Positive	
	access to credit,	Yes	Positive	
	Participation in on farm demonstration,	Yes	Positive	
	attendance at training	Yes	Positive	
	Access to extension worker	Yes	Positive	

Lynne *et al*. (1988) as sited in Baidu-Forson (1999) pointed out that possible loss of information may occur if a binary variable is used as the dependent variable. Instead of specifying as single dichotomous choice Baidu-forson (1999) proposed the use of an extension of Tobit estimation method and found that extension visits and risk attitude play significant role in adoption decision.

In spite of the importance of study on intensity of technology adoption, few studies were conducted on the intensity. For example, Mushtaq *et al*., (2006) has paid particular attention to adoption of water saving irrigation. They proposed the use of Tobit estimation method to figure out the factors play role in the intensity of adoption of irrigation technology. Their result revealed that education level of farmers, farming experience and wealth has no significant effect on the intensity of adoption but land quality and farm size negatively influence the intensity of adoption. This result is actually strange but they tried to point out the reason. Moreover, Gebremedhin and Swinton (2003) conducted research on adoption of soil conservation which is highly similar with adoption of irrigation. They used a double hurdle model to examine the causal factors for adoption of soil conservation and intensity of adoption. Accordingly, the adoption of technology associated with plot distance from home, active family member labor availability, land tenure, farmer age and learning opportunities via extension education in the long term and insecure land tenure is strongly linked to adoption. Plot area, market distance from residence and distance of all-weather road from residence related to intensity of adoption of the technology. Even though their study was not conducted by using double hurdle estimation model, J. de Graaf *et al*., (2008) pointed out that fertile land farm size and education influence the level of investment in technology adoption.

Awotide *et al*. (2012) used Logit to examine the determinants of the agricultural technology adoption and Tobit model to examine the determinants of intensity of technology adoption among small holder rice farmers in Nigeria. This finding pointed out that age of household head, education level, wealth index, extension contact, membership of organization, farm size, income, and access to credit influence the intensity of adoption. similarly, Mariano *et al*. (2012) used poisson regression model to point out the variables affecting intensity of the technology. According to this study, the intensity of adoption influenced by schooling, household size, non-rice income, farm size, distance to nearest market, credit access, participation in on-farm demonstration, attendance at training and access to extension workers.

Although wide-raging body of literature in the area of agricultural technology adoption explained above, studies conducted in the area of adoption of irrigation in specific is insufficient. Especially there is a few literature in the area of intensity of adoption of agricultural technology as a genera and even very few in the area of intensity of adoption of irrigation technology specifically. In the sole study of which we are aware, Mushtaq *et al*. (2006) tried to investigate some variables that influence the intensity of adoption of irrigation. Most studies have not focused on the intensity; instead they have focused on adoption alone using logit or probit estimation model as presented above.
Adoption may be a threshold-based decision subject to several constraints (informational, physical or/and material constraints); however, intensity of adoption is the rate at which adopted technology used. Most studies tested the hypothesis of both by similar econometric model mostly Tobit model. However, this hypothesis cannot be tested by Tobit analyses that treat the decision jointly, such as Tiamiyu *et al*. (2009); Chiputwa *et al*. (2011) and Mushtaq *et al*. (2006).

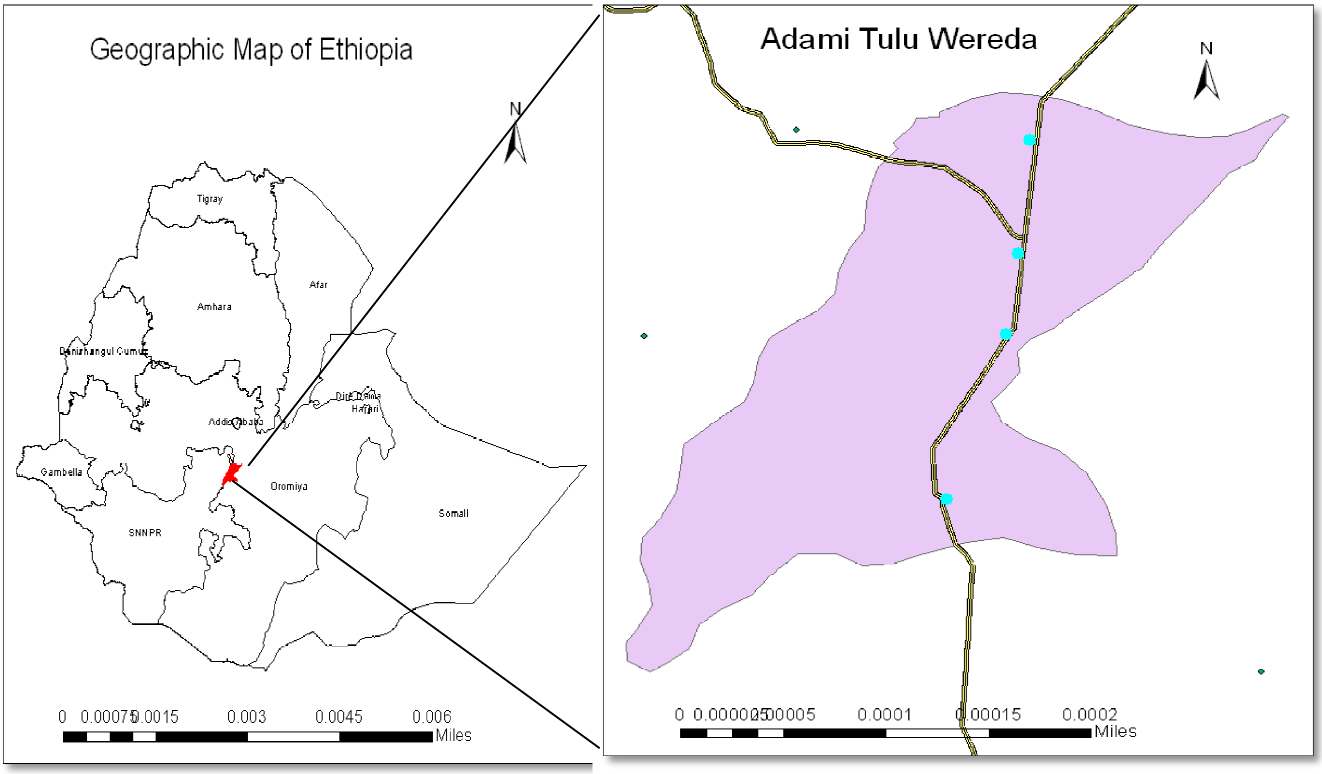
Thus this study tried to fill this kind of research gap regarding determinants of adoption of irrigation and intensity of adoption by 130 farmers in central rift valley of Oromiya, Ethiopia during 2004 E.C survey. Adoption of irrigation is estimated using probit econometric model while the intensity of adoption of technology is estimated using truncation regression model separately.

3. Description of the Study Area

3.1. Location and agro-ecology

Adami Tulu Jido konbolcha District is among the 12 districts found in Eastern shoa zone of Oromiya regional state located to the southern part of the region at 168 km from Addis Ababa. It is located at 7.58^{o}N latitude and 38.43^{o}E longitudes, in the southern part of Oromiya. The altitude ranges from 1500 – 2300m.a.s.l except the area around Mount Aluto. The average annual rainfall ranges from 650 – 750 mm and the distribution is highly erratic with high variation between and within years. This irregular rainfall coupled with frequent pest attacks, give crop production a high degree of risk and uncertainty leading to great dependency on food aids. Agro-ecologically the area is categorized under the semi arid. The total land area is 1403.3 km^2. Batu Lake and Bulbula River are the main source of irrigation and drinking water. Open woodland consists of Acacia species and other species generally characterizes the vegetation cover of the area. The identified major soil types of the district were Andosols (60.4%), Rendzinas and phaeozems (30.4%) and Luvisol (9.2%) (www.oromiyaa.com/english/index.php).

Figure 3.1. Map of the study area



3.2.Crop production Status and Livestock Rearing

Even though crop is dominating, crop-livestock mixed farming system characterizes agriculture in the district. The important livestock species reared by the farmer in the district are: cattle, goats, sheep, chicken and equines. Shortage of feeds due to unavailability of rainfall and veterinary service coupled with low genetic merit of local breeds are major constraints for livestock productivity in this study area. Hence, the livestock rearing activities in this study area is less practiced relative to crop production. Maize, sorghum, haricot bean, *teff*, wheat, barley and sweet potato are major crops grown by farmer under rain fed condition. Among crop grown under rain-fed, haricot bean is major cash crop for the farmers in the district. Besides onion, tomatoes, pepper, and cabbage are major vegetable crops grown by irrigation and also used as cash crops for the farmer in the district. The production season of horticultural crops grown under irrigation especially onion and tomato, mostly starts from September to end of May due to their easily perishable properties when exposed to rain fall. The production season of crop under rain-fed starts from late May until late November but it fluctuates from year to year due to unpredictability of rain fall condition. Hence the production of crop under rain-fed entails high risk due to this unpredictability of rain fall condition. On the other side, the production of crop under irrigation requires high cost when compared to rain-fed production. This is due to production under irrigation needs high inputs and capitals compared to rain-fed. These are fuel, poles for tomato, high fertilizer, pesticides, high herbicides, high labor and different capital inputs (e.g. pump).

The cost incurred to and the return achieved from crops grown under rain-fed and irrigation is not the same even on similar crop. This is summarized as follows.

Table 3.1. Average total production costs and ranges of costs of different crops under irrigation in the six sampled PAs (in birr[1]/0.25 ha and Kg/0.25ha).

Type of crop	Average production cost	Ranges of production cost	Average yield	Ranges of yield	Average Revenue	Ranges of revenue
Maize for improved seed	3580	3000-4000	1350	1200-1500	12150	10800-13500
Maize under irrigation but not for improved seed	1980	1500-3000	1200	900-1300	6000	4500-6500
Onion	8914	8000-10000	5833	5000-7000	46664	40000-56000
Tomato	8181	6000-12000	8000	6000-10000	48000	36000-60000
Pepper	4000	3500-4300	268	240-300	7504	6720-8400
kale	2800	2500-3000	65 quintal	50-80 quintal*	7800	6000-9600
Cabbage	3100	2850-4000	87 quintal	70-95 quintal*	5220	4200-5700

Source: ATJK district Office of Agriculture and Rural Development

Note: the depreciation cost of the pump have been included in the production cost in the table

Table 3.2. Average total production costs and ranges of costs of different crops under rain-fed in the six sampled PAs (in birr[1]/0.25 ha and Kg/0.25ha).

Type of crop	Average production cost	Ranges of production cost	Average yield	Ranges of yield	Average Revenue	Ranges of revenue
Maize	1650	1327-1800	930	800-1000	4650	4000-5000
Sorghum	720	660-800	500	450-850	2000	1800-3400
Haricot Bean	1150	1000-1317	480	350-500	2880	2100-3000
Wheat	1700	1500-2000	570	500-600	4560	4000-4800
Barley	1250	1000-1400	640	600-700	3200	3000-3500
Teff	1160	1100-1200	270	200-300	4050	3000-4500

Source: ATJK district Office of Agriculture and Rural Development

As it is presented in the table 3.1 and 3.2 farmers have no incentive problem under irrigation activities compared to the production under rain-fed. Obviously profit achieved from irrigation activities is more than the rain-fed production. However, production under irrigation requires more production cost when compared to rain-fed production.

[1] Birr is an Ethiopian currency. 1 Euro = 23 birr at the survey time.

3.3. Irrigation activities

Adami Tulu district has huge irrigation water sources which still did not utilized for the irrigation purpose. In this district there are 43 peasant associations. Among these PAs only 13 of them have access to irrigation water. The name of these peasant associations are Bochesa, Halaku, Golba aluto, Dodicha, Iddo Gojola, Ilkachelemo, Walin Bula, Negalign, Abbayyi Dannabo, Dasta Abjata, Abine Germama, Annannoo and H/G/Boqqee . The total numbers of household head of the district are 26190. From this 20721 are male headed household and 5469 are female headed household (Adami Tulu Jidokonbolcha District OoARD report, 2012). The total number of household head of the 6 sampled PAs those who have access to irrigation water are 3392. From this 678 are female headed and 2714 are male headed household. Among the total numbers of households that have access to irrigation, 130 were selected for the survey.

Total arable (cultivable) land of the district excluding irrigable land is 62352 hectare (OoARD report, 2012). The irrigation potential (total irrigable land) in the district (in Hectare) is 10,000 and from this only 2657 Ha were used under irrigation in 2012 (OoARD report, 2012). The average land holding for the sampled household was 2.3 ha and the range is from 0.25 ha to 6.25 ha. There are three types of irrigation infrastructure in the study area. These are: small scheme, large pump and small pump. However, the number of small scheme and large pumps are very few and they were donated by different NGOs and governmental organization.

3.3.1. Irrigation activities individually

In the study area the donated small scheme and large pump has no capacity to cover all the irrigable area of the study area. Hence, some of the adopters have been using their own small pump to drive water from the lake, river and shallow groundwater. In addition, some famers have been using both group pump (small scheme and large pump donated by NGOs and GOs) and their own small pump in case of their farm extent is more than the capacity of the schemes and pumps or in case of the farm location is outside of the coverage area of donated schemes and large pumps. Thus, those farmers who have no plots in the irrigation command area of scheme and large pump did not organized in to groups. In Ethiopia as a whole and in the study area specifically, land is the property of government but the usufruct right was given to individual farmers (people). This means that land shall not to subject to sale but farmers have the legal right to use and drive profit from the land allocated to them. Hence, at the study area among farmers those who have no land in the irrigation command area of schemes and large pumps, some of them have been renting-in land from the irrigation command area. Thus, if they have interest and capacity to produce crop under irrigation, land can limit at some extent but not strongly limit their irrigation practice. However, if they have no capacity to rent in land, their irrigation activities can be highly limited. The irrigation water source for both individual farmers and grouped farmers are Ziway Lake, Bulbula River and shallow groundwater (hole). Some individual farmers dig a hole around lake up to 2.5 meter deep in to ground to draft water. For this they do not need to pay cost and they are doing themselves. However, this has the opportunity cost. They are using small pumps to drive water from lake, river and this hole. The minimum cost of small pump (6.5 Horse power/ 3 inches) is 7500 ETB and this cost varies according to the capacity (horse power) of the pump. The irrigation coverage area of pumps also varies according to their horse power. A water pump which has 6.5 horse powers (3 inches) can cover 3 to 4 ha of irrigation area. The pumps can be easily moved from a place to place and do not need labor cost to install. Farmers easily get a fuel to their pump from Ziway town which is the town of the ATJK district. Farmers can resell their pump to other farmers at the time they need.

3.3.2. Group Based Irrigation Activities

In the case of both small scheme and large pump that were donated by NGOs and GOs, farmers organized in to groups and they have their own rules and bylaw in which it is expected to ensure the interest of all farmers. Farmers those who have plots in the irrigation command area of small scheme and large pump, organized in to different groups (WUA). Farmers those who have plots in this irrigation command area of small scheme and large pump, have developed the rotational system by setting sequential irrigation turn of each group starting from the head to tail-end of the water source. Any farmer can join the group at the time they need as long as they fulfill the following criteria:

- Need to pay the membership fee,
- Need to accept the group bylaw
- Need to have plot of land inside of the irrigation command areas
- Age of member famers must be equal or greater than 18 years
- Only member of one irrigation group
- Must be dependent on agriculture

The water pump donors contact the ATJK district Office of Agriculture and Rural Development when they need to install water pump for farmers. Hence, the office selects the irrigable area and pick specific area from the irrigable land area they selected by chance (lottery system) to ensure the equality of farmers for the access of pump. Thus, farmers also have no power to install the pump at their specific interest area.

The irrigation activities under group based is similar to individual base irrigation. Even if they control the pump in group, the benefit from irrigation is directly for individuals due to production cost is also at individual base. However, the purpose of forming a group is only for the sake of using the donated water pump jointly.

Groups have elected water committee who take initiatives in management activities of small scheme and large pump. This management activity includes water allocation, water distribution, scheme/pump maintenance & canal cleaning, resource mobilization and conflict resolutions.

3.3.2.1. Allocation of Water among Grouped farmers

Water can be supplied to farmers continuously when there are small numbers of famers in the water user association; or it can be supplied in rotational forms if the numbers of water user are high in the group. In the latter case the lengthy in which water supplied for a farmer and discharge rate may be relatively fixed. However, in both situation, the flexibility in setting up of the time of irrigation (scheduling) for each individual farmers is depends on the common agreements between each farmers in each groups of farmers. In this regards, all the sampled PAs those who have small scale irrigation scheme adopts the rotational water access system owing to the numbers of farmers that already included in the group is high; which are receiving water by turns at pre-fixed time. Those farmers, who have water pump individually, have the right to use the water at any time and the amount they need due to water resource is high and due to they are using their own pumps and fuels. In the case of small scheme and large water pump, nobody has the right to use the amount he/she need and at any time he/she need due to the scheme and pump was donated by several NGOs and governmental organization to them. In the case of large pump, famers use their own fuel at the time allocated to them and they get pumps rotationally due to high numbers of members in the group. Every group has water committees who have responsibility in allocation of water, organizes the rotational water distribution and other activities like maintenance of irrigation infrastructure and canal cleaning.

3.3.2.2.Water Distribution among the Group

According to the information elicited from key informants and OoARD of the district, the scheme and large motor pump has water committees. The water committee is responsible for coordinating the physical water distribution by nominating responsible persons who are responsible to open gate as per the program of each of the groups member (formed based on their farm location). In case of small pump, farmers have no water committee owing to they are using individually.

In the study area, in each group the water committee consists of four members to organize and control water distribution in the irrigation command area of the small schemes and large pumps. Although the water committee coordinates most irrigation activities, they were found to be inefficient some time in water distribution in terms of equity and timeliness. According to the information elicited from key informants, some of the committee members deceive equal water distribution and time of distribution. They favor those people they like and prohibit the water those who they do not like. As said by this key informants, the performance of scheme decline from time to time and most of them currently not functional. Thus, it contributes to weak performance of water committee and thereby to unfair distribution of water. This cause to certain socioeconomic groups obtains more water for their farm activities than others.

3.3.2.3.Maintenance of Schemes and Pumps and Canal cleaning

The members of the WUA are responsible for the maintenance of pumps, schemes and canal cleaning. The water committees are in charge of calling meeting and coordinate maintenance and canal cleaning activities when it is necessary to do so. In addition, members are responsible to mobilize resources that are used for the maintenance and canal cleaning. Hence, the cost of maintenance and canal cleaning is covered by the members of the WUAs. The cost of maintenance depends on the extent at which schemes and pumps damaged. Farmers have low technical knowledge which leads to repeatedly small to high damage of small schemes. They can get maintenance technician from their district town which is called Ziway. The technician estimates the amount of maintenance cost for them in case of scheme and pump failure. Hence, the water committee is responsible to calculate each farmers share and inform them to pay the cost needed for the maintenance depending on the extent of irrigable plots they have. Farmers themselves participate on canal cleaning without incurring costs for the cleaning. However, those who cannot participate on the cleaning due to health issue or another issues, will hire daily laborer and sometimes in case of health problem group also understand their problem.

3.3.2.4.Conflict and its resolution

"The link between natural resource management and conflict is strong" (Wood, 1993). In this study area case, water for irrigation is not scarce; however, there is a conflict among the members of water user association on how to utilize the scheme and large pump. With regard to six sampled PAs; water users and key informants revealed that a conflict arising from improper scheme use for water distribution is a common phenomenon among irrigators with in a group. They mentioned that lack of proper control of schemes for water distribution and increasing competition within the group due to increasing number of water users and shortage of schemes and large pumps as the prominent factors for group member conflict. Due to this shortage of schemes and large pumps and increasing numbers of water users, some of the members of the group need to use the scheme without keeping their own turn.

According to the information revealed from key informants, the water committee sometimes tried to resolve the conflict themselves immediately when it rose and sometimes they suspend the cases owing to the water committee takes the defaulters to peasant association social courts whenever there are perpetrators. This situation can delay the decision on the defaulters due to the courts always need eyewitnesses for the offences done.

The interview revealed that in case the courts make decision against the defaulter for instance, if the person is deceived the using of scheme; he/she will be penalized. If the case is beyond the capacity of the water committee, it will be submitted to the peasant association social court. This kind of problems are not exist among small pump owners owing to they are using their own pump individually.

3.4.Output and Input Market Condition

Adami Tulu district is relatively better in terms of basic infrastructures than other rural parts of Ethiopia. It is situated along the highway from Addis Ababa to Awassa, which crosses it from one end to other. Due to its topographic feature and all PAs locations nearness to highway and Addis Ababa, there is no problem of access to market and road transportation is also suitable even in the rural areas of the district compared to other districts. Figure 2 give some highlights about proximity of irrigable areas of the study area to highway. Hence, the agricultural outputs of the study area are accessible to Awassa, Shashemene, Arsi Negelle, Ziway, Meki, Alemgena, Mojo, Dukam and Addis Ababa traders. Farmers sell their perishable horticultural products like tomatoes and onion directly on farm fields. When their products reach maturity stage, farmers give call to brokers and inform them about when they want to sell and estimation of production amount. Depending on the information given to him/her, brokers first visit the farm field of farmers and give call to traders. Owing to traders trust brokers, they directly come to farmers' field to buy from them. Thus, famers sell all the quantity they want to sell except low quality output. Low quality product is sold in the local open market. The price fluctuates not only for study area but also at country level. When the central market at Addis Ababa saturates, market of the study area also easily saturates.

Figure 3.1. Highway crossing the rural irrigable areas of ATJK district

Farmers buy their inputs like insecticide, fungicide, fertilizer, shovel, hoe, water pump, etc. from private shops and open markets in Ziway town.

3.5.Labor market

In the study area there is big Dutch flower farm which has a capacity to provide employment opportunity for more than 8000 people. Thus, Peoples migrate highly from Southern Nations and Nationalities of Ethiopia to the study area to find job. However, all migrated people cannot find job in the flower farm. Hence, there is a labor market for agricultural activities in the study area but the labor price is high. Daily laborers request farmers to pay 30-40 ETB which is not affordable to some of farmers except wealthier famers. Some male farmers generate off-farm employment form petty trade, horse and donkey cart. In this study area few women farmers also generate off-farm income from selling local alcoholic drinks. However, both female and male famers cannot generate income from the off-farm activities as high as their living expenses are.

3.6.Credit Market

The source of credit service available to district as a whole are private banks like Construction bank and Dashen Bank and also government banks like commercial bank of Ethiopia and Development bank of Ethiopia. However, these banks are extremely limited to provide credit service to farmers. Even if they provide, they need strong collateral like house constructed by bricks and stone plastered with cement and different vehicles that anticipated paying back the loan; however, majority of the farmers have no such collateral. Thus, there is no well-established formal credit service to farmers in the study area. However, some farmers have access to informal credit service. The informal credit services available to some farmers of study area are local money lender, borrowing from relative and friends but these all are rarely available to farmers. Borrowing from local money lender has risky due to the interest rate is highly expensive even sometimes equal to the principal. Hence, farmers are highly limited to borrow from local money lenders. Some farmers those who have wealthier trader from family may access credit service without paying interest rate but this is also rare. Thus, the only option farmers have is using own saving for purchasing of working capital but own saving is less in the study area.

4. Theoretical framework

In this study, adoption of irrigation can be considered as one of technology option available to household farmers owing to it enables them to carry out multiple cropping, diversify their production and overcome moisture deficiency partly or fully. Adoption according to Rogers (1983) is a decision to make full use of an innovation (new method) at best appropriate course of action available. Appropriate technologies are not always adopted even where the need is obvious (Amsalu, A., 2006). Famers may refuse or dump technologies that have been useful owing to different factors or constraint behind. This highlights the need to develop a better understanding of the condition that encourage or discourage sustained adoption of irrigation practice in this study case.

The degree at which the respondent farmers have adopted irrigation in this study case can be measured by Adoption index. This adoption index is a continuous variable which can be calculated as follows.

$$AI = \sum_{i=1}^{n} \frac{Li}{Lt} * 100\% \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where:

AI is refers to adoption index of irrigation, L_i is land area allocated to irrigation measured in kert (0.25ha), L_t is total land owned by each farmers and n refers to the number of respondent farmers.

This adoption index can be calculated for individual farmers as well.

$$AI_i = \frac{Li}{Lt} * 100\% \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where, AI_i is adoption index of i^{th} respondent farmers.

The i^{th} individual decision may be modeled as maximizing the expected utility from adoption of irrigation or non-adoption (rain fed). Thus, farmers' have two option in which their objective is achieved (adoption of irrigation or rain fed). However, the second option (rain fed) is not promising in the study area since the area is drought prone. Hence, there may be other constraints under different factors which affect the utility achieved from irrigation and caused for non-adoption. This means that due to existence of different constraints, farmers may not adopt technology and may not increase level of adoption of irrigation activities even though there is higher expected income from irrigation. Thus in order to highlight constraints affecting irrigation adoption and level of investment in irrigation, they were categorized under different factors in this study. Farmer utility is assumed to be increasing in adoption of irrigation (*IR*) and decreasing in existence of constraints. For the simplicity of the analysis these constraints can be categorized in to capacity to invest factor, institutional factor and physical incentive factor.

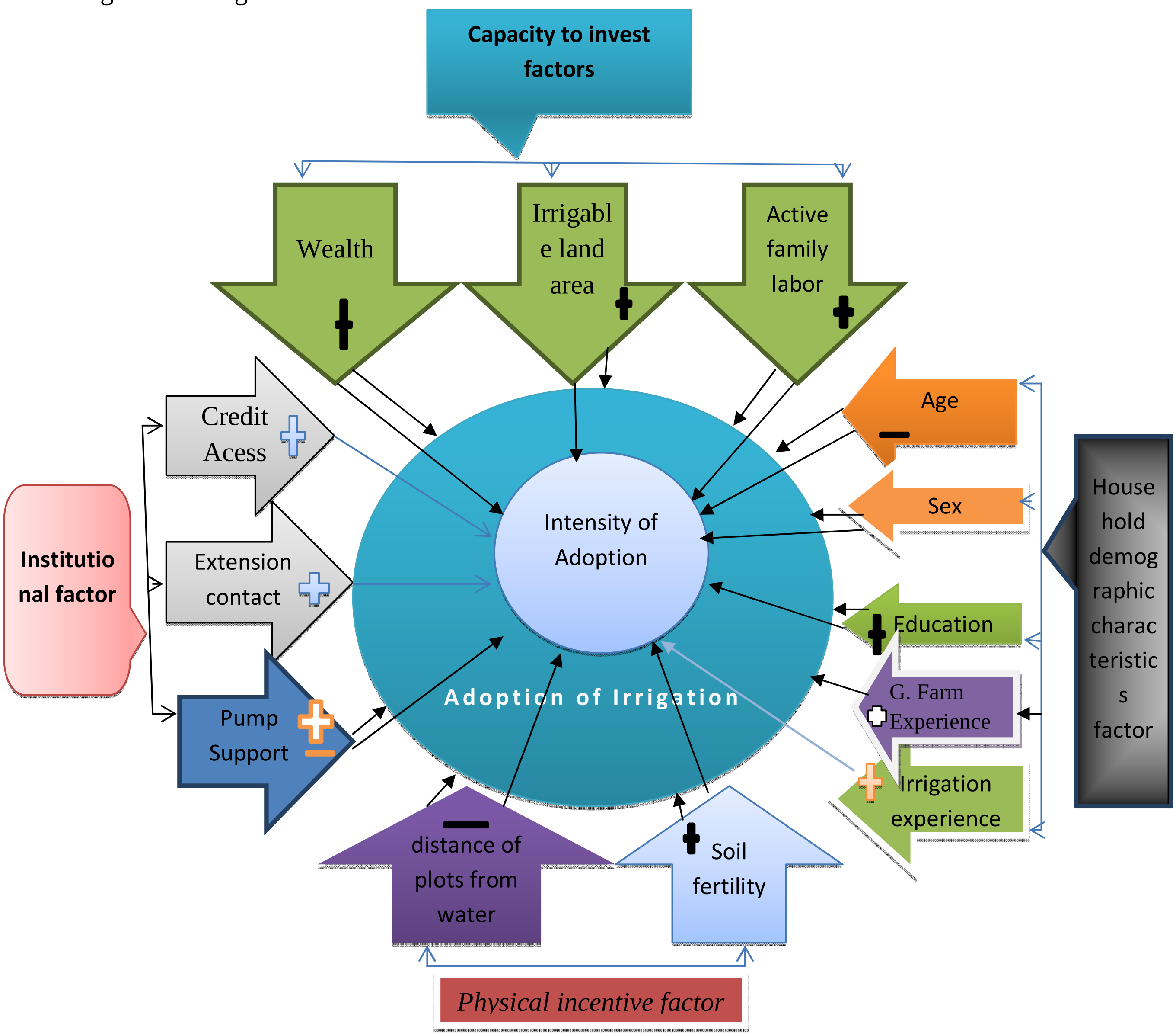
Adoption of irrigation increases with *capacity to invest factors*. This indicates that existence of constraints of capacity to invest play a role in reducing adoption of irrigation as well as the intensity of adoption. In this study case capacity to invest factor includes cash income, wealth, irrigable land area and active family labor. However, because of under report behavior of farmers, income did not included in the empirical study. Irrigation requires more financial capital than rain-fed for the purpose of purchasing variable inputs and fixed inputs required for production. Thus, famers who have more cash income are assumed to more likely adopt irrigation. The wealthier farmer can afford to take more risk (Mushtaq *et al.*, 2006). Irrigation obviously requires high capital when compared to rain-fed crop production. This clearly favors wealthier farmers to adopt irrigation technology than poor farmers. *Wealth* makes easier for farmers to get credit also (Awotide et.al, 2012). Adoption and intensity of adoption of irrigation is assumed to increase with the size of *irrigable land* area. Farmers' those who have large irrigable land can rent part of their land to others to get money that can help them to purchase several inputs which in turn help them to participate in irrigation practices. *Own labor* is assumed to encourage adoption and intensity of adoption of irrigation either due to availability of labor to do work or due to the need to feed more people (Berhanu Gebremedhin, 2002). In the study area farmers are using irrigation mostly for vegetable production. However, vegetable production needs high labor so that active family labor is needed due to hiring labor is add extra costs on farmers which in turn reduce the adoption of irrigation technology and its intensity. In addition during peak time labor cannot available and even if it is available, it is at high cost. This can discourage farmers to adopt the technology. Therefore, availability of active labor in family is expected to play role in the adoption of irrigation.

An *institutional factor* includes credit institution, extension contact and pump support from NGOs and GOs. Irrigation activities need more money to buy inputs needed for it. Credit is helpful to purchase inputs such as water pump, improved seed, fertilizer, fuel, etc. Hence access to credit is expected to have positive relationship with intensity of adoption of irrigation (Jara-Rojas, 2012). Adoption of technology can be affected among other things by access to information. Lack of extension agent contact is one of informational constraint that may negatively affect adoption and rate of technology adoption. In case of new knowledge of agricultural practice farmers need the assistance of extension agent as long as they are not familiar with the activity. In irrigation technology farmers may should have to know how and when to apply inputs needed and how and when watering is possible, etc. Access to such kind of capacity enhancement extension services increases the technology adoption and its intensity (Mariano *et al.*, 2012). Pump support form NGOs and GOs may have negative influence on individual irrigation adopters. This is due to individual farmers can anticipate pump support from NGOs and GOs rather than buying water pump themselves and adopt irrigation. However, this is not mean that pump support from NGOs and GOs negatively influence public irrigation adoption owing to those farmers who may got pump support really adopt irrigation.

Physical incentive factor that may constrain or favor investment in irrigation technology includes distance of plots from irrigation water source and soil fertility condition of farmers plots. Long *distance* of framers' plot from water source can causes farmers for extra cost when compared to nearest plot to water source. Farmers those who have nearest plot to irrigation water source can use small water pump with short pipeline to drive water from its source to the plots. However, in case of long distance of plots from water source both large water pump and long pipeline needed to drive and discharge water on the plot to watering crop. As the distance of plots from water source increases, either modern scheme or large water pump is needed. This is highly constrain farmers to adopt irrigation technology owing to farmers financial capacity is less than the cost of the modern scheme or large water pump. In case of farmers plot close to irrigation water source, farmers become more efficient in reducing costs (Abdulai et al., 2011). Another physical factor is farmers' plot *soil fertility* condition. A drought prone area is a full of rain fall uncertainty. Thus, farmers prefer to allocate fertile plots to the production under irrigation due to production of crops under rain-fed is not promising owing to unpredictability or absence of precipitation. Even they may be not able to offset at least the cost incurred on the production of crop under the rain-fed. Hence, it is not logical to allocate fertile plot which has more value than non-fertile plot to the production of crop under rain-fed for which the fate is unknown.

Household demographic characteristics factor can also affect the adoption of new technology and its intensity positively or negatively. Due to socio-cultural and norms, males have freedom of mobility and participation in different meetings and as a result have better access to information than women. In addition, women have less access to institutional services due to this culture. Hence, women farmers may face informational constraints (e.g. less contact with extension service provider) and material constraints (e.g. lack of in-kind or cash credit) than men farmers. Therefore, in this study *sex* is expected to have influence on adoption of irrigation. Adoption of irrigation assumed increases with literacy; because it enhances farmers' ability to perceive, analyze and use of information relevant to adoption of irrigation. Hence, *education level* of household head of farmers expected to play role in adoption of irrigation. More educated farmers have the tendency to adopt new technology, involving periphery technique and sieving technology in fetching irrigation water, as well as watering can with shower outlet for transporting and applying irrigation water (Abdulai *et al*., 2011). Older farmers may not be able to adopt new technology due to they have shorter planning horizon (Chiputwa *et al*., 2011).According to the theory of human capital, young household heads have a greater chance of absorbing and applying new knowledge (He *et al*., 2007). Moreover, irrigation may entails risk owing to it needs more costs than traditional farming practice what farmers already have. Hence, more *aged* farmers' wants to stick to traditional farming practice what they already know rather than adopting new technology and they may have less confidence to adopt new technology. Famers with longer *farming experience* are supposed to have more ability in assessing the characteristics and potential benefit of irrigation than farmers with shorter experience. Through more experience more skill and knowledge can be achieved. Since crop production by irrigation needs more skill and knowledge than rain fed, farmers who have high general farming experience in agriculture more likely adopt irrigation and farmers who have high *irrigation experience* in specific tends to invest more in irrigation activities (intensity of adoption).

Figure4.1. Diagram of theoretical framework



5. Empirical Methods and Data

The hypotheses of this study were tested using data from a survey of single period (2004 E.C.).

5.1. *Sources of data*

Both qualitative and quantitative data were collected from primary and secondary sources. Secondary data relevant to this study were collected from different stakeholders particularly from Adami Tulu Jidokonbolcha office of agriculture and rural development and other organizations supposed to have relevant information. The primary data were elicited from sample respondents on different issues such as household characteristics and all other variables hypothesized to influence adoption of irrigation using formal and informal survey.

5.2. *Sapling and data collection technique*

The primary data were elicited from randomly selected farm households. Two stage sampling procedure were employed to select peasant association and sample respondents. Initially, Peasant Associations those who have access to irrigation water were selected purposively being with ATJK office of agriculture and rural development. Then households were stratified as individual irrigation adopters and non-adopters in the selected PAs. Finally, 51 individual irrigation adopters and 79 non-adopters were selected randomly.

Then after, a structured household questionnaire was administered to 51 sample households of individual adopters and 79 non-adopters in the selected PAs. The questionnaire was pre-tested prior to conducting the formal survey. To do this, training on method of data collection and contents of interview schedule was given to enumerators and follow was made to ensure that whether trained enumerators collect data smoothly.

To have detailed information useful to draw the right conclusion from the survey work, informal survey also was undertaken to gather qualitative data. Collection of this qualitative data was administered through holding discussion with focused group in the selected PAs. This triangulation of data source helps to cross check information and to ensure the validity and reliability of collected data.

5.3. *Data Analysis Technique*

In this study several data analysis technique were used. Descriptive statistics, Analysis of independent sample T test to test mean difference among adopters and non-adopters, probit and truncation regression were used.

5.3.1. *Descriptive statistics*

Descriptive statistics such as percentage, mean, standard deviation and tables were used. This descriptive analysis does not show the relationship between variables. However, it often provides guidance for more advanced quantitative analysis.

5.3.2. *Independent sample T test*

To test the mean difference across adopter and non-adopter independent sample t test was used.

5.3.3. *Econometric Specification*

The research objective of this study is to understand both the factors affecting the probability of Individual irrigation adoption and the factors affecting the intensity of individual irrigation activities adopted. In this study case it is necessary to go beyond the typical binary dependent variable methods applied to cross sectional survey in the adoption of technology (Feder et.al., 1992). In this study, the analysis of data using tobit model is not useful since factors affecting adoption of irrigation should have to be known first and factors affecting the level of use of adopted technology should be identified next (Gebremedhin 1998 as sited in Gebremedhin, B. and Swinton, S.M., 2003). Thus adoption and intensity of adoption of irrigation technology are separated for this data set. Hence, probit and truncated regression models were used in this study. The decision to adopt technology can be modeled by probit while the intensity of adoption can be modeled by truncation regression.

In this study the dependent variable (Individual irrigation adoption) can be made continuous variable in order to know the intensity of adoption of irrigation. This adoption of irrigation index of individual household farmers can be calculated by dividing the amount of land allocated to irrigation to the total land of individual household farmers. Adoption index is thus a continuous dependent variable which is affected by several independent variables to be investigated. Hence, the truncated regression model was applied to identify factors contributing to intensity of adoption of irrigation. Analyzing the adoption of irrigation using all observation carried out firstly and then the analysis of factors affecting intensity was followed.

Following Marno Verbeek (2012), the factors affecting the adoption of irrigation can be modeled as probit regression.

$$F(x_i'\beta) = \Phi(x_i'\beta)$$

Where Φ is cumulative density function and $x_i'\beta$ is vectors of independent variables. The parameters β are typically estimated by maximum likelihood. It is possible to motivate the probit model as latent variable model.

$$y_i^* = xi'\beta + \varepsilon i$$

Where y_i^* latent variable and ε_i = error term which is assumed to be $NID(0, \sigma^2)$

$$y_i = \begin{cases} 1, & if\ y_i^* > 0 \\ 0, & if\ y_i^* \le 0 \end{cases}$$

Following Marno Verbeek (2012) the decision on the intensity of irrigation adoption can be modeled as a regression truncated at zero.
Assume that there exists a latent variable y* determined by x*, such that:

$$y_i^* = x_i^{*\prime}\beta + \varepsilon i$$

Where neither y_i^* nor x_i^* are observed unless y_i^* is above a threshold, say $y_i^* > 0$.

Then $f\,(y_i^*|x_i^*) = \frac{1}{\sigma}\,\phi(\frac{y_i^* - x_i^{*}{\prime}\,\beta}{\sigma})$ is in the population under study.
But, given that we observe only y_i(not y_i^*), we need to drive and use the density of y_i (Verbeek, M., 2012).

It can be shown that the density of a potential observation is:

$$f\,(y_i|x\mathrm{i}, y_i > 0) = \left(\frac{f\,(y_i|x\mathrm{i}\,)}{prob\,(y_i > 0)}\right)$$

5.4. *Independent Variables and Their hypothesis*

The adoption and intensity of adoption models were specified using several factors, derived from the several literature of adoption and intensity of adoption. There are no general rules for which variables to include in the model (Anderson *et.al*. 2009). However, the researcher is guided by economic theory and empirical studies conducted previously to know which independent variables influence both adoption and intensity of adoption of individual irrigation. Hence different independent variables were identified below and their hypotheses were set.
Household demographic factors include the following variables.
i. *Education Level (EduHH)*: This was measured in the number of years of formal schooling for the household head. It was hypothesized that more educated farmers tends to adopt new technology and increase the level of adoption (intensity of adoption).
ii. *Age of household head (Age)*: This variable was continuous and measured in years. As the age of household head increase, it reduces the technology adoption and its intensity. Therefore, it is hypothesized to negatively influence the adoption and its intensity.
iii. *Sex of Household Head* (Sex): It is a dummy variable which takes the value of 1 if the household head is male and 0 otherwise. It was assumed that male household head more likely adopt irrigation technology and increase the level of investment in irrigation.
iv. *Farm Experience of Household Head (Exper)*: It is continuous variable which was measured by years of general farming experience. As the number years of experience increases, farmer more likely adopt irrigation technology.

v. *Farming experience in irrigation (Experirg)*: it is continuous variable measured in years of experience of farming among adopters of irrigation only. It was assumed that as the number of years of experience in irrigation increase, the intensity of adoption of irrigation increases.

The factors expected to affect the capacity to invest include cash income, wealth, irrigable land area and active family labor. Of these, the cash income data were not considered due to under-reporting problem.

vi. *Estimated wealth of household (Ewealth)*: Is a continuous variable which was measured in ETB. Total household fixed asset has been taken in to consideration and estimated in ETB during survey time. It was hypothesized that wealthier farmers more likely adopt irrigation as well as the intensity of irrigation adoption.

vii. *Number of Active Family labor (NFlabor)*: this variable was measured in numbers of household members aged 15-64 years (Gebremedhin B. and S.M. Swinton, 2003). High active family labor was hypothesized to positively influence the adoption of irrigation technology and the level of adoption (investment).

viii. *Total Irrigable Land of Household (Tirrigableland)*: This variable was measured in quarter of hectare (0.25ha) which was called kert in local language. Large amount of irrigable land was hypothesized to influence the adoption of irrigation positively.

The variables that may constrain the adoption of new technology categorized under physical factor were:

ix. *Distance of nearest plot from water source (Disirrip)*: Measured by meter from the irrigation water source to the nearest farmers plots. The longest distance of plot from water source was hypothesized to influence the adoption of irrigation and intensity of adoption negatively.

x. *Soil fertility of farmers' plots (SoilFer)*: This variable was a dummy variable which takes the value 1 if on average the soil fertility of the plots good and 0 if bad. During the survey, farmers were rated the fertility condition taking in to consideration all the plots they have. Good soil fertility was hypothesized to influence the adoption and intensity of adoption of irrigation positively.

The institutional factor includes the following variables:

xi. *Access to credit (Credit)*: is dummy variable which takes the value 1 if farmers have access to credit for the purpose of irrigation activities and 0 otherwise. This variable was hypothesized to positively influence the intensity of adoption of irrigation activities only. Credit variable was not used as the determinants of adoption due to farmers can use the credit for another purpose rather than irrigation activity. Farmers those who not adopt irrigation can also have access to credit. Hence, credit that used for the irrigation purpose only was collected from the adopters of irrigation.

xii. *Extension contact (Exagvisit)*: Is dummy variable which takes the value of 1 if farmers have contact with the extension agents to get information on irrigation activities frequently in 2003 and 2004 E.C. It was hypothesized that extension contacts positively influence the intensity of irrigation adoption.

xiii. *Pump support from NGOs and GOs (Pumpsupp)*: It is a dummy variable which takes the value of 1 if the farmers as a group already received pump support from NGOs and GOs prior to the survey time and 0 otherwise. It was hypothesized that pump support to group of farmers (group irrigation) negatively influence the individual irrigation adoption and intensity of adoption.

6. Results and Discussion

This chapter consists of the overall findings of the study that was presented under different sections. Firstly the descriptive analysis part of the study was presented. Following that, the influence of different constraints/factors categorized under capacity to invest factor, institutional factor, physical incentive factors and demographic characteristics factors on adoption and intensity of adoption of irrigation was discussed consecutively.

6.1. Results of Descriptive statistics

Adoption is a procedure that entails decision making from a person who is going to adopt that specific technology. There are several factors that influence farmers' technology adoption decision. Different researcher in different literature, group these variables under several main categories based on the aim of their study. In this study the independent variables expected to have positive or negative effect on adoption of irrigation are grouped as household demographic characteristics, capacity to invest, institution and physical factors. The descriptive statistics of these variables are discussed under the following sub topics.

6.1.1. Household Demographic Characteristics

6.1.1.1. Education of Household Head

The average household education level of the sampled farmers was 5.32 years of schooling with standard deviation of 4.035. The maximum education level of the sample farmers was 12 years while the lowest education level was 0. The adopters of irrigation had better educational level on average 8.65 years of schooling than non-adopters who on average had an educational level of 3.177. The mean difference of adopters and non-adopters is significant ($t = 10.058$, $p = .000$) at 1% significance level.

6.1.1.2. Age of Household Head

The mean age of sample households was 46.23 with standard deviation of 14.1. The maximum age for the sample households head was 73 years while the minimum was 23 years. The result of independent sample T-test indicated that there was significant mean difference ($t=-3.99$, $p=.0001$) among adopters and non-adopters at 1% significance level. Comparatively speaking, the adopters of irrigation technology are younger (40.411 years) than non- adopters of the technology (52.85 years).

The findings of this study in agreement with the one conducted by He *et al.*, (2007) on adoption of rainwater harvesting and supplementary irrigation which has indicated that younger famers were more likely to adopt irrigation technology. Moreover it is similar with the study of Adesiina, A.A. and Baidu-Forson, J. (1995) and Sidibe (2005).

6.1.1.3.Sex of Household Head

In this study as indicated in table 3 (Appendix part), the Pearson chi-square was conducted to see the relationship of probability of individuals farmers' adoption of irrigation and sex of household head. This correlation test using Pearson Chi-square indicated that Sex of household head have significant relationship ($\chi^2 = 13.56$, df = 1, p = .000) with adoption of irrigation technology at 1% significance level.

The low adoption rate of female headed households in irrigation technology may be related to their access to information and other resources. To avoid this gap, women constraint should be addressed by development interventions to achieve wider adoption of irrigation technology by female households.

Regarding the relationship of household head sex and adoption of irrigation technology; many of the previous studies revealed the positive effect of sex of household head on adoption. For example, Jamala *et.al*. (2011), in their study on Evaluation of factors influencing farmers' adoption of irrigated rice production in Fadama soil of North Eastern Nigeria found that male headed households are more likely to adopt fertilizer than female headed households. Similarly, Mekuria Tafesse (2003), reported that women are marginalized in irrigation activities and have limited leadership role in irrigation management.

6.1.1.4.General Farming experience of household head

The average general farming experience of sample farm household was 19.25. Comparatively speaking, the average general farming experience of the household head for individual adopter was 22.63 years while average general farming experience of the household head of the adopters was 16. 987 years. This figure roughly shows relationship between adoption of irrigation and general farming experience of household head. An independent sample t-test was conducted to test the irrigation adopters and non-adopters group mean difference. The result of this test indicated that there is statistically significant mean difference (t = 2.8394, p = .000) among individual adopters and non-adopters at 1% significance level.

This result is in agreement with the study previously conducted by Jamala *et al*. (2011).

6.1.2. *Capacity to Invest Factors*

6.1.2.1. Total size of irrigable land

In this study, the average land holding for the sampled household was 9.269 kert[2]. The minimum irrigable land holding is 1 kert while the maximum is 25 kert. Comparatively speaking, the average irrigable land holding of Adopter farmers was 13.1 kert while that of non-adopters was 6.797 kert. Independent sample t-test was conducted to see whether the mean difference is significantly different from zero. Accordingly, the mean difference among the Adopters and Non-adopters was significant ($t = 8.177$, $p = .000$) at 1% significance level.

This result is in line with the findings of Amsalu, A. and de Graaff, J. (2006) on Determinants of adoption and continued use of stone terraces for soil and water conservation in an Ethiopian highland watershed.

6.1.2.2. Family Labor Availability

The average number of family labor available in sample household farmers was 4.346 man equivalents with standard deviation of 2.25. The average labor available for adopter farmers was 5.2 with standard deviation of 2.22 while that of Non-adopters was 3.78 man equivalents with standard deviation of 2.104. The independent sample t-test was conducted to see whether there was significance mean difference among adopters and non-adopters. The result shown that there was a significance mean difference in labor availability between adopters and non-adopters of irrigation practice ($t = 3.7$, $p = 0.003$) at 1% significance level.

6.1.2.3. Wealth

The average estimated wealthy of sample household farmers was 145,854.9 ETB[3] with the standard deviation of 107673.4 ETB. The minimum estimated wealth of sample household farmers was 35,010 ETB while the maximum estimated wealth of household was 508,285 ETB. Comparatively speaking, the average estimated wealthy of adopters was 220415.4 ETB while the average estimated wealth of Non-adopters was 97720.85 ETB. Result of independent t- test also shows that the mean difference between the Adopters and Non-adopter was significant ($t = 7.62$, $p = .000$) at 1% significance level.

The unavailability of capital was a very important constraint that limits the further expansion of irrigation (Kulshreshthal, S.N. and Brown, W.J., 1994). Thus, this result is in line with the finding of Kulshreshthal, S.N. and Brown, W.J., 1994, on the adoption of irrigation: a review of the South Saskatchewan River irrigation district.

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[2] Kert is local land measurement instrument which is equal to 0.25ha

[3] ETB = Ethiopian currency

6.1.3. Physical Factors

6.1.3.1. Distance of nearest plot from water source

The average distance of sampled farmers' plot from water sources (river and lake) was 0.245 Km with the standard deviation of 0.2958. The minimum distance of nearest plot from water sources was 0.01 km while the longest distance of the nearest plot from water sources was 2 km. The average distance of nearest plot of individual farmer irrigation adopters from water sources was 0.1035 km while that of non-adopters was 0.3376 km. The result of independent sample t-test revealed that the mean difference of Adopters and Non-adopters was significantly different from zero (t= -4.76, p = 0.000) at 1% significance level.

6.1.3.2. Soil Fertility

The Pearson Chi-square was conducted to see the relationship between soil fertility and adoption of irrigation. As it was indicated on the table 4 in the appendix part, there was significant relationship ($\chi^2 = 20.67$, df = 1, p = 0.000) with Soil fertility of plots and Adoption of irrigation technology.

6.1.4. Institution Factors

Several institutional variables were expected to influence adoption of irrigation technology. This institutional factor in this study context includes contact with agricultural extension service and credit services.

6.1.4.1. Extension contact

The Pearson Chi-square was conducted to see the relationship between extension contact and adoption of irrigation. As it was indicated on the table 5 in the appendix part, there was significant relationship ($\chi^2 = 40.7$, df = 1, p = .000) with extension contact and Adoption of irrigation technology.

6.1.4.2. Access to Credit

Among farmers that individually adopt irrigation technology in this sampled household, 57% farmers have no access to credit service while 43% of farmers have access to credit service for the irrigation activities.

6.1.5. Summary of the Descriptive Results

Before going to the analysis of econometric model (probit and truncated regression), it is necessary to summarize descriptive analysis results of variables determining the adoption. By excluding variables which assumed to have multicollinearity problem from the analysis, in general 10 and 12 independent variables were included in the analysis of determinants of both adoption and intensity respectively. From the total variables included in the analysis of probit model, seven of them have shown significant relationship with adoption and also from the total variables included in the truncation regression model, six of them significantly different from zero. These variables standard deviation, means and other descriptive statistics were summarized in table (6.1) below.

Table 6.1. Summary of Results of Descriptive Statistics Analysis

Variables	Means (SD) Overall mean	adopter	non-adopter	Overall SD	X-Squared	T-test
Dependent Variables						
Individual Adoption	0.39	_	_	_	_	_
Individual Adoption Index	0.35	_	_	_	_	_
Household demographic characteristics						
Education Level of Household Head	5.32	8.64(2.41)	3.18(3.36)	4.035	_	10.05***
Age of household head	46.23	40.41(8.2)	49.99(15.7)	14.10	_	-3.99***
Sex of Household Head	0.8	_	_	_	13.56***	_
General Farming experience of Household	19.2	22.6(8.25)	16.98(12.5)	11.357	_	2.8***
Irrigation Farm Experience of Household Head	_	5.146154	_	6.078	_	_
Capacity to invest						
Estimated Wealth of Household	145854.9	220415.4 (112661.1)	97720.8 (71107.2)	107673.4	_	7.618***
Number of Active Family labor (15-64 years)	4.35	5.215 (2.22)	3.7848 (2.10)	2.25	_	3.704***
Total Irrigable Land of Household	9.27	13.1(4.9)	6.797(3.8)	5.27	_	8.177***
Physical factors						
Distance of nearest plot from water source	0.25	0.10(0.10)	0.337(0.34)	0.295803	_	-4.76***
On Average soil fertility of farmers' plots	0.6	_	_	_	20.67***	_
Institutional Factors						
Access to credit service	_	0.5686	_	_	_	_
Extension contact	0.6	_	_	_	40.7***	_

*** Significant at 1% significance level.

6.2. *Regression Results*

In the descriptive part of sample population, I have tested for existence of association between the dependent and single explanatory variables using chi-2 test. This is not enough for the recommendation of policy actions if the analysis of relative influence of each variable is not conducted by multiple regressions to know their effect for priority based intervention.

Before running the model, multicollinearity problem was checked among all the hypothesized explanatory variables. According to this test those variables that have multicollenieарity problem was dropped from the analysis and those have no multicollinearity problem were added in the analysis. Independent variable which has the VIF value less than 10 was included in the analysis.

Table 6.2. Variance inflation factor of variables used in probit model

```
. collin EduHH Age SoilFer Sex Ewealth PumpSupp NFlabor Exper Tirrigableland Disirrip
(obs=130)

  Collinearity Diagnostics

                        SQRT                   R-
  Variable      VIF     VIF    Tolerance    Squared
----------------------------------------------------
     EduHH      2.50    1.58    0.4004      0.5996
       Age      4.04    2.01    0.2478      0.7522
   SoilFer      1.28    1.13    0.7807      0.2193
       Sex      2.64    1.62    0.3789      0.6211
   Ewealth      1.66    1.29    0.6038      0.3962
  PumpSupp      1.53    1.24    0.6532      0.3468
   NFlabor      1.66    1.29    0.6021      0.3979
     Exper      3.09    1.76    0.3235      0.6765
Tirrigableland      2.09    1.45    0.4776      0.5224
  Disirrip      1.38    1.17    0.7272      0.2728
----------------------------------------------------
  Mean VIF      2.19
```

Table 6.3. Variance inflation factor of variables used in truncated model

```
. collin EduHH Age SoilFer Sex Ewealth PumpSupp NFlabor Tirrigableland Disirrip Experirg Credit E
> xagvisit
(obs=130)

  Collinearity Diagnostics

                        SQRT                   R-
  Variable      VIF     VIF    Tolerance    Squared
----------------------------------------------------
     EduHH      2.71    1.65    0.3692      0.6308
       Age      2.71    1.65    0.3690      0.6310
   SoilFer      1.40    1.18    0.7125      0.2875
       Sex      1.54    1.24    0.6506      0.3494
   Ewealth      1.96    1.40    0.5105      0.4895
  PumpSupp      1.98    1.41    0.5048      0.4952
   NFlabor      1.69    1.30    0.5930      0.4070
Tirrigableland      2.69    1.64    0.3714      0.6286
  Disirrip      1.46    1.21    0.6863      0.3137
  Experirg      5.72    2.39    0.1747      0.8253
    Credit      1.73    1.32    0.5782      0.4218
 Exagvisit      2.30    1.52    0.4352      0.5648
----------------------------------------------------
  Mean VIF      2.32
```

6.2.1. Factors Determining Adoption of irrigation

The regression results (table 6.4) shows that household adoption of irrigation technology is influenced by broad range of factors. A total of ten explanatory variables were considered to be included in to probit regression. The estimated coefficients of the parameters and marginal effects in the probit model are summarized in (table 6.4). The Wald chi-squared test statistics is significant at 1% significance level, which indicates the joint significance of irrigation adoption variables. The power of prediction of the estimated model also shows that 78.3% of the observations were accurately predicted by probit model. The result of this study shows that general farming experience and sex of household head is not significantly different from zero among the household demographic characteristics. Soil fertility of the household farm plots also has no significant influence on the adoption of the irrigation. The rest seven variables are significant at 1% significance level.

The household demographic characteristics that influenced the adoption of irrigation technology are education level and age of household head among the four variables included in the analysis.

The study result (table 6.4) revealed that the coefficient of education level of household head significantly different from zero and positive which is suggesting that farmers who have more education level, more likely adopt irrigation activities than less educated farmers. Adoption of a given technology is a behavioral change process, which is the result of a decision to apply that particular innovation. To make right decision farmers need enough information about the technology. Education increases the capacity of farmers to obtain, process, and utilize information disseminated by different sources. Hence, level of adoption of irrigation may be influenced by education level of household head. According to Mariano *et al*. (2012), educated farmers have the capacity to search for technologies suitable to their production constraints than less educated farmers. Educated farmers may easily process and search information for appropriate technologies to alleviate their production limitation than non-educated farmers (Chiputwa *et al*., 2011).This result is similar with several studies previously conducted by Mafuru.J., (1999), Abdulai *et al*. (2011),. Pender, J. L and Kerr, J. M. (1998), Upadhyay *et al.* (2002), Feder.G., Umali.D.L., (1993), de Graaff *et al*. (2008), Norris, P.E. and Batie, S.S., (1987), He, X.-F., *et al*. (2007).

Among the others household demographic characteristics, age also useful to describe households decision regards to adoption of technology. According to the result of the probit model (Table 6.4) of this study, farmers age have negative significant effect (p = 0.000) on the adoption pattern of irrigation technology. A study by Kulshreshthal, S.N. and Brown, W.J. (1994) revealed that as the farmers' age gets increase, it is possible to argue that traditionalism become established after a some number of years of farming. This means, older farmers prefer to practice their own traditional farming practice what they already know rather than adopting new technology. In addition, older famers have no willingness to take risk and reluctant to adopt new farming technologies (Mazvimavi.K and Twomlow.S, 2009). Gebremedhin. B and Scott M. Swinton (2003), Stan G.Daberkow and William D.McBide (2003), revealed similar result that age negatively influences agricultural technology adoption. Contrary to this, the result of de Graaff *et al*. (2008) and Chiputwa *et al* (2011) revealed that the age of farmers positively influence adoption technologies. As pointed out by Abdulai.A (2011), at younger ages an increase in age increase the likelihood of adopting agricultural technology and at older age increasing in age tends to decrease probability of adoption. Some studies revealed that the age of household head has no significant impact on adoption of agricultural technology (Jara-Rojas *et al., 2012*, Jara-Rojas *et al., 2013*). In addition, older farmers often prefer different goals rather than maximizing income from technology adoption (Tjornhom, 1995). This is due to their perception of new technology may lead to risk and may not generate additional income than traditional farming practice what they already known. According to Mulugeta (2009), several literatures considered age variable in adoption studies with the hypothesis that older farmers might have high farming experience which allows them to easily take on new technology. However, contrary to this idea, age is highly related to risk avoiding characteristics of individual farmers and even older farmers prefer to practice their own traditional farming practice what they already know rather than adopting new technology. Moreover, increasing in age is not necessarily meant that farmers will have high experience. This may be due to for example the former trader, soldier, etc are now become farmers. In the study area farmers are using irrigation for high value crop (Onion, Tomato, Pepper, and etc). However, in these high value crop productions, the high production cost, variability in yield, perishable characteristics of the product, frequent fluctuation of market price entails greater production and marketing risks. Thus because of their risk averting nature, older farmers are usually reluctant to adopt new technologies.

The wealthy status of the farmer might influence adoption of irrigation technology. The coefficient of household wealth is positive and significantly different from zero ($p = 0.002$). This indicates that wealthier farmer more likely to take more risk for they can afford it in case failure happens (Mushtaq *et al*, 2006). Irrigation obviously requires high capital when compared to rain-fed crop production. This clearly favors wealthier farmers to adopt irrigation technology than poor farmers. According to Awotide *et.al* (2012), wealth makes household less averse to risk and makes it easier for them to get credit. Similar results are reported by Jara-Rojas *et al.*(2012).

The likelihood of adopting irrigation technology is higher for farmers with large working family labor. The coefficient of family labor is positive and highly significant ($\alpha < 0.01$) which indicates a household with higher active labor force may in position to manage labor intensive agricultural technologies like irrigation activity. This result is in line with the study conducted on adoption of safer irrigation technology by Abdulai *et al*. (2011). They have pointed out that the tendency to take on irrigation technology is higher for famers with larger household active family labor size probably due to more manual labor involved in sieving the irrigation water. Similar studies conducted previously (Jara-Rojas *et al.*, 2012; Jara-Rojas *et al*., 2013; Chiputwa *et al*., 2011; Mutune *et al*. (2011) concluded that family size is positive and significant which supports the idea that the likelihood of adopting labor intensive agricultural technology rises as family labor becomes more abundant. In the same study paper but different topics, Chiputwa *et al*., (2011) concluded that labor capacity negatively and significantly affects the adoption and use intensity of technology which is contrary to this result. Large working labor force in a family means, the household may not need to hire more additional labor and the money saved due to use of own labor force could be used for purchasing other inputs needed for irrigation activities. This may increase the likelihood of adopting irrigation technology.

Table 6.4.
Probit Regression Result for Adoption of Irrigation Technology

Variables	**Coefficient**	**Robust Std. Err.**	**P>|z|**	**Marginal effect**
Household demographic characteristics				
EduHH	0 .2459409	0.0889212	0.006	0.0505906
Age	-0.140972	0 .04812	0.003	-0.0289983
Sex	-1.445721	1.12192	0.198	-0.4273147
Exper	0 .0628967	0 .0422214	0.136	0 .012938
Capacity to invest				
Ewealth	0.0000101	3.21e-06	0.002	2.09e-06
NFlabor	0.3324075	0.1191542	0.005	0.068377
Tirrigableland	0 .214723	0 .0923642	0.020	0 .068377
Physical factors				
Disirrip	-6.897831	2.170675	0.001	-1.4189
SoilFer	0.6299065	0 .4685788	0.179	0.121179
PumpSupp	-1.333666	0.5122312	0.009	-0.2210775
_cons	0.8603196	2.57309	0.738	_
Regression diagnostics				
Chi-square	54.93	_	_	_
Probability > Chi-square	0.0000	_	_	_
Pseudo R-square	0.7830	_	_	_
Predicted probability at mean	0.12486865	_	_	_
Sample size (n)	130	_	_	_

Source: Own survey data (Authors calculation)

The irrigation farm size coefficient is positive and highly significant (p = 0.000) which pointed out that farmers those who have more irrigable land tends to more likely adopt irrigation technology. This is may be due to farmers who own large areas of irrigable land are free from land rent costs. In addition they can rent out part of their irrigable land to others to get money that can be used for purchasing inputs and capitals (e.g. water pump) required for irrigation activities. Mariano, Villano et al. (2012), proved that land area is among variables positively affecting adoption of agricultural technology due to farmers who have large areas of land can spread the risk of technology failure by allocating only a fraction of their land to irrigation activities and this option may not available to farmers who have no more lands. This results is consistent with the previous technology adoption research result where the farm size increased the likelihood of adoption (Jara-Rojas, Bravo-Ureta et al., 2012; de Graaff, Amsalu et al., 2008; Mazvimavi and Twomlow, 2009; Jara-Rojas, Bravo-Ureta et al., 2013). Contrary to this results, Abdulai, Owusu et al. (2011) pointed out that farm size is negatively influence adoption of watering can with shower outlet due to having smaller farm size encourages the use of watering can with shower outlet.

Distance of plots from irrigation water source appears to be negatively significant ($\alpha < 0.01$) which indicates that distant plots tend to reduce the probability of adoption of irrigation technology. When there is a water source nearby the irrigable plot, the cost incurred for the purpose of transporting irrigation water from the source to plots may reduced when compared to plots located at a considerable distance. This result is supported by previously conducted research by Abdulai, Owusu *et al. (2011)*. They have pointed out that farmer closer to irrigation water source tends to use watering cans and close watering technique for water application. This is due to water can is most efficient (cost reducing) means of transporting irrigation water from water source to nearby irrigable plots. Thus this reduces cost of production and farmers can use more of their land for production under irrigation.

The coefficient of water pump support in group is highly significant and negatively associated with individual irrigation adopters. This result indicates that the individual farmers count on assistance to the extent that they reduce their involvement in buying their own pump for the irrigation even if they have a capacity to buy pump. This is due to the fact that individual farmers who not received pump support unlike of others received the pump in group, may waiting for the support rather than buying water pump themselves and adopt irrigation. This result is in line with the research conducted by Lind, J. and Jalleta, T. (2005).

6.2.1.1. ***Determinants of Intensity of Irrigation Technology Adoption***

The second stage (truncated model) measures the extent of adoption among individual adopters of irrigation technology. The regression results (table 6.5) shows that household intensity of adoption of irrigation technology is influenced by broad range of factors.

Irrigation Farming experience is one of the factors that can influence intensity of adopted technologies. The coefficient of farmers experience in irrigation activity is positive and highly significant for the individual adopters of the irrigation technology. This indicates that the existence of the relationship of experience and intensity of adoption. Tiamiyu *et.al*., (2009) suggested that there was a positive relationship between farmer experience and adoption index and improvement in this variable would lead to higher level of technology use. According to Mazvimavi, K. and Twomlow, S, (2009) also, there is a positive influence of experience on the level of adoption of several technology components. This is due the fact that the longer household practice; the more likely it is to adopt all components of technology packages. In addition, the result of this study supported by Mafuru *et al*., (1999) explaining that an increase in farmers experience among adopters also increases the intensity of adoption. Moreover, the effect of farming experience on the intensity of adoption of agricultural technology could be due to the famers' managerial ability, certainty and understanding of faming system as a result of many years of farming experience (Jamala *et al*., 2011).

Table 6.5

Truncated Regression Result for Intensity of Adoption of Irrigation Technology

Variables	Coefficient	Std. Err.	P>|z|
Household demographic characteristics			
EduHH	0.0089599	0.0058227	0.124
Age	-0.0030019	0.0029639	0.311
Sex	-0.02575	0.0662537	0.698
Experirg	0.0127064	0.0048371	0.009
Capacity to invest			
Ewealth	1.72E-07	1.51E-07	0.254
NFlabor	0.0132049	0.0078619	0.093
Tirrigableland	-0.0058656	0.0036477	0.108
Physical factors			
Disirrip	-0.1888401	0.1259885	0.134
SoilFer	0.1107708	0.0309516	0.000
Inistitutional Factors			
Credit	0.0722894	0.0277337	0.009
Exagvisit	0.10619	0.0525375	0.043
PumpSupp	0.0755501	0.0249658	0.002
_cons	0.5237397	0.142414	0.000
/sigma	0.0756553	0.0074186	0.000
Regression diagnostics			
Wald chi2(12)	171.63	_	_
Probability > Chi-square	0.0000	_	_
Sample size (n)	52	_	_

Source: Own survey data (Authors calculation)

The coefficient of number of family labor of households is positive and significant ($\alpha < 0.1$) which points out that there is a relation between intensity of individual irrigation adoption and number of family labor. In the study area high value horticultural crop like onion, tomato and pepper have been producing although they are labor intensive. A household with higher labor force will be in position to manage the labor –intensive irrigation activities. Moreover, large working labor force in a family means, the household may not need to hire more additional labor and the money saved due to use of own labor force could be used for purchasing other inputs needed for irrigation activities which in turn may increase the intensity of irrigation technology adoption. The result was in agreement with study conducted by Faturoti *et al*. (2006), He *et al*. (2007), Tiamiyu *et.al*., (2009), Mutune *et al*., (2011) and Jara-Rojas *et al*. (2013).

The coefficient of *soil fertility* is highly significant ($\alpha < 0.01$) and positive. This result indicates that farmers prefer to allocate more their fertile land for the production under irrigation. This is due to irrigation are resource taking and the income generated from this irrigation production should offset the cost incurred on irrigation. In the study area farmers produce high value crop using irrigation. It is obvious that crop production under irrigation need more cost than rain-fed crop production even on an identical crop. Thus, the return from crop under irrigation should be high to offset the cost incurred on it. Soil fertility contributes for high crop return assuming other variables are controlled. So, famers may prefer to allocate fertile land for crop under irrigation than rain-fed to guarantee high yields and thereby to cover cost incurred on it. Under rain-fed farmers incur small cost but the yield achieved also small due to shortage of rainfall in the district. So, famers may prefer to cultivate fertile land under irrigation than rain-fed to inhibit loss of productivity from fertile land because of shortage of rain fall (uncertainty of rain fall). Low fertility under irrigation can generates small yield; however, cost under irrigation is high. Thus, low yield cannot offset cost incurred. In this case, high fertile soil encourages intensity of adoption of irrigation than low fertile soil. This means fertile land is necessary to generate more yields and thereby generate more income to offset the cost incurred on irrigation than non-fertile land. However, under irrigation there is no uncertainty of water but it needs more cost of production than rain-fed. de Graaff, Amsalu et.al (2008) pointed out that as farmers have access to more fertile land, they prefer to invest more in this productive land. Moreover, farmers with poor soil fertility have a lower probability of adopting agricultural technology (Jara-Rojas *et al*., 2013).

Under institutional factors three variables play roles in the intensity of adoption of irrigation technology. Credit is highly significant and its sign is positive which indicates that there is high positive relationship between access to credit and level of adoption of irrigation (intensity of irrigation). In rural areas financial constraint is one of the common problems facing farmers. This financial constraint is relatively more critical particularly for irrigation users owing to irrigation activities need more capital than rain-fed. A farmer who has access to credit can overcome financial problem and can purchase several variable inputs and capital (e.g. water pump) needed for production of crop using irrigation. Thus access to credit play an important role in the intensity of adoption of agricultural technologies. Various studies have found similar results and concluded that access to credit service is an important institutional variable that determine the intensity of irrigation activates. For example, Mariano, Villano *et at*. (2012) pointed out that credit access found to have influence on the level of technology adoption due to most of the time complementary agricultural technologies entails more investment cost. Thus the availability of credit service to smallholder farmers who often have capital constraint will enhance the level of irrigation technologies adoption. According to Tiamiyu *et al*., (2009), credit variable was significant and positively associated with the level of adoption and improvement in this variable would lead to higher level of technology use. This finding is in agreement with findings from other studies such as: Faturoti. B. O., (2006); Awotide *et.al* (2012); He, X.-F., *et al*. (2007) Jara-Rojas *et al*. (2012).

The coefficient of extension agent visit is positive and significant ($\alpha < 0.05$). This indicates that farmers who have contact with extension agents are more likely to allocate more land area to the irrigation activities. This is due to new information which reduces information asymmetry of new technology become available to farmers; hence famers may have full information and willing to take the risk of adopting new technology (Chiputwa *et al*., 2011). According to Awotide *et.al* (2012), Extension agent visit has the potential to enhance technology diffusion and its management at low cost to the farmers. Moreover, this extension contact is useful to relay farmers' demand to innovators and government policy makers to ensure that new technology adopted meet local need. Availability of information to famers may have the potential to reduce subjective uncertainty about irrigation technology, thus extension contact will introduce adoption of the technology. Farmers who have frequent extension agent contact are expected to be more familiar and more knowledgeable about the use of improved agricultural innovation (Tiamiyu *et al*., 2009). This finding supported by previously conducted research on determinants of technology adoption such as: Mafuru *et al*. (1999), Mazvimavi and Twomlow (2009), Abdulai, Owusu *et al*. (2011), He *et.al.* (2007), Mutune *et al*., 2011), Chiputwa *et al*. (2011), Baidu-Forson (1999), Feder.G and Umali.D.L.(1993), Mariano *et al*.(2012) and Adeoti, A. I., (2009).

The coefficient of water pump support in group is significantly different from zero and positively associated with the intensity of adoption of individual irrigation. Providing water pump to groups of people means adding competitor of irrigation in the area. Thus, farmers that already adopted the irrigation activities individually can diversify the activities more when there is competitor in their surroundings. This is due to they have awareness of the irrigation benefits and tries to attract buyers by producing more horticultural crops or other crop than their competitors. When the famers' products reach the maturity stage, farmers give call to brokers or traders directly if they know them. However, the traders give priority to buy the products from farmers whose amount of production is higher. This can create initiation for the individual irrigation adopter farmers to produce crop/horticultural crop larger than what they had been producing and competing with others on sale.

7. Conclusion and Policy Implication

The Central Rift valley of Ethiopia is draught prone area. In drought prone areas, development of irrigation, provision of sufficient water and sustainable water for agricultural function is a viable option to secure food production. Despite the existence of huge water resource (Lake Ziway) and importance of irrigation in mitigating drought and drought consequences, increase food supplies, improve household income and poverty reduction; production and productivity as well as income of farmers is still very low in the study area (Adami Tulu Jidokombolcha). Understanding factors behind such diversity and farmers current level of adoption of irrigation is of paramount importance in providing critical input to the appropriate design of future programs and projects related to irrigation activities. Therefore, this study was carried out to fill out the knowledge gap of what factors determine adoption and level of adoption of irrigation technology in drought prone areas. An irrigation practice is highly useful especially in drought prone areas. Its contribution to households' nutrition, income and food security is very high. Although adopting irrigation technology generate these benefits, it is difficult for farmers in developing countries to do so owing to several factors that were outlined in the study. Hence in this study I have examined the factors affecting adoption of irrigation and intensity of irrigation.

Among other factors, the study was focused on Household demographic characteristics, Capacity to invest, Physical factors and Institutional factors. The empirical results generally showed that among independent variables included under household demographic characteristics, Education and Age of household head significantly influence the adoption of irrigation. However, sex and general farm experience were not significantly different from zero. Likewise, four variables (Education, Age, Sex and irrigation experience of household head) were included in the truncation regression. Among these explanatory variables only irrigation experience of household head positively influenced the intensity of irrigation adoption.

According to the result, the other important determinant of adoption of irrigation was capacity to invest factor. Estimated wealth, number of active family labor (15-64 years) and total irrigable land were variables associated with capacity to invest and they were positively influenced the adoption decision of the individual farmers. Likewise, the same variables were included in the truncated regression analysis. Among them only number of active family labor (15-64 years) and total irrigable land positively influenced the intensity of adoption.

Among physical incentive factor that may constrain or favor adoption of irrigation technology, only distance of plots from irrigation water source negatively influence the adoption, indicating that long distance of framers' plot from water source can causes farmers for extra cost when compared to nearest plot to water source. In contrast, distance of plots from irrigation water source has no significance impact on the intensity of irrigation adoption. However, soil fertility has positive influence on the intensity of adoption of irrigation.

An *institutional factor* (credit institution, extension contact and pump support from NGOs and GOs) play significant role in intensity of adoption of irrigation. According to the result, farmers access to credit for irrigation purpose, extension contact for irrigation purpose and pump support were positively influence the intensity of adoption.

Irrigation technology entails the use of several practices which require knowledge and skill of application and management. Hence, depend on the results revealed in this study; an important implication is the need to widening the farmers' opportunity to access to education and technical assistance programs that encourages the adoption and intensity of adoption of irrigation technology. Moreover, adoption of irrigation was found to be influenced by distance of plot from irrigation water source. The long distances of irrigable plot from water source require a long pipeline to drive water from its source to farmers' plots which need additional costs. This indicates that the need to intervention by government or/and any organization to construct new and rehabilitation of existing irrigation facility which discharge water to cover long distance; or provide the irrigation facility in-kind credit form to solve the problem of long distance of plots from water source. In this case it is possible to increase the number of farmers who have access to irrigation water and thereby increase the adoption and level of adoption of irrigation technology.

Intensity of adoption also found to be influenced by soil fertility of the plot. Awareness creation on for example compost making and other methods should have to be made by development agents to improve soil fertility of farmers' plots. This can encourage the farmers to adopt and increase the level of irrigation adoption.

Another implication of this finding is that access to credit service and extension visit are important to intensify the level of adoption of irrigation technology. Thus, increasing association of non-governmental organization and formal financial institution with farmer could improve access to credit service either in cash or in-kind which in turn increase the level of technology adoption. It is important to extension agents participate in the promotion of irrigation technology to enhance wider adoption. Farmers may deviate from the recommended rate of watering, frequency of watering, when and how watering is possible. Thus, provision of extension service to improve farmers' access to information and advice on technical parts of irrigation activities has to be strengthened.

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Appendix

Table 1. Independent Sample T test of each individual variables

```
. ttest   EduHH, by(Waterpuind)

Two-sample t test with equal variances
------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
       0 |      79    3.177215    .3782291    3.361774    2.424219    3.930212
       1 |      51    8.647059    .3381884    2.415148    7.967787     9.32633
---------+--------------------------------------------------------------------
combined |     130    5.323077    .3539058    4.035147    4.622866    6.023288
---------+--------------------------------------------------------------------
    diff |           -5.469844    .5438108               -6.545866   -4.393821
------------------------------------------------------------------------------
    diff = mean(0) - mean(1)                                      t = -10.0584
Ho: diff = 0                                     degrees of freedom =      128

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 1.0000
. ttest   Age, by(Waterpuind)

Two-sample t test with equal variances
------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
       0 |      79    49.98734      1.7765    15.78988     46.4506    53.52408
       1 |      51    40.41176    1.148631    8.202869    38.10467    42.71886
---------+--------------------------------------------------------------------
combined |     130    46.23077    1.236811    14.10181    43.78371    48.67783
---------+--------------------------------------------------------------------
    diff |            9.575577    2.397968                4.830787    14.32037
------------------------------------------------------------------------------
    diff = mean(0) - mean(1)                                      t =   3.9932
Ho: diff = 0                                     degrees of freedom =      128

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.9999         Pr(|T| > |t|) = 0.0001          Pr(T > t) = 0.0001
. ttest Ewealth, by(Waterpuind)

Two-sample t test with equal variances
------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
       0 |      79    97720.85    8000.183    71107.18    81793.71      113648
       1 |      51    220415.4    15775.71    112661.1      188729    252101.9
---------+--------------------------------------------------------------------
combined |     130    145854.9    9443.581    107673.4    127170.5    164539.2
---------+--------------------------------------------------------------------
    diff |           -122694.6    16105.65               -154562.4   -90826.79
------------------------------------------------------------------------------
    diff = mean(0) - mean(1)                                      t =  -7.6181
Ho: diff = 0                                     degrees of freedom =      128

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 1.0000
. ttest NFlabor, by(Waterpuind)

Two-sample t test with equal variances
------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
       0 |      79     3.78481    .2367357    2.104153    3.313506    4.256115
       1 |      51    5.215686     .310993    2.220934    4.591038    5.840334
---------+--------------------------------------------------------------------
combined |     130    4.346154    .1976944    2.254063    3.955011    4.737297
---------+--------------------------------------------------------------------
    diff |           -1.430876    .3862937               -2.195224   -.6665281
------------------------------------------------------------------------------
    diff = mean(0) - mean(1)                                      t =  -3.7041
Ho: diff = 0                                     degrees of freedom =      128

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.0002         Pr(|T| > |t|) = 0.0003          Pr(T > t) = 0.9998
. ttest Exper, by(Waterpuind)

Two-sample t test with equal variances
------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
       0 |      79    16.98734    1.409903    12.53149    14.18044    19.79424
       1 |      51    22.62745    1.155366    8.250965    20.30683    24.94807
---------+--------------------------------------------------------------------
combined |     130        19.2    .9960806    11.35707    17.22923    21.17077
---------+--------------------------------------------------------------------
    diff |           -5.640109    1.986395               -9.570531   -1.709688
------------------------------------------------------------------------------
    diff = mean(0) - mean(1)                                      t =  -2.8394
Ho: diff = 0                                     degrees of freedom =      128

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.0026         Pr(|T| > |t|) = 0.0053          Pr(T > t) = 0.9974
. ttest Tirrigableland, by(Waterpuind)

Two-sample t test with equal variances
------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
       0 |      79    6.797468    .4328973    3.847676    5.935636    7.659301
       1 |      51    13.09804      .68614     4.90002    11.71989    14.47619
---------+--------------------------------------------------------------------
combined |     130    9.269231    .4623949    5.272112    8.354371    10.18409
---------+--------------------------------------------------------------------
    diff |           -6.300571    .7705279               -7.825192    -4.77595
------------------------------------------------------------------------------
    diff = mean(0) - mean(1)                                      t =  -8.1770
Ho: diff = 0                                     degrees of freedom =      128

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 1.0000
. ttest Disirrip, by(Waterpuind)

Two-sample t test with equal variances
------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
       0 |      79    .3375949     .038332    .3407024    .2612818    .4139081
       1 |      51    .1035294    .0144895    .1034761    .0744263    .1326325
---------+--------------------------------------------------------------------
combined |     130    .2457692    .0259436     .295803    .1944391    .2970994
---------+--------------------------------------------------------------------
    diff |            .2340655     .049166                .1367821    .3313489
------------------------------------------------------------------------------
    diff = mean(0) - mean(1)                                      t =   4.7607
Ho: diff = 0                                     degrees of freedom =      128

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 1.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 0.0000
```

Table 2. Relationship between sex of household head and adoption of irrigation technology

```
. tab  Sex Waterpuind , chi2
```

Sex of Household head	Irrigation using individually water pump 0	1	Total
Female	24	2	26
Male	55	49	104
Total	79	51	130

Pearson chi2(1) = 13.5598   Pr = 0.000

Source: own survey data, 2012

Table 3. Relationship between soil fertility of nearest plot and adoption of irrigation technology

```
. tab  SoilFer Waterpuind, chi2
```

Soil fertility of farmers plot	Irrigation using individually water pump 0	1	Total
poor	44	8	52
Good	35	43	78
Total	79	51	130

Pearson chi2(1) = 20.6718   Pr = 0.000

Source: own survey data, 2012

Table 4, Relationship between extension contact and adoption of irrigation technology

```
. tab Exagvisit Waterpuind , chi2
```

Extension contact	Irrigation using individually water pump 0	1	Total
no	49	3	52
yes	30	48	78
Total	79	51	130

Pearson chi2(1) = 40.7036   Pr = 0.000

Source: own survey data, 2012

Table 5. Summary of Descriptive Statistics

```
. tabstat Adoption Adopindex EduHH Age Ewealth NFlabor Exper Experirg Tirrigableland Disirrip Soi
> lFer Sex Credit Credit Exagvisit Exagvisit, statistics( mean sd ) columns(variables)
```

stats	Adoption	Adopin~x	EduHH	Age	Ewealth	NFlabor	Exper	Experirg
mean	.5	42.03992	5.323077	46.23077	145854.9	4.346154	19.2	5.146154
sd	.5019342	44.07667	4.035147	14.10181	107673.4	2.254063	11.35707	6.078443

stats	Ti~eland	Disirrip	SoilFer	Sex	Credit	Credit	Exagvi~t	Exagvi~t
mean	9.269231	.2457692	.6	.8	.2692308	.2692308	.6	.6
sd	5.272112	.295803	.4917931	.4015474	.445276	.445276	.4917931	.4917931

Table 6. Probit Model Analysis

```
. probit Waterpuind EduHH Age Sex Exper Ewealth NFlabor Tirrigableland SoilFer Disirrip PumpSup
> p, vce(robust)

Iteration 0:   log pseudolikelihood =  -87.069991
Iteration 1:   log pseudolikelihood =  -38.340005
Iteration 2:   log pseudolikelihood =  -27.051518
Iteration 3:   log pseudolikelihood =  -21.706041
Iteration 4:   log pseudolikelihood =  -19.393047
Iteration 5:   log pseudolikelihood =  -18.919902
Iteration 6:   log pseudolikelihood =   -18.89093
Iteration 7:   log pseudolikelihood =  -18.890628
Iteration 8:   log pseudolikelihood =  -18.890628

Probit regression                                 Number of obs   =        130
                                                   Wald chi2(10)   =      54.93
                                                   Prob > chi2     =     0.0000
Log pseudolikelihood = -18.890628                  Pseudo R2       =     0.7830
```

Waterpuind	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
EduHH	.2459409	.0889212	2.77	0.006	.0716586	.4202232
Age	-.140972	.04812	-2.93	0.003	-.2352854	-.0466585
Sex	-1.445721	1.12192	-1.29	0.198	-3.644644	.7532021
Exper	.0628967	.0422214	1.49	0.136	-.0198557	.1456491
Ewealth	.0000101	3.21e-06	3.16	0.002	3.85e-06	.0000164
NFlabor	.3324075	.1191542	2.79	0.005	.0988696	.5659453
Tirrigable~d	.214723	.0923642	2.32	0.020	.0336924	.3957536
SoilFer	.6299065	.4685788	1.34	0.179	-.288491	1.548304
Disirrip	-6.897831	2.170675	-3.18	0.001	-11.15228	-2.643386
PumpSupp	-1.333666	.5122312	-2.60	0.009	-2.33762	-.3297109
_cons	.8603196	2.57309	0.33	0.738	-4.182845	5.903484

Table 7. Marginal Effects of Independent variable on Individual adoption

```
Marginal effects after probit
      y  = Pr(Waterpuind) (predict)
         =  .12486865
```

variable	dy/dx	Std. Err.	z	P>|z|	[95% C.I.	]	X
EduHH	.0505906	.02223	2.28	0.023	.007025	.094157	5.32308
Age	-.0289983	.0098	-2.96	0.003	-.048214	-.009783	46.2308
Sex*	-.4273147	.36723	-1.16	0.245	-1.14707	.29244	.8
Exper	.012938	.00735	1.76	0.078	-.001461	.027337	19.2
Ewealth	2.09e-06	.00000	1.68	0.093	-3.5e-07	4.5e-06	145855
NFlabor	.068377	.04093	1.67	0.095	-.011841	.148595	4.34615
Tirrig~d	.044169	.0283	1.56	0.119	-.011305	.099643	9.26923
SoilFer*	.121179	.11708	1.04	0.301	-.108286	.350644	.6
Disirrip	-1.4189	.42104	-3.37	0.001	-2.24413	-.593673	.245769
PumpSupp*	-.2210775	.07448	-2.97	0.003	-.367046	-.075109	.338462

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

Table 8. Truncated Regression model Analysis

```
. truncreg InAdindex EduHH Age Experirg Sex Ewealth NFlabor Tirrigableland SoilFer Disirrip Pum
> pSupp Credit Exagvisit, ll(0)
(note: 78 obs. truncated)

Fitting full model:

Iteration 0:   log likelihood =   59.476982
Iteration 1:   log likelihood =   60.119154
Iteration 2:   log likelihood =   60.455408
Iteration 3:   log likelihood =   60.456716
Iteration 4:   log likelihood =   60.456716

Truncated regression
Limit:   lower =          0                            Number of obs =       52
         upper =       +inf                             Wald chi2(12) = 171.63
Log likelihood =  60.456716                             Prob > chi2   = 0.0000
```

InAdindex	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
EduHH	.0089599	.0058227	1.54	0.124	-.0024525	.0203722
Age	-.0030019	.0029639	-1.01	0.311	-.0088111	.0028072
Experirg	.0127064	.0048371	2.63	0.009	.0032258	.022187
Sex	-.02575	.0662537	-0.39	0.698	-.1556049	.1041049
Ewealth	1.72e-07	1.51e-07	1.14	0.254	-1.24e-07	4.68e-07
NFlabor	.0132049	.0078619	1.68	0.093	-.0022041	.0286138
Tirrigable~d	-.0058656	.0036477	-1.61	0.108	-.013015	.0012839
SoilFer	.1107708	.0309516	3.58	0.000	.0501068	.1714347
Disirrip	-.1888401	.1259885	-1.50	0.134	-.4357729	.0580927
PumpSupp	.0755501	.0249658	3.03	0.002	.026618	.1244821
Credit	.0722894	.0277337	2.61	0.009	.0179323	.1266465
Exagvisit	.10619	.0525375	2.02	0.043	.0032184	.2091615
_cons	.5237397	.142414	3.68	0.000	.2446134	.802866
/sigma	.0756553	.0074186	10.20	0.000	.0611151	.0901955

Table 9. Marginal Effects of Independent variable on adoption index

```
. mfx

Marginal effects after truncreg
      y  = Fitted values (predict)
         =  .87795746
```

variable	dy/dx	Std. Err.	z	P>|z|	[95% C.I.	]	X
EduHH	.0089599	.00582	1.54	0.124	-.002453	.020372	8.53846
Age	-.0030019	.00296	-1.01	0.311	-.008811	.002807	40.5
SoilFer*	.1107708	.03095	3.58	0.000	.050107	.171435	.826923
Sex*	-.02575	.06625	-0.39	0.698	-.155605	.104105	.961538
Ewealth	1.72e-07	.00000	1.14	0.254	-1.2e-07	4.7e-07	217059
PumpSupp*	.0755501	.02497	3.03	0.002	.026618	.124482	.576923
NFlabor	.0132049	.00786	1.68	0.093	-.002204	.028614	5.19231
Experirg	.0127064	.00484	2.63	0.009	.003226	.022187	10.9615
Tirrig~d	-.0058656	.00365	-1.61	0.108	-.013015	.001284	12.9038
Disirrip	-.1888401	.12599	-1.50	0.134	-.435773	.058093	.111154
Credit*	.0722894	.02773	2.61	0.009	.017932	.126647	.557692
Exagvi~t*	.10619	.05254	2.02	0.043	.003218	.209161	.942308

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

<u>A QUESTIONAIRE TO COLLECT DATA ON DETERMINANTS OF INVESTMENT IN IRRIGATION IN ADAMI TULU JIDOKONBOLCHA DISTRICT OF OROMIA REGIONAL STATE, ETHIOPIA</u>

Belay Deressa (MSc Researcher)

Instruction

Before starting the question introduce yourself and aware them the objective (<u>Note</u> written below) of the survey to the respondent and ask their permission politely. When you finish please check whether all question are addressed correctly and answers are filled accordingly.

Note: this Questionnaire is totally for academic research purpose. The answer given to the questions are not passed over to government officials, tax collectors or any other third party that the respondents do not allow to the access of such information. Therefore, respondents are kindly requested to give their honest response to every question. Thanks

1. General information

1.1. Name of interviewer_____________________ signature ____________

1.2. Date of interview ___________________________

1.3. Name of Peasant Association (PA) _______________________ Village ________________

2. Farmers Identification and Village characteristics

2.1. What is family language? 1. Afaan Oromo, 2. Amharic, 3. Other_________

2.2. Religion of the household head ____ ***1. No religion, 2. Muslim, 3. Orthodox Christian, 4. Catholic, 5. Protestant, 6. Other Christian, 7.Wakefata, 8. Other specify***________________

2.3. Experience in general farming (years) _______________

2.4. Experience in using irrigation (years)__________________________

2.5. Taking in to consideration all food sources (own food production + food purchase +food hunted form lakes), how would you define your family food consumption in the last year (2004 E.C*)?****1. Food shortage through the year, 2. Occasional food shortage, 3. No food shortage but no surplus, 4. Food surplus***

2.6. Distance to the village market from residence (Km)_________ minutes of walking time _______

2.7. What means of transport do you use mainly to get to the village market? ***1. Walking, 2. Bicycle, 3. Car, 4. Cart, 5. Other specify*** ____________________________________***E***

2.8. Average single transport cost (per person) to the village market using this means of transport (ETB/person)___________________________

2.9. What is main means of transporting agricultural output to village market or main road***? 1. By donkey 2. Car 3. Own cart 4. By renting other person cart***

2.10. Distance to main road from residence (Km) _____________ minutes of walking time _____

2.11. What is main means of transport from residence to main road? ***1. Walking, 2. Bicycle, 3. Car, 4. Cart, 5. Other specify*** ______________________

2.12. Average single transport cost from residence to main road? ____________

2.13. Number of month's residence to main road is passable for cars? ________________

2.14. Quality of road from residence to main road? ***1. Very poor 2. Poor, 3. Average, 4. Good, 5. Very good***

2.15. Distance to nearest main market from main road? _____________

2.16. What is main means of transport from main road to main market? ***1. Walking, 2. Bicycle, 3. Car, 4. Cart, 5. Other specify*** ______________________

2.17. Average single transport cost from main road to main market? ____________

2.18. Number of month's main road to main market is passable for cars? ________________

2.19. Quality of road from main road to main market? ***1. Very poor 2. Poor, 3. Average, 4. Good, 5. Very good***

2.20. Distance to the nearest source of improved seed dealer from residence (km) _____ minutes of walking time _____

2.21. Distance to the nearest source of fertilizer dealer from residence (km) _____ minutes of walking time _____

2.22. Distance to the nearest agricultural extension office from residence (km) _____ minutes of walking time _____

2.23. Are you a model or follower farmers? [1. Yes 0. No] _______model _______follower

Socio-demographic characteristics of the household (table1)

No	Name of household members	Relation to HH **(Codes A)**	Age in year	Marital status **codes B**	Sex **codes C**	Education **Codes D**	Occupation **codes E**		Own farm labor contribution **Codes F**
							Main	Secondary	
1									
2									
3									
4									
5									

6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									

Codes A	**Codes B**	**Codes C**	**Codes D**	**Codes E**	**Codes F**
1. husband 2. wife 3. Daughter 4. Son 5. Employee 6. Other relatives 7. others, specify --------------------	1.married living with spouse 2.married but spouse away 3. never married 4. Divorced 5.widow/widower 6. Not applicable (NA) 7. Other specify…..	1.male 0. female	**0**.None/illiterate **1**.Adult Education or 1 year of education ***give other education in years**	1.Farming (crop + livestock) 2.sallaried employment 3.self employed off farm 4. self employed non farm 5.Causal laborer off-farm 6.causal laborer non-farm 7.school/college child 8.herding 9.Household chores 10.other, specify…..	1.100% 2.75% 3.50% 4.25% 5.10% 6.no contribution

3. Household Asset (Resource Endowment)

Section A: Production equipment and Major household furniture (table2)

Asset	Number (if no equipment put zero)	Original purchase price (ETB)(if more than two items reported in column 2 take average price)	If you would sell […] how much would you receive from the sale? (ETB)(if more than two items reported in column 2 take average price	Total current price
1	**2**	**3**	**4**	**5=2*4**
1.Horse cart				
2.Donkey cart				
3.Horse saddle				
4.push cart				
5.Ox-plough				
6.Sickle				

7.Pick Axe				
8.Axe				
9.Hoe/Jemba				
10.Knapsack sprayer				
11.water carrier made of canvass/skin/inner tire tube				
12.Stone grain mill				
13.Motorized grain mill				
14.water mill				
15.Mechanical water pump (hand, foot)				
16.Motorized water pump (diesel)				
17.Spade or Shovel				
18.Radio, cassette or CD player				
19.Cell phone				
20.Improved charcoal/wood stove				
21.Kerosene stove				
22.Bicycle				
23.Motorbike				
24.Cars				
25.Picks-up				
26.Trucks				
27.Tractors				
28.trailer				
29.Jewellery:gold,silver,wristwatches				
30.Wooden box				
31.metal box				
32.Leather bed				
33.Wooden bed				
34.Metal bed				
35.TV				
36.Chairs				
37.Table				
38.Gun				
39.Grass roofed house				
40.Corrugated house				
41.Fish pond				
42.Sofa				
43. Shovel				
44. Chemical sprayer				
45. Grain storage				
46.Other, specify …………				

Section B: Land holding in kert (1/4Ha) at 2004 E.C production year and its market (table3)

Source of	Irrigable	Allocated	Irrigated	Fallow	Forest	Grazing	Home	Others	Total

land	land in kert (1/4Ha)	to Rain fed	land	land		land	stead	Specify	
Own land (A)									
Borrowed in land from relative(B)									
Borrowed out land for relative(C)									
Rent in land(D)									
Shared in land(E)									
Shared out land (F)									
Rent out land(G)									
Total owned land A+C+F+ G									
Total operated land in 2004									

If you rented in land, what is the price of land per kert(in ETB)? _____and total value of rented in land (in ETB)______

If you rented out land, what is the price of it per kert(in ETB)?______ and total value of rented out land(in ETB) _____

If you have an irrigable but not irrigated farmland, indicate the reason why you did not irrigate. 1) Labors shortage in the family, 2) Lack of oxen, 3) Lack of improved seeds, 4) Lack of credit to buy water pump and other variable inputs, 5) labor price is high 6) Enough production from main rain cultivation, 7) others (specify) _________

____

Section C: Livestock Ownership in 2004 E.C (table 4)

Type of	Number Owned	Number of sold	Average price	Total price	Estimate price of	Type of animal	Number Owned	Number of sold	Average price	Total price	Estima te price

animal	at starting of **2004 E.C**	in 2004			those livestock do not sold		at starting of **2004 E.C**	in 2004			of those do not sold
Ox						Sheep					
Cow						Poultry					
Heifer						Horse					
Bull						Mule					
Goat						Donkey					

4. Soil type and soil fertility of each crop plot (Table5)

Name of crops **(Code A)**							
Soil type	1=Acidic, 2= Basicity 3 = Normal	Irrigation					
		Rain-fed					
Soil fertility	1= Good, 0= bad	Irrigation					
		Rain-fed					

<u>Code A</u>: 1 = Maize, 2 = sorghum, 3 = tomato, 4 = onion, 5= H.beans, 6=cabbage, 7) = pepper, 8)= other (specify in the table

6. Different Sources of income in the production year of 2004 EC.

Did you or any of your family members work on off-farm jobs? *Yes* ______ *No* _______
If yes, fill the table 6 below
Table 6

*Type of off-farm	Which family member? *1=Household head 2=Spouse/partner 3=Children 4=Others*	Monthly earning in birr												Total (sep-aug)	Left after expenditure
		Se	O	N	D	J	F	M	Ap	May	Ju	Jly	aug		

<u>*Type of off-farm</u>: 1= Daily laborer on another person farm 2= Cattle trading, 3= Selling of fish, 4= Grain trading

Did you or any of your family members work on non-farm jobs? *Yes* ______ *No* _______

Table 7

*Type of non-farm	Which family member? *1=Household head* *2=Spouse/partner* *3=Children* *4=Others*	Monthly earning in birr												Total (sep-aug)	Left after expenditure
		Se	O	N	D	J	F	M	Ap	May	Ju	Jy	Aug		

<u>*Type of non-farm</u>: 1= Selling of alcoholic drinks, 2= Sand mining, 3= Hiring of donkey cart, 4= Hiring of horse carts, 5= Petty trade

8. Institutional support to irrigation

8.1 Credit

Have you borrowed money in 2004E.C? 1=yes, 0= no
If yes, fill the following table 8
If no, why? ____
Do you have interest to borrow in future for irrigation? 1=yes, 0= no
If no, why? ____

Table 8

Source	Amount you borrowed	Year in you borrowed	Bureaucracy 1= easy 2=difficult	Interest rate (%)	Maximum duration of loan (in months	Are you asked for mortgage? 1 =yes, 0=no If yes, like what?	For what purpose did you used the obtained credit? *1= production activities under irrigation* *2= production activities under rain fed* *3=Marketing activities* *4=Social obligations* *5=Others*	
Government Bank								
Private Bank								
Service Co-operatives								
Micro-finance								
Local lender								
Neighbors								
Friends								
Relatives								
Others								

8.2. Extension Services and source of information

Is there an extension agent (Development Agent, DA) in your locality? 1= Yes, 0=No
If yes, since when? _________ *EC*
If yes, do you visit the DA when you need some expertise advises in production using irrigation? 1= Yes, 0=No
How many times a year do you visit the agent to ask about irrigation information in 2004 E.C.? ______
How far is the residence of the extension agent from your home? _______ *Km (or ______ hrs of walk on foot)*
Do you think the technical supports you got from development agents are sufficient, up to date and helped you in developing you agricultural knowledge under irrigation? 1= Yes, 0=No
Do you have another source of information on irrigation? 1= Yes, 0=No
If yes, who are them? 1. Research, 2. Radio, 3.Union, 4. Others (specify)__________________________

8.3. Social capital and Networking

Have you and/or your spouse been member of formal and informal institutions in the last 3 years?____ [1=Yes, 0=No]. If yes please fill the following table and if no go to next section.
Section A: Membership in formal and informal institutions in the last 3 years (husband and wife only.
If yes, what is the type of the husband/wife/is/was member of? ***1.Input supply/farmer coops/union, 2.Crop/seed producer and marketing group/coops, 3.local administration, 4.farmers' association, 5.women association, 6.youth association, 7.church/mosque association/congregation, 8.funeral association, 9.Government teams, 10.Water user's association, 11.Edir, 12.Equb, 13. Other, specify …….***

Section B: Social Networks

1. Number of years the respondent has been living in this village _________--
2. Number of people that you can rely on for critical support in times of need within this village Relatives______________________________ non-relatives __________________________
3. Number of people you can rely on support in times of need outside this village Relatives_____________ non-relatives____________________-
4. Are any of your friends or relatives in leadership positions in formal or informal institutions within and outside this village? ____ 1. Yes 0.No
5. Do you think you can rely on government support (subsidies, food aid etc) if your crop fails? __ 1. Yes 0.No
6. How many times do you contact your neighbor in week?________
7. Have you exchange labor for agricultural production activities with your neighbor during production time of 2004 E.C? 1= Yes 0= No

9. Water Use and Irrigation

1. Do you have water pump in group?   1= yes, 0= no

2. If yes what is its initial cost? ________________ How many people buy it together? ______ when do you buy? ____For how long it will retain after this time (estimation)? _____ Estimate its price if you want to sell it now ______

3. Do you have water pump individually? 1 = yes 2= no

4. If you have water pump, do you rent your water pump to others? 1) Yes 0) No

5. If yes, how much do you rent (in birr) in a given period? -----------------------

6. If you have no water pump, do you rent water pump from others? Yes 0) No

7. If yes, how much do you pay per timad/kert of land?__________ and how many time do you watering in one production season? _________________________________

8. If you were using irrigation how do you perceive the income you have generated from it? 1. Low, 2. Medium, 3. High
9. What is the distance in kms between the source of water for irrigation and your nearest farm plot?____
10. What is the distance in kms between the source of water for irrigation and your distant (remote) farm plot?____
11. Is water user association organized in the area? 1. Yes 0. No
12. Are you the member of water user association? 1. Yes 0. No
13. Are there any criteria to be a member of water users association? 1. Yes 0.No
14. If yes, indicate the criteria____
____
15. Is there any government, private, non-governmental organization working on irrigation development in your area? 1. Yes 2. No
16. If yes can you mention some of its activities and contributions working on irrigation development in the area?
17. Have you been supported by any of these organizations to improve your irrigation activities? 1.Yes 2. No
18. If yes specify some of the supports you got so far.___________________

10. General opinion

10.1. Please mention all problems associated with irrigation development activities in your area_____________________________________

10.2. Give your view as to what interventions must be made for better implementation of irrigation technologies on your farm ______________________

10.3. Give your idea with regards to any negative impacts and constraints of irrigation ________
____