BAHIR DAR UNIVERSITY

COLLAGE OF BUSINESS AND ECONOMIC

DEPARTMENT OF ECONOMICS

IMPACT OF SMALL SCALE IRRIGATION TECHNOLOGY ON FARM HOUSEHOLD WELFARE IN AMHARA REGION: EVIDENCE FROM DANIGLA AND BAHIR DAR ZURIA DISTRICTS

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By

Belainew Belete

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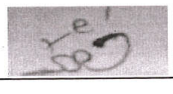
Surafel Melak (Assistant Professor) Signature  Date Oct, 2016

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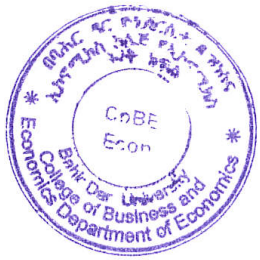

DECLARATION

I, the under sign, declare that this Msc. thesis is my own work. In conformity with internationally accepted practices I have duly acknowledged and referenced all materials used in this work. I understand the non-adherence to the principle of research ethics; academic honesty and integrity, fabrication of any idea/data/ fact source will ground for disciplinary action by the university and can also evoke penal action from the sources which have not been properly cited or acknowledge.

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ACRONYMS

5DEs	Five Domains of Empowerment
AE	Adult Equivalent scale
APC	Average Propensity to Consumption
ATE	Average Treatment Effect
ATT	Average Treatment effect for Treated
CIA	Conditional Independency Assumption
CPI	Consumer Price Index
CSA	Central Statistics Agency
DFID	Department for International Development
DHS	Demographic Household Survey
EDHS	Ethiopian Demographic and Health Survey
ETB	Ethiopian Birr
FAO	Food and Agricultural Organization
FtF	Feed the Future
GPI	Gender Parity Index
GTP	GTP growth and Transformation Plan
HAZ	Height -for-Age Z-score
HDI	Human Development Index
ICID	International Commission on Irrigation and Drainage
IDD	Irrigation Development Department
IFPRI	International Food Policy and Research Institution
ILSSI	Innovative Lab for Small Scale Irrigation
LEO	Leveraging Economic Opportunities
IV	Instrumental Variable

MOARD	Ministry Of Agriculture and Rural Development
MOFED	Ministry OF Finance and Economic Development
OPHI	Oxford Poverty Human development Initiative
PASDEP	Plan for Accelerated and Sustainable Development to End Poverty
PSM	Propensity Score Matching
SDG	Sustainable Development Goal
SDPRP	Sustainable Development Poverty Reduction program
SDs	Standard Deviations
SSI	Small Scale Irrigation
UN	United Nation
UNDP	United Nation Development Program
USAID	United States Agency for International Development
WAZ	Weight-for-Age Z-score
WHZ	Weight-for-Height Z-score
WB	World Bank
WEAI	Women Empowerment in Agriculture Index

ABSTRACT

This study evaluate the impact of small scale irrigation technology on farm household welfare (specifically, on households' consumption behavior and women empowerment) of 201 sampled household in Dengeshita and Robit-Bata Kebele, Amahara National Regional State, Ethiopia. Data were collected using structured questioner from respondents selected through multistage sampling procedure. The data were analyzed by propensity score matching and descriptive statistic methods. Out of 201 household, 146 household with similar characteristics were used in the analysis. The descriptive result shows adopter and non-adopter households were heterogeneous in terms of education level of the household head, number of adult family size, land holding and access to credit. Women in the study area are disempowered.

The econometric estimation result show that the likelihood of adoption of small scale irrigation technology was significantly and positively affected by head of household sex, education level of the household head, number of adult family member, land holding size, market distance and access to credit. It was concluded that small scale irrigation technology adoption had significant impact on the improvements of farm household saving habit and welfare status. However, technology adoption exacerbates the disempowerment of women.

The empirical results of this study intimate that, diffuse of low cost labor saving small scale irrigation technology is an important means of improving farm household welfare. Moreover, to diffuse the technology areas such as education (training), land management, market integration and provision of credit access are focus of attention. Likewise, Policy and other interventions should give due emphasis on cross-cutting issues like gender.

Key words: small scale irrigation, propensity score matching, technology adoption, household welfare, impact analysis.

CHAPTER ONE

INTRODUCTION

1.1. Background of the Study

Natural environment intensive economic activities, mainly agriculture are the main source of well-being of Ethiopians (Yami and Snyder, 2012). In Ethiopia, as many part of sub sharan Africa, agriculture is the mainstay of the livelihood of the household. Ethiopian economy has grown at historically unprecedented rates and is one of the fastest growing economies in the world. Real GDP grew at 10.3 percent as a result of services and agricultural sector due expansion in the year 2013/14 (UNDP, 2015).The lion share of the country's GDP is occupied by service sector with 46.2percent share of GDP, agricultural sector follow with 40.2 percent of GDP share, and the remaining 14 percent of GDP is accounted by Manufacturing sector (African economic outlook, 2014).

The Economic growth of Ethiopia brought eventual poverty reduction in both urban and rural area. For example, World Bank outlook (2014) and UNDP (2015) report indicate that in 2004/2005 fiscal year 38.7 percent of Ethiopians were lived in extreme poverty, five years later this was 29.6 percent by using Growth and Transformation Plan (GTP), it reduced further to 26.0 percent by 2012/2013. Despite its decline and improvements in social and economic status of Ethiopia, poverty is still the challenge for the country. For instance in the year 2014, 25 million Ethiopians were under poverty and vulnerability problem, and the country is still under the class of low human development country with 0.435 HDI in the year 2013 (UNDP, 2015).

The government of Ethiopia design and implement poverty reduction strategies so as to achieve high economic growth and improved wellbeing status of the people. The country embarked the fourth poverty reduction strategic plan as growth and transformation plan II (GTP-II) following SDPRP, PASDEP and GTP-I to achieve sustainable development and secure welfare of the people by promoting irrigation development (MoARD, 2010). On each strategy due emphasis is given to agricultural sector since the sector is the foundation of both rural and urban households' livelihood (Ayele, 2011).

Although agriculture is the main source of Ethiopian household welfare; it is undermined by erratic climate change like drought (Ayele, 2011; Hagos et al, 2009). This climate change is a threat to agricultural production and productivity, which expose households to a high degree of risk and misfortune (Foltz et al., 2013; Domenech and Ringler, 2013). The household in rural Ethiopia who

was victimized by bad weather and drought between 1999 and 2004 have a series problem on their consumption and welfare (Dercon, Hoddinott and Woldehanna, 2005 cited in UNDP, 2015). Consumption level of this prone household is 16 percent lower than non-affected household consumption; this implies that drought has long term welfare impact (UNDP, 2015).

In areas where rainfall is scarce or inconsistent and resources are under employed, irrigation system add great value to cultivated lands (Renault and Makin, 1999). Moreover, agricultural water management and irrigation development potentially reduce vulnerability to climactic instability and improve productivity in any country (Awulachew, 2010).Adoption of efficient irrigation technology enables farmers to adapt and strengthen their resilience to climate change vulnerable regions. Irrigation contributes to agricultural productivity, induces farmers to apply modern inputs, harvest all over the year and creates employment opportunity to household members (FAO, 2011, Ayele, 2011; Hagos et al., 2009; Namara et al., 2005).

Recent studies indicate that irrigation is a means to improve welfare of farm household. For example empirical investigation of Anwar (2014); Gebrekidan (2012) and Hagos et al. (2009) show that, agriculture intensification through resource expansion and adopting irrigation technology to improve agricultural efficiency is pillar for improving rural household welfare of farm household in Ethiopian. Likewise, the application of irrigation with appropriate technology enables Indian farmers to produce high-value crops, which enable them to improve their welfare status (Namara et al., 2005).

Despite irrigation contribute amenable efforts to alleviate poverty and improve overall economic performance of developing countries like Ethiopia, it is still small scale, traditional and subsistence with limited access of technology and institutional service (Desta, 2004 cited in Aseyehegn, 2012).

Though Ethiopia has ample water resources, the nation's agriculture does not fully benefit from irrigation and water management technologies (Awulachew, 2010). As a result, most of the population is deprived with poverty and malnutrition due to lack of irrigation infrastructure. In most developing countries like Ethiopia irrigation infrastructure /technology investment is mostly funded by the government (Kulkarn, 2011). Involvement and investment of private sectors, projects and non-government organization are crucial for scaling up irrigation technology and irrigation.

Feed the Future Innovative Lab for Small Scale Irrigation (ILSSI) is a five year project started since 2013, aiming to increase food production, improving nutrition, livelihoods of farm household,

accelerating economic development and protecting the environment through improved access to small scale irrigation technologies. The technical intervention (irrigation technology provision) of the project is aimed to expanding irrigable land using optimum irrigation technique in order to battle poverty and malnutrition problems, and improve the livelihood of farm household in Tanzania, Ethiopia and Ghana.

According to Woldehanna (2014) review many programs and projects intervene to rural and agricultural development to improve food security, but substantially it affects production and productivity to increase food access. Food security has a great role on the nutritional status. Although the intervention emphasized on the production and productivity of crops and food, it does not select specific micronutrient rich crops and food type. So failure to crop choice implies that weak link of the intervention and the nutritional status of the household.

Achievement of food and nutrition security is mainly rolled by women, who are responsible for food production, procurement, preservation, storage, preparation, consumption and food distribution among family member and women are the caretakers of family welfare (Reinhard & Wijeratne, 2000).

Women in Ethiopia have low level of education and heavier work load than men, but they are excluded in the household decision and have no power to control the income generated from farm income source (MoARD, 2010). Because women are vulnerable in socio-economic position they shoulder the greater burden and they are disempowered in agricultural activities.

Empowerments of women in agriculture can influence the nutritional status of children and the household (Malapit et al., 2013). Product diversity as a result of irrigation practice helps to have dietary diversity if women are empowered, capable to access resources and make decision on the allocation of the product for food so as to have nutritious food for their own and their family (Malapit et al., 2013). Consequently, dietary diversity due to irrigation combined with gender empowerment improves nutrition and wellbeing of child and household member.

Hence, poverty eradication and welfare improving role of small scale irrigation is not well quantified. It is vital to know the effect of technical intervention on welfare of the household and empowerment of women. Theoretically, it is accepted that technical intervention augments the wellbeing of the individual and the community. Hence, this study explores welfare impact of the small scale irrigation technology.

1.2. Problem Statement

Agriculture gives notable role in providing employment and livelihoods opportunities in rural areas of lower income countries. As cited in Munongo and Shallone (2014) World Bank report (2008) show that improving productivity, profitability and sustainability of small holder farming is the main lane to eradicate poverty through Agricultural development. Growth and development of agriculture is possibly sustained if yield enhancing technology is appropriately applied (Sharma and Singh, 2015). The outlook of Wichenls (2015) deduces that to achieve national food security in the near future intervention and investment in both irrigated and rain fed agriculture is vital. Such goal is achieved through intensive irrigation practicing and improvement of agricultural productivity and production through technology intensive input combination.

Technology adaptation improves wellbeing through direct and indirect effects (Moyo et al., 2007 cited in Munongo, 2014). The direct benefit of small irrigation technology includes adoptions reduce production cost and increase production level and income (Munongo& Shallone, 2013; Hagos et al, 2009; Adeoti, 2008; Namara et al., 2005). Indirectly, it expands the demand for labor as a result of increasing production supply. Increasing agricultural production and productivity, institutional development, and technology diffusion are a means of improving wellbeing of people. However, technology adoption is challenged due to many factors such as technical, economic and institution (kulkarni**,** 2011)[1].

The foundation of any intervention is livelihood and Welfare aspect of the community, household, and individual. It ultimately addresses the question of how the interventions affect well-being (Gertler et al**.,** 2011:3**).**

In microeconomic theory the goal of economic behavior of the households is to maximize the household or the individual welfare of the household members' (Strengmann 2000). However, by its very nature welfare is not directly observable. Alkire and Biant (2009) and Henninger (1998)

1. Technical factors:- gap between prevailing technology and local need, application and spare part. Economic factors include high cost of technology, low investment capability of farmers, low and slow return of farm investment. Institutional factors include poor infrastructure and incapable extension services.

portrait that human wellbeing indicators are two types such as means (include food consumption, health service) and outcome measures including nutritional status, life expectance and literacy rate.

Normally, policy makers, program managers and other stockholders mainly focused on inputs and immediate outcomes (distribution and employments of resources) of the intervention rather than whether the intervention have achieved the anticipated goals of improving the well-being of the household particularly and the society generally (Gertler et al., 2011). Generally, evaluating the intervention is vital to identify what does and doesn't work to improve welfare and reduce poverty.

In developing country, with resources are scarce and each dollar spent on any activity is aimed to maximize its role /impact on poverty reduction and improving welfare, impact evaluation is critical (Baker,2000).

Interventions in agriculture lead to a shift in food production, production variability; dietary variety, labor productivity and change the role of women (Hagos et al., 2009 and Namara et al., 2005).

The way these changes take part will also have impacts on nutrition, gender, health outcomes and living standards (Domenech and Ringler, 2013). But the effect differs on different members of household and community, such as beneficiaries, non-beneficiaries, children, and women.

Measuring and identifying the differences is critical to redesign and implement effective irrigation interventions, to maximize benefit, minimize risk of the intervention, and to optimize the wellbeing of the household and community.

So far, few scientific investigation by Anwar (2014), Sinyolo et al. (2014), Adeniyi (2014) Domenech and Ringler (2013), Haji et al. (2013), Namara (2011), Tekana and Oladele (2011) investigate the impact of small scale irrigation on farm household welfare.

In Amahara region particularly in ILSSI project site, to the best of my knowledge, the welfare impacts of small scale irrigation technology is not well documented. Beside, no attempt has been made to analyze the impact of small scale irrigation technology on gender empowerment.

Cognizant that, conceptual, methodological and spatial gap, the researcher is motivated to undertake this research to explore household welfare impact of small scale irrigation technology and fill the gap by focusing on gender issue of farm household. It also attempted to contribute to the project so as to achieve the main goal of improving gender empowerment and wellbeing of the household.

1.3. *Objective* of the Study

The general objective of the study is to evaluate the impact of small scale irrigation technology on household welfare in the study area. More specifically, it intends to:

- Evaluate the impact of small scale irrigation technology on consumption behavior of households.
- Explore the impact of small scale irrigation technology on women empowerment.

1.4. Research Hypothesis

Based on the theoretical and economic theory the following hypothesis was hypothesized.

1. Small scale irrigation technology adoption improves consumption smoothing habit of the household in the study area.
2. Adoptions of small scale irrigation technology empower women.
3. Adoptions of small scale irrigation technology have significant impact on the improvement of farm household welfare.

1.5. Significance of the Study

This thesis contributes to irrigation literature by providing a micro outlook of small scale irrigation technology on rural farm household. Particularly, it tries to examine whether investment in small scale irrigation brings a feasible means to welfare enhancing or not. Moreover, it is believed to be an indicator to ILSSI, who intervene in Dengeshita and Robit-Bata sites, to redesign its intervention so as to achieve its primary goal. Beside, the finding could provide a set of lessons for policy makers and other development agencies for future project design in similar agricultural interventions in developing countries. The study will also use as a reference for further research conducting on similar topics and related issues.

1.6. Scope of the Study

The study has conducted to address the welfare impact of small scale irrigation technology in ILSSI project sites such as Dengeshita and Robit, Amahara regional state, Ethiopia. To evaluate the welfare enhancing role of small scale irrigation technology, the study adopted one-dimensional welfare based on cross-sectional data collected from the treated and control sample household.

1.7. Limitation of the Study

The study was undertaken in Dengeshita and Robit sites of ILSSI in Amahara Regional State, Ethiopia, with the aim of evaluating the impacts of small scale irrigation technology on outcome of interest such as farm household welfare, consumption behavior, women empowerment and nutritional status. However, this study was limited by the following factors such as: absence of base line data, lack of previous empirical finding to compare and contrast the research findings; and the study doesn't see environmental and ecological impact, the link between irrigation, nutrition and women empowerment.

1.8. Organization of the Study

This study has organized in to five chapters. The first chapter gives an overview on the introductory part including background of the study, statement of the problem, hypothesis, and objective of the study and limitation of the study. The second chapter tries to review the theoretical and empirical literatures. The third chapter elaborates the methodology employed for this study including data collection, sampling procedure, and data analysis. The fourth chapter presents the empirical result and discussion of both descriptive and econometric results. The last chapter close the paper by concluding the main finding and suggesting some recommendation.

CHAPTER TWO

LITERATURE REVIEW

This ingredient of this paper attempt to reveal related literatures reviewed in relation with small scale irrigation technology and household welfare, gender empowerment concepts, definitions, and measurement. Afterward, it tries to discourse the major theoretical perspectives on small-scale irrigation, welfare and consumption and gender, giving due emphasis on linkages and role of small-scale irrigation technology to household welfare, consumption and gender empowerment. Finally, synthesis of empirical studies undertaken on the issue was also highlighted in this chapter.

2.1. Theoretical Framework

2.1.1. Definition of Irrigation and Irrigation Technology

According to CSA (2015) irrigation is defined as the practice of providing water other than rain on area of land to improve crop production. But, rivers or streams overflow as wild flooding is not considered as irrigation.

Others define irrigation as an artificial application of water to the land or soil for assisting the growing of agricultural crops, maintenance of landscapes, and moisturized the soils in dry areas and season. Moreover, irrigation protects plants against frost, curb weed growth and avoid soil consolidation.

The source of irrigation water is either ground (water from underground) or surface water (water from lacks, seas, rivers and ponds) (Duperies and Leener, 2002 cited in Kebede, 2011). Irrigation water in each source requires water lifting technologies which simplify life and save water.

Irrigation technology mean the physical water supply infrastructure include scheme infrastructure, water lifting, and field irrigation equipment (Perry, 1997).According to Perry (1997) irrigation technology could be either manual (small scale) or mechanized (large scale) irrigation technology.

Manual irrigation technology: is used by farmers to irrigate farm plots of 0.5 hectare or less than. It is a small scale irrigation technology. Even today it is used because it is easy to use and culturally accepted. Mechanized irrigation technology such technology addresses the needs of farmers with irrigation plot of more than 0.5 hectare.

Small-scale irrigation technologies are applied in areas where farmers have financially capable, have know-how and produce marketable products. Poor small rural households use low cost technologies vary from bucket and drum kit irrigation to rope & washer pump systems, and more advanced treadle pumps to hand operated pressure pumps for home gardening rural areas (GIZ, 2006). Now a day's farmers demand to apply irrigation technology up on their capability. Even though demand for irrigation technology increase, farmers face significant barriers like lack of capital and know-how about water distribution and the way it quickly recharges after use (Awulachew,2010).

2.1.2. Irrigation Method

Irrigation method is a system of obtaining and applying water for irrigation from its source. As cited by Kebede (2011); Dupriez and De Leener (2002) identify topography, water resources, cultivated crop type, land tenure systems, cropping season as a determinant factor of irrigation methods. Beside, Irrigation systems have different forms range from small to large scale due to differences in water sources and water channeling. According to Kerbed (2011) generally, there are two methods of applying irrigation water which are surface and sub-surface irrigation.

Surface irrigation is application of irrigation water from above the surface gravity by diversion of water from rivers, lakes, springs and water in groundwater irrigation done via manual devices such as treadle pumps, rope pumps, traditional lifting devices or mechanical pumps (http://www.globalenvision.org).

In this system of irrigation farmers influence time and volume of irrigation; however, duration of irrigation cycle hampers production of crops that require regular water (e.g. vegetable).

This type of irrigation technology has superlative benefit such as low investment requirement, low energy and operational cost, and applicable in wind. But it has so many flaws including large water loss, low efficient irrigation, and spread plant diseases, not usable for adverse slope.

While, sub-surface irrigation: is the application of irrigation water from underground water source which is not subject to evaporation. Irrigation using ground water is more reliable since water from the ground is naturally renewable, natural storage, no trans-boundary consideration, and ease of use in many places (Awulachew, 2010). However, it requires special technology to uplift water. The most common irrigation technologies applied for irrigating crop are water pump, rope-and-washer, pulley, and sprinkler and drip irrigation technology.

2.1.3. Overview of Irrigation Technology in Ethiopia

Crop failure Problem as a result of climate variability and drought are common events in rural Ethiopia (MoANR, 2011).It is recommended have to have irrigation to mitigate such chronic problem. Irrigation development in Ethiopia is vital because irrigation increase labor and land productivity, reduce rainfall reliance and mitigate risk of rain fall variability, reduce natural resource degradation, increase export earnings and job opportunity (Awulachew, 2010).His finding index that, irrigation is a pillar for Ethiopian agricultural development with the contribution of 140 billion ETB to the economy and improves 6 million household to food secured household. But, irrigation practice of Ethiopia is low only 14.8 percent is utilized out of a potential area of about 1,208, 548 million hectare for irrigation in year 2014/2015 (CSA, 2015).

According to Awulachew (2010) irrigation scheme is widely different in size and structure, ranging from micro irrigation to river diversion, pumping, small or large dams. Accordingly, irrigation in Ethiopia can be grouped in to three. (1) Small scale-irrigation (SSI): Small scale irrigation is an irrigation practice in areas less than 200 hectares. It is often community-based and traditional methods such as household-based rain water harvest, hand dug wells, shallow wells, flooding (spate), individual household-based river diversions and other traditional methods. (2) Medium-scale irrigation (MSI)**:** MSI is either publicly sponsored or community based with area of 200 to 3,000 hectares. (3) Large-scale irrigation (LSI): LSI is commercially or publicly sponsored covering more than 3,000 hectares include large irrigation scheme.

Transformation of SSI to large and medium scale one requires intervention either government and non-government agencies. Any intervention in irrigation is to manage water resource and increase productivity through the application of technology to storing, harvest, conveyance and distribute. By citing UN and FAO report, Balcom (2015) testified that irrigated land is twice as productive as rain fed cropland and hence irrigation helps farmers to grow high value cash crop. The major bottleneck of increasing irrigated food production through irrigation is lack of low cost productive technology and other barriers to adopt irrigation technology.

2.1.4. Contribution of Irrigation to the Household

Irrigating farming is imperative in most developing nations with inherent risky rain-fed production; frequent and chronic drought. Irrigation is considered as one of the best technologies for ensuring household food security and sustainable rural development within Africa's largest semi-arid zone

(*Namara et al., 2011,* Tekana and Oladele, 2011). Evidence from Australia infer that irrigation development has a strong multiplier effect on other sectors of the economy i.e. dollar worth of output from irrigated agriculture offer more than five dollars' worth of value (Ali and Pernia ,2003 cited in Tekana and Oladele ,2011).

Recent study by *Namara et al. (2011) in eastern Gahanna* revealed that shallow groundwater irrigation system create jobs and reduce rural - urban seasonal migration , seasonal under employment during dry season, poverty, and enhance food security status of the practitioners. More generally, irrigation schemes play a significant role in improving household food security (Tekana and Oladele, 2011).

2.1.5. Determinants of Irrigation Technology Adoption

The dimension of irrigation such as availability, access and use compliment with water lifting and application technology play a great role on the way irrigation intervention affect the farm household. The effects of Irrigation system on rural households' consumption, health, nutrition and over all wellbeing is depend on many factors that facilitate the adoption of irrigation technology (Domenech & Ringler, 2013).

Various empirical studies show that participating in irrigation activity is determined by various factors depending on the situation of irrigation technology and irrigation area. For example study by Sinyolo et al. (2014) probit model result show that land quality, household size, access to market and extension service motivate KwaZulu-Natal Ian (South Africa) farmers to be an irrigator, but those farmers are discouraged to participate in irrigation as their farm size increased. Moreover, relative advantages of the technology, difficulty to adopt and use, tradability (accessibility), number of extension visit, are the factors potentially encourage the irrigation technology adoption of Kwara state farm household. But, year of schooling, dependency ratio, irrigation frequency, membership of cooperative society, household size, low awareness to irrigation technology adoption and technology type selection are among factors which adversely affect adoption of irrigation technology in Kwara State (Rogers, 2005 cited in Adeniyi, 2014).

The Empirical evidences of Upadhyay, Samad, & Giordano, (2005) in Nepal also show farm household decision to adopt drip irrigation technology in Nepal was constrained by lack of capital. The empirical finding of Adeoti (2008) in Gahanna using 108 sample farm household shows that the household with high availability of labor that can assist the technology in the irrigation activity

and frequently visited by Agricultural extension worker have higher probability to adopt irrigation technology.

To sum up, irrigation technology adoption decisions of farm household is highly influenced by factors like physical asset (land), human asset (quality of household labor, education level of the household, quantity of labor in the household), financial asset (access to formal and informal credit), market access, social network, non-farm activities of the farm household (Gebregziabher et al., 2014; Godfrey et al., 2014; and Adeoti, 2008).

2.1.6. Gender and irrigation

Social constructs determine women's ability to access resources and services, produce food and earn income (Marslen, 2015). Given the opportunity and input, women are equally efficient as men; however women are less access to input, credit and information (FAO cited in Marslen, 2015). Closing such gap would increase agricultural productivity, reduce poverty and provide economic gains for the society.

It is common in developing country to engage women in precarious work (work with poor safety, health and benefit) and domestic work relative to both their men counterpart in agricultural sector and their women counterpart in non-agricultural sector (Department for International Development [DFID], 2014). The report also shows empowering women participation in agriculture have multiple effects on productivity, efficiency and economic growth through the chain of improving future economic participation of women and men via consumption, nutrition improvement and other investment in children.

Even though technology is crucial to maintain and improve agricultural productivity and product quality, gender gap exists in variety of agricultural technology adoption (particularly irrigation technology, improved plant varieties and animal breeds, fertilizers) distribution and access (FAO, 2011).

According to Awulachew (2010) even though irrigation offer opportunity for women by enabling to increase income, access to food and non-food resource, improve household nutrition and diversifying food Varity, it loads labor burden on women and allow men to share gains from farm earning on the shoulder of women. Hence, empowerment role of irrigation can be shown if net effect can be identified.

2.1.7. Measuring Empowerment

Empowerment is defined in various way based on personality, personal experience and aspiration. Alkier et al (2012) summarize the definition as empowerment is improving people's ability, which was the denied ability, to make strategic life choices and it is the capabilities of denied (poor) people to access, participate, influence, control, and make decision on the action that determine their lives.

Fed the future, IFPRI, OPHDI and USAID on February 2012 developed a novel index called Women Empowerment in Agricultural Index (WEAI) to measure the direct and indirect impact of intervention on women empowerment in multidimensional way and to quantify gender gap with in household (Alkier et al.,2012; Alkier et al., 2013). This innovative tool is composed of sub-indexes which measures both absolute (5DEs) and relative (GPI) measures of women empowerment. The absolute empowerment of women indicates the empowerment of women using the five equal weighted domain of empowerment such as control and decision over production, credit, income, leadership and time allocation in the sample which accounts 90 percent of total WEAI score. While the relative measurement index associates men and women empowerment achievements using the five empowerment domain in the same household and this sub index accounts 10 percent of WEAI score (Alkier et al.,2013).

According to Alkier et al. (2013) five domains of empowerment (5DEs) are measured using 10 weighted sub indicators. Each sub-indicator measures the adequacy achievement of the individual in each indicator. According to Alkier et al. (2013) the five domains of empowerment and its sub component is presented as follows:

Domain1: Agricultural Production domain: the dimension is concerning on agricultural production decision. The dimension consists of two indicators such as input in productive decisions and Autonomy in production. Input in productive decision is about: (i) Input to decision making about food crop farming, cash crop farming, livestock rising, and fish cultivation. (ii) Sole or joint decision over cash and food crop, farming, livestock, food and autonomy in agricultural production.

Women's decision making improvement through intervention is visualized through ensuring extension and advisory access to women, offer gender sensitive trainings that promote women's decision making over production and communication to promote women's decision-making over production (LEO, 2014; Alkier et al.,2013,McOmber and Ludgate, 2012).

Domain2: Resources domain: it is access, ownership and decision making power over productive resources like land, labor agricultural equipment and technologies, durable consumers and credits. Three indicators such as asset ownership; purchase, seal or transfer of asset and access to and decisions on credit are used to measure access to productive resource in WEAI. Intervention may improve women's resource access via women's access and control over land, furnish access to credit, facilitating to creating market linkage, and lastly by improving information technology access to women.

Domain3: Income domain: This dimension is the measure of the individual's sole or joint control over income and expenditure which is indexed by control over use of income. Opportunity for employment and off-farm business, market skill development, facilitating to technology access and adopting equitable decision making at household level are means of interventions used to augment women's control of income.

Domian4: Leadership domain: it addresses empowerment through social capital. It is aimed to assess economic or social group membership and public speaking difference between men and women. Group membership and speaking in public are indicators in WEAI to measure community leadership. Development of women's leadership role, women's active participation in group and collectives and facilitating literacy and or numeracy training are the role played by interventionist.

Domain5: Time domain: this domain is used to assess gender disparity and similarity of allocating time for farming activities and leisure activities. Time allocation dimension in WEAI is measured by leisure and workload indicators. Access to labor, time saving technology; and create awareness on sharing household and care giving activities with men are the role of the intervention to increase women's control over their time.

Moreover, Empowerment index concentrated on input in decision making not on values of income and achievement such as education (Malapit, 2013). Women Empowerment in Agricultural Index is context specific so empowerment in a specific domain does not guaranteed empowerment of women in aggregate (Alkier et al., 2013; Malapit, 2013; McOmber and Ludgate, 2012).

2.1.8. Household Consumption Behavior

In microeconomics theory the ultimate goal of the consumer is satisfaction and the economy is primarily ruled by consumer's desire called consumer sovereignty (Goodwin et al., 2008). But, is the act of consumption is the foundation of the final goals of all economic activities?

In the traditional views of smith all economic activities such as production, distribution is for final consumption so as to improve the wellbeing of the consumer in the "welfarist" view well-being is derived from the consumption of goods and services. This is why economists suggest the sole end and purpose of production is consumption.

On the contrary, consumption is not an end but it is the lifestyle (living standard) goal because people get satisfaction from work and production. A consumer seem turned to perceived satisfaction with reference point, reference group, and membership than the experienced absolute satisfaction (Durning, 1992). This implies consumption behavior of the consumer is depending on their current income status and their future life span decision.

In Keynesian absolute income hypothesis it is current disposable income not interest rate that matter consumption behavior of the consumer in developing country (Keynes, 1936). Even though the theory is prominent in consumption science, it has flaws both in theory and empirics. Theoretically, the forward looking behavior of economic agents concentrates on both current and future income to maximize their utility in their life time span. Empirically, the relationship between income and consumption creates a paradox called Kuznets paradox, which is in line with Keynes theory in the short run but not in the long run, APC is constant and MPC are equal.

Moreover, consumption is not solely determined by current income rather the relative consumption pattern derived from the pattern of income and the relative income, relative to pervious income and to other individuals' (Dusenbery, 1949 cited in Tapsin and Hepsag, 2014).

On the view of M. Friedman's permanent income hypothesis, consumption is depending on income, which is subject to both permanent and temporal income fluctuations. But consumption reacts with only to the variation of permanent income since the individual seek to smooth consumption (Tapsin and Hepsag, 2014). Consumption is smoothed via saving and borrowing so that consumption depends on current income; and weighted average future income and wealth, which is viewed by Modigliani as life cycle hypothesis.

The life cycle model of consumption predict that individual smooth their consumption by keeping marginal consumption constant across their life stage. This smoothing is through borrowing at early age, accumulating wealth at working life and dis-saving at retirement stage of their life span (Browning and F. Crossle, 2001).

According to halls' (1978) "rational expectation theory", consumers use all the available information about their future income and make their decision based on the information at hand to smooth consumption (Dornbush, et al., 2010: 393, Hijdra, 2002).

According to Durning (1992) high-consumer enjoy luxury life, moderate-consumer moderate mode of life and deprived consumer unable to access basic necessities such as minimal nutrition, shelter, clothing, elementary education, basic health care and sanitation for its members[2]**.** Thus consumption situation of the household, individual is an indicator of household and individual nutritional and over all well-being (welfare) (Moratti, and Natali, 2012; Deaton, 2002).

2.1.9. Concept and Measurement of Household Welfare

Welfare is the provision of a minimal level of wellbeing and social support for all citizens, sometimes welfare is referred to as *public aid.*

The concept of welfare and utility are related but not identical: welfare is derived from either a direct consumption of goods or characteristics of goods while utility is derived from only consumption (Grootaert, 1982). Atkinson (1998) cited Sen.'s view of "welfare theory" it is beyond individual utilities weather it is treated as pleasure or fulfillment". This is why standard welfare economics is criticized since it neglects health, morbidity and longitive information.

As cited by Grootaert (1982) Muellbaure (1980) outlined that welfare is determined by consumption of goods and services at household level, household composition and access to public services; and leisure time at individual level. For Sen "it is not commodities, its characteristics, nor utility derived

[2] Durning (1992) classified consumers as **first**, high-consuming consumer: who enjoy luxury life, travel by car and air, eat meat-based diets, and live in spacious and single-family residences. **Second,** moderate consumer: comparing to their reference group they seem deprived, but they are well-off indeed when compared to any but the richest individuals. They access healthy diet, public transportation, use mechanized tools; light, heat, and running water in homes and workplaces; much improved and convenient sanitation. **Third,** deprived consumer: is deprived of the necessities of life such as unable to obtain minimal nutrition, shelter, clothing, elementary education, basic health care and sanitation for its members.

for the commodity, but something called capability[3] matters welfare" (Sen, 1983 cited in Atkinson, 1998).Welfare study identifies the group who are getting better or worse-off, and the dimension (s) in which they mainly do so in society.

In welfare analysis the central issue is determining plausible welfare indicator for use. However, getting credible welfare indictor is not as such easy since the living standard concept is inherently multidimensional (Deaton, 2002; Grootaert, 1982). Grootaert (1982) summarized the measure of welfare in to three such as true index of welfare, full total income and full expenditure.

(1).True index of welfare: the index is derived from household consumption and employment behavioral model with the idea that association of welfare associated with preference such as goods, leisure, household composition, access to public service, decision to have children. Even if this method of measuring welfare is well recognized in its direct measure it has critics such as: it is not applicable in areas where labor market is failed or absent, it falls to capture voluntary non-participation. Thus, the identification and measurement problem lead to unreliable and inconsistent measure of welfare.

(2). **Full income concept:** in this approach welfare is measured by the total income the household generate from any source of income plus the monetary value of leisure activities and non-paid home activities (opportunity wage rate for home activities) (Adeniyi, O. A., 2014). But, welfare measure by income is subject to measurement error since income source of farm household is more diversified, income is volatile; and by its very nature and sensitivity income is under reported by the owner (Natali & Moratti, 2012; Deaton, 2002; Slesnick, 1998).

(3). **Measure of welfare by consumption**: welfare is considered as the function of consumption of goods and services with the assumption preference is revealed by purchase of goods and services (Deaton, 2002; Deaton and Ziadi, 2002). Moreover, in welfarist approach individuals are the rational judge for their needs which is revealed through consumption, utility and hence welfare.

Although, different indicators are used for welfare analysis, consumption is taken as a proxy for living standard indicator (Moratti, and Natali, 2012; Deaton and Zaidi, 2002; Deaton, 1997; Grootaert, 1982 and Amendola and Vecchil, n.d).

[3] Capability refers to what a person can achieve such as being able to take part in the life of the Community. Capability well-being is measured directly by capabilities itself; such as, the percentage of underweight children or indirectly, access to a trained health professional at birth, education and other public services.

The consensus on favoring consumption over other indicators (true index of wealth or asset) especially in a developing country context is because: first, material well-being is opted from consumption of goods and services not from either permanent or temporal income (Citro and Michael, 1995 cited in Moratti and Natali, 2012); hence consumption optimally capture standard of living. Second, Consumption is more stable and smoothed over season especially for agricultural societies; as a result, it is a reliable indicator of real living standard (*Browning and Crossley, 2001*). Third, measuring income of the household is difficult especially in self-employed households and informal sector. In addition, consumption is conceptually clearer than income and wealth though collecting data on consumption is time consuming. Lastly, consumption is less likely to be more sensitive issue for respondents than income (Deaton, 1997 cited in Moratti, and Natali, 2012): hence respondents are willing to participate in the survey or to respond.

Individual welfare is more prominent to compare the welfare status of people especially in comparative analysis but the per capita measure may mislead due to economy of scale in consumption. But, the best to do is adjusting total household expenditure via adult equivalence and inflation.

Even though there is no standard measure of equivalent scale, as cited in Deaton (2003) the national research council (1995) formulates the adult equivalent scale is calculated as:

$$AE = (A + \alpha\omega)^{\theta} \quad ----------(2.1)$$

Where AE *is adualt equvalence,* A *isnumber of adult in the household,* α is relative cost of children, ω *is number of children and* θ *is economies of scale.*

Cost of children and economies of scale are sensitive to nation's status. As Deaton (2003) noted that cost of children in developing countries are so cheap but in developed countries are expensive so "α " close to 0.3 and one respectively. Likewise, economies of scale is related to either the good mostly consumed is common or private good, in developing countries food consumption which is a private good takes three-quarter of the household budget as a result economies of scale is limited . Hence, "θ" close to unity but for a developed country economy of scale is relatively higher perhaps it is closed to 0.75 regions.

Therefore, Welfare indicator must account welfare difference as a result of household size and adjust with appropriate living cost (Deaton and Zaidi, 2002; Deaton, 1997).

Thus, welfare indicator is total nominal household consumption expenditure adjusted to price difference (inflation and price differences across geographical area) and household need (need difference due to household demographic structural different).

As formulated by Amendola and Vecchi (n.d)

$$Welfareindicator = \frac{\text{Nominal household consumption expenditure}}{(temporalCPI) * (spatilCPI) * (householdequvalentsize)}$$

2.1.10. Impact Evaluation and Impact Evaluation Approaches

2.1.10.1. Impact *Evaluation*

Impact evaluation assessment is simply evaluating how outcomes of interest are changed as a result of particular intervention such as project, program or policy (Gertler et al. 2011, Khandker, 2010; Koolwal & Samad, 2010. In other words, impact evaluation proving the changes in the outcome is due to only the specific intervention and get an affirmation whether the beneficiaries are truly benefiting from the program or not.

Moreover, any intervention has a policy quest to determine the effectiveness of the intervention to enrich the pertinent goal. Thus, impact evaluation may qualitative, quantitative or both.

Qualitative impact evaluation is simply the assessment of the impact regarding on the identification of the way to implement, operate the intervention not the outcome of beneficiaries due to intervention. Hence, it can't indicate what if in the absence of the intervention (Gertler et al., 2011 and Khandker et al., 2010). Unlike qualitative impact evaluation, quantitative impact evaluation indicates what happen in the absence of the intervention and evaluate the outcome against the counterfactual outcome (Gertler et al., 2011). Quantitative impact evaluation may be two types ex post and ex ant. An ex-post evaluation examines the actual impact/ outcomes after program based on actual data either after or both before and after program implementation across participants and non-participants (Khandker *et al.*, 2010). While an ex-ante evaluation predicts the possible benefits or pitfalls of an intervention using data before intervention through simulation or economic models at the given individual behavior and markets (Gertler et al., 2011; Todd and Wolpin, 2006; and Bourguignon and Ferreira, 2003 cited in Khandker et al., 2010; and Baker, 2000).

2.1.10.2. Impact Evaluation *Approaches*

The main challenges in impact evaluation are three main challenges (1) determining the impact of the intervention on interested outcome because the outcome may occur as a result of factors other than the intervention (Khandker et al., 2010 and Backer, 2000), (2) causality establishment(Gertler et al., 2011) and (3) Determine what would have happened to the beneficiaries in the absence of the program (Khandker *et al.,* 2010).Such problems are solved by applying rigor empirical methodology to estimate difference of the outcome with and without intervention (Baker, 2000). But it is difficult to observe an individual with and without intervention simultaneously. So the contest is to create a convincing and reasonable counterfactual for beneficiaries. Counterfactual is determined by net out of the impact of intervention from other factors via comparison of "control"[4] groups to "treatment"[5] groups (Gertler et al., 2011 and Baker, 2000). The appropriate counterfactual is obtained either through experimental and non-experimental approaches (Leeuw, and Vaessen, 2009; Baker, 2000 and Shadish et al., n.d).

2.1.10.2.1. Experimental Designs *Approach:*

This design use random allocation of intervention among eligible beneficiaries create statistically equivalent treatment and control group at the appropriate sample size, which enable to reduce selection bias (Baker, 2000).The impact of the intervention (treatment effect) on the beneficiary group is simply computed as the difference between the outcome of the treatment and the control group as average treatment effect (Khandker et al., 2010 and Baker, 2000).

Though experimental design is treated as an optimal approach to evaluate impact of the program researchers prefer to use quasi-experimental approach because of its flaw such as: unethical issue, difficult to maintain treatment and control group, don't accounting for spillovers effect, and heterogeneity in participation and ultimate outcomes (Khandker et al., 2010 and Baker, 2000).

2.1.10.2.2. *Quasi*-Experimental *(Non- Experimental) Approach*

A quasi-experimental (nonrandom) method is carried out when it is not possible to construct treatment and control groups through experimental design. Control and treatment groups are

[4] Control group refers a group without program intervention, who are not-beneficiary of the program, in our case non technology user.

[5] Treatment group refers a group with program intervention, who are beneficiary of the program in our case irrigation technology adopter.

selected randomly conditional on observed characteristics such as land size, family size, and age and so on.

The technique generate comparison (control) group, which have similar features with treatment group at least in observed characteristics, to match with treatment group through econometric methodology (Baker, 2000).

Even though quasi-experimental design is quick and cheap to implement, implement after intervention, it is subject to flaws like problem of selection bias which causes inaccurate results.

It is possible to solve such observable and non-observable bias and problems through statistical techniques econometric methodologies such as propensity score matching, double difference methods, instrumental variables methods, and reflexive comparisons (Baker, 2000).Of the various quasi-experimental design techniques, matched-comparison technique is generally considered as a second-best alternative to experimental design.

Propensity Score Matching (PSM) Method: Basically matching approach is used to estimate what would have happened to someone under the counterfactual through estimating participant's outcome in the absence of participation using the observed outcome for a similar non-participant (Lance et al., 2014). The ultimate goal of matching is match participants with non-participants based on the probability of participation in the treatment through observed characteristics (Khandker et al., 2010). The underling concept in PSM is that if treated and control groups are matched, both have same probability of being participant (Baker, 2000).

Once a matched sample has been designed, the treatment effect is estimated by comparing outcomes of treated and controlled group in the matched sample.

Propensity score matching has advantages and disadvantages. Advantages propensity methods over the other method are: first, it reduces dimensionality of matching (Gilli and Rampichini, 2011). Second, it is possible to do in the absence of baseline or panel data (Khandker *et al.,* 2010). Third, it avoids an ethical problem which is denying of potential beneficiaries as a result of random assignment (Baker, 2000). Fourth, data generation is less costly as compared to experimental method.

While requiring large sample, group overlapping in propensity score, sample exclusion with propensity score[6] outside common support and an unobservable bias are among the flaws (Gertler et al., 2011).

Difference-in-Difference (DD) Approach: it is a powerful non randomized statistical tool that compares the change in outcome overtime between the treatment group and the comparison group (Gertler et al., 2011). The method compare the outcome of treatment and comparison group before (first difference) and after (second difference) intervention by using panel data (Gertler et al., 2011, Khandker *et al., and* 2010, Baker, 2000).

In this method there is no problem of selection bias since the unobserved heterogeneity is time invariant (Khandker *et al.,* 2010).

Relaxation of conditional exogeneity assumption or selection only on observed characteristics and provision of a tractable, intuitive way of accounting unobserved characteristics for selection are advantages of the method. While, the assumption of time invariant bias is the main drawback of this method (Gertler et al., 2011 and Khandker *et al.,* 2010).

Instrumental Variable (IV) approach: this method is used when a variable called 'instrument' identified as instrument which is highly correlated to participation but not to outcomes. After identifying such variable treatment effect is estimated via instrumental variable approach (Khandker *et al.,* 2010).

IV method allows endogeneity either in individual participation, program placement, or both. In this approach, selection bias on unobserved characteristics is corrected by finding a variable (or instrument) correlated with participation but not correlated with unobserved characteristics that affect the outcome (Khandker *et al.,* 2010). Instruments should be selected carefully. This "instrumental variables" are used to predict program participation; and then to see how the outcome indicator differs with the predicted values (Baker, 2000). The advantages of IV method are capturing measurement error via calculating intention to treat (ITT). But appropriate instrument is not easily accessible.

Reflexive comparisons: In this approach, baseline survey before the intervention and follow-up survey after the intervention is done on the participant. Impact is measured by the change in

[6] Propensity score is the probability of being participant (treated by the intervention).

outcome indicators before and after the intervention, baseline provides the comparison group (Baker, 2000).

2.2. Impact Evaluation Studies

Well-being maximize resource allocation decision of farm household is mainly relied on resource endowment (natural, physical, human social capital and financial capability), social, political and institutional factors. Likewise, either positive or negative shocks (such as technology change) affect perception and decision of farmers, which mainly influence their consumption level and behavior (Sharma and Singha, 2015). Household decision on irrigation technology adoption affects the expected outcome such as production and then consumption (welfare) of the household.

The empirical finding of Dillon (2011) adopt the propensity score matching to investigates differences in household production and consumption among small- and large-scale in Mali and the cross-sectional evidence infer that small scale irrigation has no effect on consumption of farm household, but his pooled estimate show that large scale irrigation improve consumption of the household.

Irrigation practice boosts consumption capability of the household through production and accessibility improvement. Study finding of Gebregziabher et al. (2009) in Tigray region, Ethiopia; Sinyolo et al. (2014) in KwaZulu-Natalian, South Africa, and Adeniyi, 2014 in Kwara state, Nigeria show that irrigators have more consumption expenditure per adult equivalent per year than non-irrigator.

Study conducted by Upadhyay et al. (2005) in Nepal to analysis gender issues in micro-irrigation technology and impacts of drip irrigation on men and women's lives found that drip irrigation technology reduce the time spent to collect water but increase women's work load which improve women's empowerment in agricultural activates such as rights in household resource and control over income, income use and control, decision making role in the household, membership in groups (self-help group) and participate in meeting. The impacts of irrigation intervention on women's empowerment depend on the situation women involved in agricultural activities either as laborer and decision maker. (Domenech & Ringler, 2013, van kopen, 2002).

On the contrary, due to cultural norm women are no equally fortune to adopt and empower their selves by adopting irrigation technology. For example rice producer women in Gambia allowed

adopting pump irrigation technology because women in the area are allowed to engaged and control only the rain feed agriculture (spring and Swallow (2015).

Women's access and participation in irrigation has a multiplier effect on improving household wellbeing both in the short and long run since women mainly invest more on nutrition, health and education than men (www.ifpri.org/ilssi).

Recent studies demonstrated that gender empowerment/involvement in agriculture adversely affect the nutritional status of children. For example, study by Steiner et al. (2012) investigate mother and children nutritional status in Ghana and found that those children whose mother actively participated in agricultural and other activities out of home have low nutritional status.

On the other way round, women empowerment in agricultural activity and household welfare are highly related. The broad consensus women spend more of their income on investment in their household welfare through education, health and nutrition is also supported by evidence of Quisumbing and Maluccio (2000) and Doss 2005 cited in DFID (2014), which suggests women's involvement in income generating activities has greater impact on increasing welfare and child nutritional status of the household. Women protect household welfare by drawing down assets hence greater economic empowerment of women enhance welfare of the household.

The impacts of irrigation on consumption, women empowerment and welfare are interrelated. An improvement in one outcome (such as women empowerment) leads to the improvements in consumption and nutrition. This in turn increase health and productivities in irrigation activities, which in the long run have a potential benefit of empowering women.

If women spent much more time on irrigation activity and control the income from irrigation it is highly probably to increase the nutritional status of their child. The empirical investigation in Nepal by Malapit et al. (2013) show that that nutritional status of child under five years old is determined by women empowerment in agriculture. Likewise, study of Schnepf (1992) in Rwanda also show that mother's time allocation to breast feeding and introducing supplementary food, resource control of mothers are the main determinants of household nutritional status in general and nutritional status of the child in particular.

Malapit et al. (2013) Study in Nepal show that Work load of women in both paid and unpaid working activity disempowering them. But it improves the nutritional status of the family member as a result of income effect. On the contrary, study of Malapit et al. (2014) in Gahanna found that

women's empowerment weakly associated with child nutrition status but strongly associated with child feeding practices.

Women's relative power to men determine the power to control over income, resources, time and overall household decision making which has direct implication on their own and child nutritional status. Study of Smith et al. (2003) cited in DFID (2014) show that women in South Asian has low status and decision making power as a result malnutrition (being underweight, stunted and wasted) of their child is higher (Domenech and Ringler, 2013).

The impact assessment of intervention, program, policy and adoption of irrigation technology on household welfare employ different methods. For instance Asfaw (2010) adopted propensity score matching (PSM) to assess the welfare effect of agricultural technology in Tanzania and Ethiopia and found that the adoption of improved agricultural technology has a potential direct role on improving rural household welfare. In the same way Sharma and Singh (2015) conducted a study on the impact of access to modern Agricultural technologies on farm household welfare using household unit data collected in 2003 and found controlling of other household characters access to modern agricultural technology offer a significant positive impact on rural Indian household welfare(measured by consumption expenditure). Awotide, Diagne, & Omonona (2012) also evaluate the impact of improved agricultural technology adoption on rural farmer's welfare in Nigeria and analyze the data from 481 farm household using instrumental variable method. The Local average treatment effect result shows positive and significant improvement in productivity and household consumption expenditure (proxy for welfare). Moreover, Adeoti (2008) conduct an empirical study to identify technology adoption factor and its impact on household poverty in Gahana using Heckman two-stage model for the household level data from 108 household and found that irrigation technology adoption reduce poverty and improve welfare of farm household in Gahana. Besides, the treatment effect model and propensity score matching method result point out that household with smallholder irrigation access improve their household welfare which implies small holder irrigation plays a vital role in reducing poverty in KwaZulu-Natalian, South Africa (Sinyolo et al., 2014). Other studies also show a positive impact of agricultural technology include; Upadhyay, Samad, & Giordano (2005), Munongo and Shallone (2014).

To sum up in the review of literature there is no study that reveals the impact of irrigation technology on farm household welfare status in Amahara region. So as to fill this knowledge gap,

this study attempts to quantify the impact of technological and technical intervention on farm level agriculture.

Irrigation intervention may reduce women of collecting water and help to participate in other activities which create the workload for women. As gender role in agriculture vary depending on context, impact of irrigation intervention is not yet well identified and documented.

CHAPTER THREE

Research Methodology

The study focuses on the analysis of farm household welfare impacts of irrigation technology in the project site of ILSI in Ethiopia. Thus, this part of the paper is about the methodological parts of the study that would be employed to achieve pertinent objectives of the study. More specifically, it provides a clear picture of data type and sources, method of data collection, sampling techniques, sample size determination, data analysis and diagnostic tests.

3.1. Project Description: Innovation Laboratory for Small Scale Irrigation (ILSSI)

Feed the Future Innovative Lab for Small Scale Irrigation is a five year project started since 2013. It is a cooperative agreement funded by USAID under the feed the future; and the leadership, management and administration is led by Borlaug Institutional Agricultural /Texas A&M University. The aim of the project is to increase food production, improving nutrition, livelihoods of farm household, accelerating economic development and protecting the environment through access to small scale irrigation technologies. Furthermore, expanding irrigable land using optimum irrigation technique, increasing livelihood of farm households and securing economic wellbeing of the community are also the ultimate objectives of the project. The objectives of the project are achieved through identifying, testing and demonstrating the technological options in small scale irrigation and irrigation fodder production.

ILSSI intervenes to solve the problem of irrigation technology by providing water lifting technology and techniques of water saving irrigation. The project implements the most efficient small scale irrigation systems to battle poverty, malnutrition problems and improve the livelihood of farm household in Tanzania, Ethiopia and Ghana. In Ethiopia the project has intervening since 2014 in Dengeshita (Dangila wereda) and Robit-Bata (Bahir Dar zuria wereda) in Amahara regional state, north site; Admi Tulu and Limo in southern site in Oromia region and in south nations nationalities and peoples region respectively. The intervention in such site is technical (provision of technology like pulley, Rope-and-washer, motor pump, and solar pump technology) and crop (tomato, onion and fruits).

3.2. Description of the Study Area

The study was conducted in Amahara Region particularly in two sites of ILSSI project namely Dengeshita and Robit-Bata in Amahara regional state.

Dengeshita is found in Dangila woreda, which is one among the pilot weredas of Agricultural Growth Program (AGP) and USAID Feed the Future in Amahara regional state. It is located in southwest of Bahir Dar with 80 kilometers distance. The woreda has 27 rural Kebeles among them 16 are endowed with rivers. On average, the annual rainfall is 1600 mm with a range of 1180-2000mm. Moreover, the ground water mapping indicates that Dangila wereda has a potential for well drilling which shows the potential to demonstrate small scale irrigation technology. In this woreda only one (Dengeshita) Kebele is selected for ILSSI project implementation.

Robit-Bata is the rural Kebele found in Bahir Dar zuria wereda, 10 kilometers distance in north site of Bahir Dar. Bahir Dar Zuria wereda particularly Robit Kebele is also one of the AGP and Feed the Future site in the region. Climatically, it is sub-tropical and the Kebele is potentially endowed with ground water. Motor pumps together with manual water lifting devices are widely used in the area and shallow groundwater, river diversion and pump are the main source of irrigation water. In the year 2015, there are about 1820 ha of land was irrigated and 4000 wells are found in the Kebele. Robit-Bata Kebele is also another site of ILSSI and the area where the target household is located.

For both study areas the main economic activity relay on agriculture activities, both rain fed and irrigation based production of cereal crops, Chat, Tomato and Onion. The livelihood of both Dengeshita and Robit farm household is rely on the production of cereals and high value cash crops in both rainy and dry season. The areas are endowed with ground water; and well known to have irrigation with their open well and adopting small scale irrigation technologies such as Rope-and-Washer and Pulley in the region. Rain fed agriculture is predominantly practiced to cultivate major staples such as Maize, Millet and Teff. Manual irrigation is extensively practiced in dray season for cultivation of vegetables such as Onion, Tomato and Pepper; and Cash crop including Chat.

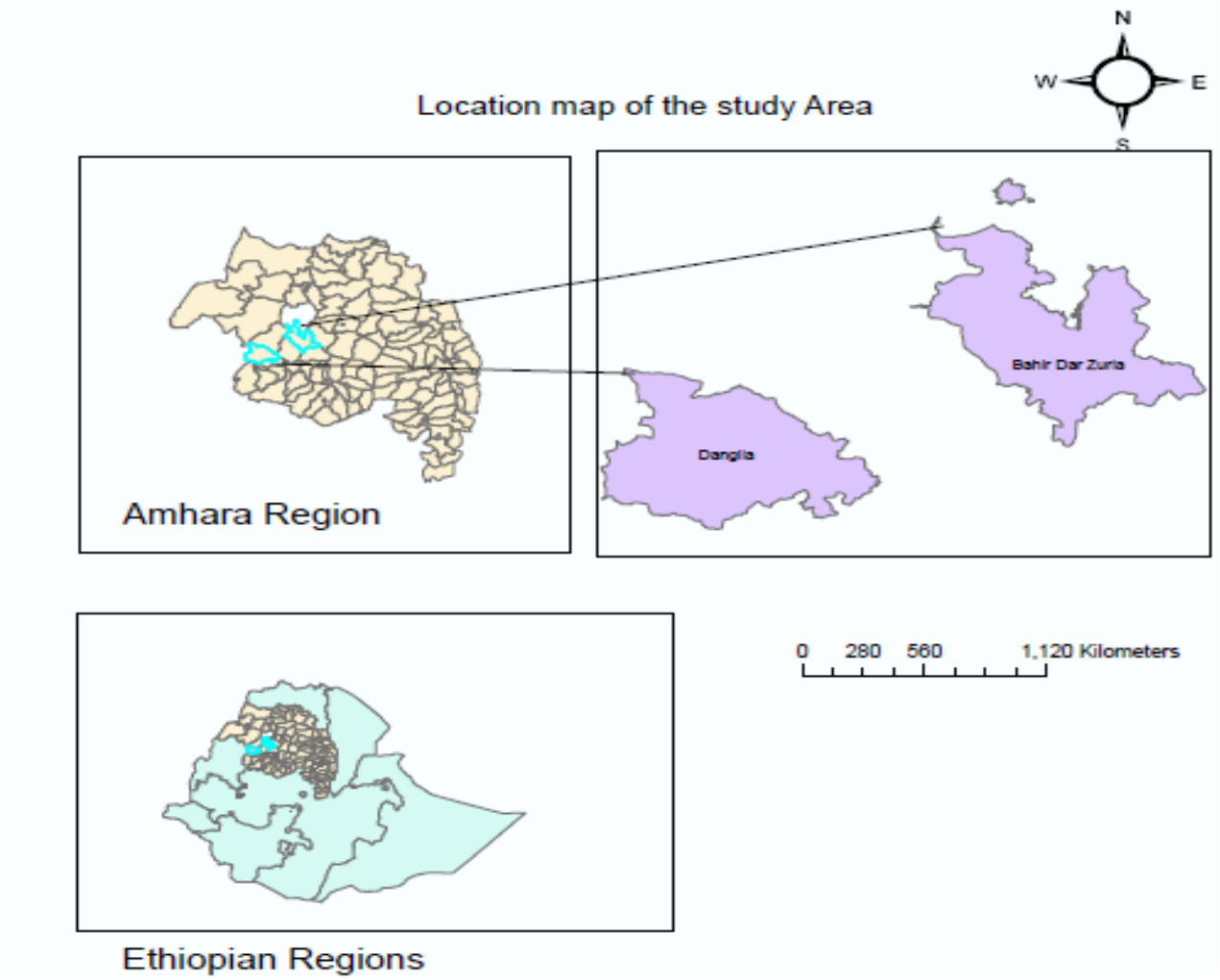


Figure 3.1: Map of the study area

3.3. Research Design

Research on impacts of interventions employs either quasi experimental or non-experimental evaluation approaches. Special impact evaluations used quasi experimental designs to construct plausible counterfactual group (WB, 2011 and Khandker *et al.*, 2010).Since, selection bias subjectivity of treatment is a common problem in such types of investigation, randomizing of treated household is difficult (Domenech, 2015). According to Lance and others (2014) Quasi-experimental evaluation is appropriate unless the participant is fully randomized.

This study being an interventional study employed a quasi-experimental research designs to address selection bias by statistical method such as propensity score matching (Boulevard, 2013). The approach captures the selection process to control the outcome variable.

3.4. Data Type, Source and Collection Techniques

The study was undertaken by using both survey (primary) data and secondary data. Survey was carried out to collect valuable information on household composition, socio economic and demographic characteristics, farm and non-farm income, asset ownership and gender empowerment were collected through a pretest structured questionnaire. The structured questionnaire was prepared in English language and translated to Amharic language for convenience of communication between enumerators and respondents. Secondary data (about consumer price index) was collected based on desk from Central Statistic Authority report.

Over all consumption data includes goods purchased, own production or stock and gift from others. Consumption expenditure data on food consumption and nonfood consumption (health expenditure, fuel consumption) and durable goods were collected by seven days, three month and 12 months recall method respectively. Data were collected using structured interview schedule through interviewing either the head or his/ her couple.

Generally, data were collected from early may through mid may 2016. The questionnaires were administered by professionals of BA degree holders in statistics with more than 3 years experience in Central statistics Agency and other NGOs.

Women's empowerment in agriculture were measured by administering the WEAI questionnaire developed by Alkier et al. (2013) and piloted in Bangladesh, Uganda, and Guatemala. Self-identified primary male and primary female decision makers were chosen as respondents to the WEAI module.

3.4.1. Data Measurement Issue

The total food consumption expenditure consists of all expenditures spend out to purchase goods and services including the values of foods consumed outside the house; and own production used for food.

Data on nonfood commodities and services were collected through recalling for the previous three months and 12 months. The three months reference period was applied to a range of nonfood consumption goods such as clothing, medical services, and leisure and entertainment, fuel, charcoal, matches, transportation, and a variety of other products. Expenses throughout 12 months period were for durable goods (like radio, tape, furniture and others) and ceremony expenditure. The

annual total consumption was computed by annualizing the weekly food consumption, three month non-food consumption via the multiplication by 52 and 4 respectively (Teppa, 2014).

3.5. Sampling Technique and Size

The study uses 201 sample farm household (79 treated and 122 non-treated). Treated households were selected by purposive sampling techniques from the two (above two purposely selected areas) ILSS project sites in Amahara Regional State namely Dengeshita and Robit. These targeted 79 households were selected by ILSSI project at the time of the intervention and distribute two irrigation technologies (Rope-and-Washer and pulley) in the form of credit to produce the same crop (Elephant grass and Tomato in Robit and Onion in Dengeshita and Pepper in all sites). These targeted households (31 from Dengeshita and 49 from Robit) were taken as a sample of treated group (irrigation technology adopter) for this study. About 122 farm households were selected as counterfactual of the treated group from the non-technology adopter household through multistage cluster sampling technique. In the first stage, Dengeshita and Robit sites were selected purposely by which ILLSI project is intervene. In second stage, non-technology adopter farm households were selected randomly in the same area. Since the population is relatively homogeneous, 122 sample sizes as a control group were considered as sufficient for constructing reliable counterfactual.

3.6. Ethical Issue

Research proposal (plans) and instruments were submitted for ethical review and approved at Amahara regional ethical review committee, Bahir Dar, Ethiopia. As part of the ethics review, guidelines of informed consent of interview participants were reviewed. In all survey informed consent pages were translated into local (Amharic) language.

3.7. Method of Data Analysis

After data set was collected, the collected data were coded and analyzed by a couple of SPSS version 20 and STATA13 statistical package software**.** In this study, descriptive statistics, inferential statistics and econometric analysis were employed to analyze the impact of the intervention on treated group. Impact indicator data may be gathered at different time i.e. before, during and after the intervention to show changes. However, when panel and/ time series data are not available comparison is made by using cross sectional data (Kumar, 1989).

Welfare impact evaluation was conducted to answer a question what if a household has not adopted irrigation technology. It is possible to observe the same households with and without irrigation

technology if there was a base line survey. Otherwise, it is important to develop a counterfactual similar to the beneficiary households, but without irrigation technology. In such away the same indicators are used to gather data from comparable groups so as to determine the change. Annual consumption expenditure adjusted to household size and inflation was used to lean more reliable and accurate measure of welfare (Amendola & Vecchi, n.d).

Descriptive statistics such as mean, percentage, cross tabulation, frequencies, graph, ratio, standard deviation were used to analyze socioeconomic, demographic characteristics of the sample household, nutrition and empowerment status of the household. In addition to this, inferential statistics like t-test and chi-square tests were also used to test the difference between technology adopter and non-adopters in terms of covariates and outcome variables.

In evaluation of intervention, participants were selected purposively not randomly hence selection bias is a key limitation though it is solved by propensity score matching (PSM). PSM was employed to estimate the impact of irrigation technology on household's welfare. Impact through this outcome variable was obtained by matching an ideal comparative group (non –technology adopter) to the treatment group based on the propensity score of the observable characteristics that determine technology adoption. By doing so, selection bias is eliminated and impact of irrigation technology on participant was obtained through comparison of the observed outcomes of participating in the program (adapting the technology) and what if not participated (Lance et al., 2014 and Leeuw& Vaessen, 2009).

But, unlike non observed (counterfactual) outcomes, only factual outcome is observed, which makes impact evaluation too difficult. The optimal remedy is getting large number of counterfactuals (Caliendo and Kopeinig, 2005). This can be done via the difference in outcomes of control and treatment group.

3.7.1. Measurement of *Women* Empowerment

The empowerment of women is measured by Women Empowerment in Agricultural Index (WEAI). WEAI is the latest index developed in 2012 by Feed the Future, USAID, IFPRI, and OPHI as direct indicator of economic empowerment and gender parity at household and individual level (Leveraging Economic Opportunities [LEO], 2015 and Alkier et al., 2012). Empowerment is dynamic and complex concept hence one indicator alone is not adequate to measure. As a result, in this research the Alkier-Foster (2013) multidimensional measure of empowerment were adopted.

The Alkier-Foster multidimensional measure of empowerment enables to show women's achievement in each ten indicators and five domains of empowerment[7]. WEAI helps to measure empowerment in multidimensional way by using the weighted five domains and ten indicators, which allows decomposing and comparing across different domains. WEAI combine two sub-indexes such as five domains of empowerment (5DE) and gender parity index (GPI) to make one final index for measuring women's empowerment. The arbitrary weights of sub-index 5DE and GPI are 90 and 10 percent respectively. Even though the weight gives prominence to 5DE, it still recognizes the importance of gender equality in empowerment.

In this paper the negative notion[8] of measuring empowerment was applied and two indices were calculated such as disempowerment index (counter of 5DE) and intra-household party index (GPI).

The five domain of empowerment sub-index evaluate whether women are empowered across the five (production, resource income, leadership and time) domains.

Even though the final goal is measuring empowerment, analyzing disempowerment allow to identify indicators to be addressed so as to improve empowerment. The disempowerment index in each five domains is constructed from the weighted ten indicators, which was constructed as a weighted aggregate of the variables that contribute to the status of the individual in each indicator. Hence forth, in each indicator the adequacy situation of an individual is determined via the multiplication of the variable with their defined weight and comparing with the inadequacy cutoff. Once adequacy score of an individual and inadequacy cutoff is determined, the overall disempowerment index (M0) is constructed using the weighted indicators (Alkier et al., 2013; Alkier et al., 2012). The disempowerment of women is decomposed by indicators and domains to show the contribution of each indicator and domain for disempowerment or empowerment. Empowerment in five domain is a counter part of disempowerment which is computed as 5DE=1-M0. 5DE are measured using ten indicators with their corresponding weights (see appendix 1). Each indicator shows whether each individual reached a certain threshold (has adequate achievement) in that area or not.

[7] See Appendix 1

[8] According to Alkier et al. (2013) there are two notions of constructing 5DE. The positive notion concentrate on percentage of empowered and adequacies among disempowered women. But the negative notion evolves on measuring the percentage of disempowered women and the percentage of women who they have inadequate achievement.

Another innovative feature of WEAI is GPI, which reflects gender differentials in empowerment (the disparity of women and men) in the same household. Mathematically:

$$WEAI = 0.9(5DEs) + 0.1\ GPI \quad \text{---------- (3.1)}$$

Where $WEAI$ index of gender empowerment, $5DEs$ is degree of empowered women and GPI is the relative empowerment of women in the household. 0.9, 0.1 are the weight given to the indexes. All indexes were generating by STATA with respective sub-indexes. See appendix 1 and 2 for details of the computation.

3.7.2. Propensity Score Matching Model

Randomized assessment of treatment ensures similarity of treatment and control groups before treatment assessment. But, due to many drawbacks such as expensiveness, non- amenable to extrapolation and ruling out of spillover effect, ethical and practical issue; random assessment in social science study is rare (Blundell and Dias, 2000). Matching method consists of statistical techniques to evaluate treatment effects of the closed comparison group using observable data (Gertler et al., 2011). Among quasi-experiment design techniques matching is the best alternative, which enables to identify the set of control groups that look most similar to the treatment group (Gertler et al., 2011; Khandker et al., 2010; Rosenbaum and Rubin, 1985, 1983a cited in Austin, 2011)

Propensity score matching (PSM) identify a group with the same observable characteristics as to participant in the intervention. This is done via estimating statistical model of participation probability (propensity score) using binary regression model, in which treatment status is regressed on observed baseline characteristics, which must not be affected by intervention. This estimated Propensity score is the predicted probability of treatment derived from the model, and treatment groups are matched with non-treatment group based on similar propensity score (Austin, 2011)

To know the impacts of adopting small scale irrigation technology on adopter individuals, the observed outcome should be compared with the outcome that would happen if that individual had not adopted the technology. However, only outcome of using the technology is observed, so called factual outcome. The outcome which would have resulted that if the participating individual had not adopted the technology, so called counterfactual outcome cannot be observed. Hence, the essential problem in program evaluation is missing data (Austin, 2011, Khandker et al., 2010).

The prominent solution for the aforementioned problem is finding large group of control groups who have similar pre-treatment characteristics with the treatment group (Austin, 2011, Blundell and Dias, 2000). In doing so, identifying the effect of treatment on potential outcome of treated group if they don't participated is possible via counterfactual group.

The observed potential outcome Y is given by the potential outcome model specified by Sianesi (n.d.) as:

$\tau_i = Y_{1i} - \boldsymbol{Y_{0i}}$, Where$Y = Y_{0,}$ if $\varphi = 0$ and $Y = Y_{1,}$ if $\varphi = 1$

So for binary treatment, let φ is program participation with value one (1) if the farmer adopt irrigation technology and zero (0) otherwise. The impact of participation on individual i, is the difference between potential outcome of technology adoption and not-adoption. In simple sense, impact of intervention on an individual is the difference between the outcomes with technology adoption (φ= 1) and the same outcome without adopting irrigation technology (φ = 0) (Lance et al., 2014; Gertler et al., 2011).

$$\tau_i = Y_1 - Y_0 \quad \text{---------- (3.2)}$$

$$\tau_i = (Y_i/\boldsymbol{\varphi} = \mathbf{1}) - (Y/_i\boldsymbol{\varphi} = \mathbf{0}) \quad \text{---------- (3.3)}$$

Where: τ_i is treatment effect of an individual Y_1 is potential outcome of the treated household and Y_0 is potential outcome of the control household.

According to Lance et al. (2014) there are two effects of the program such as Average Treatment Effect (ATE) and Average Treatment effect for Treated (ATT)

Average Treatment Effect (ATE): ATE is the average effect (impact) of the intervention across the population of the interest group. Thus, the impact of the treatment at population level is measured by average treatment effect (ATE) [9] which is defined as:

$$ATE = E[\tau_i] = E[Y_1 - Y_0] \quad \text{---------- (3.4)}$$

ATE is valuable to evaluate what is the expected effect on the outcome if individuals in the population were randomly assigned to treatment.ATE is good for random experiment, but in quasi-experiment study it may cause bias due to dissimilarity of treated and controlled groups (Katchova,

[9] ATE is the average gain in outcome of participants relative to non-participants.

2013). Moreover, as cited in Grilli and Rampichini (2011) Heckman (1997) elicit that since ATE includes the effect on non-intended persons in program, it might not be relevant to policy makers.

Average Treatment for Treated (ATT): *ATT* is the difference between the outcomes of the treated observations as a result of treatment and the outcome if they had not been treated (Katchova, 2013). It explicitly evaluates the effects of the intervention on those for whom the program is actually intended. The impact of the intervention on intended outcome is measured by Average Treatment effect for Treated (ATT)[10], which is the average effect of the treatment who ultimately received the treatment.

Hence more emphasis is given to measure impact on individual and household level, who participates in the program.

ATT is more interesting in many orders mainly; ATE measures the effect across population, while ATT captures impact of treatment on actually program participant. Hence, ATE is not interesting since it captures the effects on households not intended.

Now a day, ATT treatment impact evaluations have recognition in most literature (Lance et al., 2014; Khandker et al., 2010) which is defined as:

$$ATT = E(\tau_i/\varphi = 1) = E[(Y_1 - Y_0)/\varphi = 1] \quad \text{---------- (3.5)}$$

It can be rewritten as: $= E(Y_1/\varphi = 1) - E[Y_0/\varphi = 1]$

Where: $E(Y_1/\varphi = 1)$ is an average outcome of household who are treated (use the technology), $E[Y_0/\varphi = 1]$ Is an average outcome of treated household if they were not use the technology. However $E[Y_0/\varphi = 1]$ is unobserved and is the counterfactual of interest, what is observed is only the average outcome in the non-treated state $E(Y_0/\varphi = 0)$, is an estimate for counterfactual and then ATT can be computed as,

$$ATT = E(Y_1/\varphi = 1) - E(Y_0/\varphi = 0) \quad \text{- -3.6)}$$

[10] ATT is the average gain in outcome of participants relative to participants, if participants had not treated.

ATT is identified if the outcome of the individual from the treatment and comparison group is the same in the absence of treatment. The difference between counterfactual for treated and observed outcomes for untreated units is selection bias (Khandker et al., 2010).

Selection bias= $E(Y_0/\varphi = 1) - E(Y_0/\varphi = 0)$

The factual ATT is identified only, if selection bias is zero.

According to Khandker et al. (2010) validity of PSM is depend on:

(i). C**onditional dependency assumption**: This assumption implies, potential outcomes are independent of treatment given that participation is independent of unobserved factor.

$Y_0, Y_1 \perp \varphi/x; \forall x$

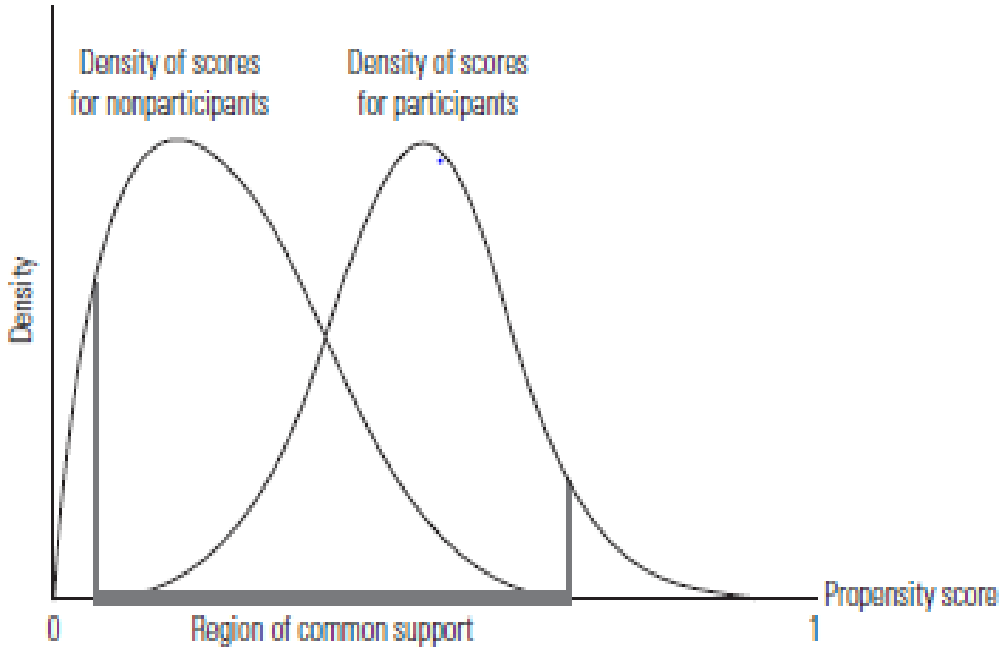
Where $\perp$ implies independency and x is observed characteristics. The assumption indicates that selection for receiving treatment relay on observables characters which include in X. Hence this inclusion allows constructing a true counterfactual group for treatment group (Khandker et al., 2010)

(ii). **Assumption of common support:** the assumption is about overlapping of propensity score across participant and non-participant. This implies for any value of X both treated and counterfactual groups have non-negative probability to participate in the program rather it range with in the interval.

$0 < P(\varphi = 1/x), < 1$

The assumption ensures that there is a sufficient overlap in the characteristics of treated and control units to find adequate matching (Hirano, Imbens and Ridder, 2000).

Figure 3.2: Example of Common Support



Source: Khandker et al. (2010)

Holding CIA and common support assumption, ATT estimator of PSM is the mean difference of potential outcome in the common support weighted by propensity score distribution.

So ATT is written as:

$$ATT = E_{p(x)/\varphi=1}\left\{E\left[\frac{Y_1}{\varphi}=1, p(x)\right] - E\left[\frac{Y_{01}}{\varphi}=0, p(x)\right]\right\} - - - - - - - - - - (3.7)$$

(iii). **No general equilibrium effects (partial equilibrium)**: there is no either positive or negative externality. Easily, treatment does not indirectly affect the counterfactual group.

3.7.3. Procedures of Propensity Score Matching Model

The six steps in propensity score matching analysis are stated her below.

3.7.3.1. Propensity *Score Estimation*

Calculating propensity score P(x) on basis of all observable covariates x that jointly affect participation (technology adoption) and potential outcome is the preliminary activity in PSM method (Khandker et al., 2010).

Propensity score is the conditional probability of being treated (adopting technology) given a set of covariates: p(x) = { φ=1/x} =E { φ/x}, where φ is indicator of treatment. If households participate in adoption of irrigation technology$\varphi = 1$, and $\varphi = 0$, households did not participate in adoption of technology. The value of propensity score ranges between 0 and 1. Propensity score produce a valid match for estimating the impact of treatment if relevant information to participate and outcome is observed.

Propensity score matching (PSM) make statistical comparison group using observed characteristics based on the probability of participating in the treatment model. Participants were matched based on propensity score or probability of participation, reflecting the probability of conditional difference based on observed characteristics (Rosenbaum & Rubin 1983 cited in Khandker et al., 2010). PSM captures the effect of different observed covariates on participating in the treatment by single propensity index. The program or intervention effect is recognized by comparing the outcome of participating and not-participating.

PSM methods compare treatment effects across participant and matched nonparticipant units (Khandker et al., 2010). In our case, Propensity Score Matching (PSM) method compares welfare of irrigation technology adopters with non irrigation technology.

The probability of irrigation technology adoption is estimated via binary logistic regression with value of 1(one) for technology user and 0 (zero) otherwise. The econometric estimation is specified as follows:

The latent (index) mode

$$Y^* = x\beta + u \quad (3.8)$$

Where Y^* *is latent variable,* $x\beta$ *is index function and* u *is the error term;* $u \backsim l(0, \frac{\pi^2}{3})$

$$pr(yi = 1/x) = \frac{1}{1 + e^{x\beta}} = \frac{e^{x\beta}}{1 + e^{x\beta}} = \Lambda(x\beta) \quad (3.9)$$

Where $pr(yi = 1/x)$ *is* the probability of success and $x\beta$ is the linear combination of covariates

While the probability of failure is specified as

$$1 - pr(yi = 1) = \frac{1}{1 + e^{x\beta}} = \quad (3.10)$$

Odis ratio (L) is obtained by dividing equation 3.9 by 3.10

$$L = \frac{pr(yi = 1/x)}{1 - pr(yi = 1/x)} = \frac{\frac{e^{x\beta}}{1+e^{x\beta}}}{\frac{1}{1+e^{x\beta}}} = e^{x\beta} \quad ---------- (3.11)$$

Take the natural log of the odds ratio we get,

$$ln\ (L) = ln(\frac{pr(yi = 1/x)}{1 - pr(yi = 1/x)}) = \ln\ e^{x\beta} = \Lambda(x\beta) \quad ----------(3.12)$$

Where $ln(L)$ is log of logit model odds ratio,$\Lambda(x\beta)$, where $\beta's$ are coefficient of the regression which is estimated through maximum likely hood estimation technique and x'_i vector of covariates that determine the dependent variable (participation in irrigation).

So, the logit (treated) model of estimating the propensity score is

$$ln(L) = x_i\beta'_j + U \quad ---------- (3.13)$$

Finally, equation 3.13 is the logit model which used to estimate the propensity score using statistical software to find the best linear combination of predictors for maximizing the likelihood of obtaining the observed outcome frequencies. The estimation result and their economic interpretation were presented in chapter 4.

3.7.3.2. Choosing *a Matching Algorithm*

After estimating the propensity score of both treated and controlled group choosing the matching algorithm to match the comparison group with the treated group is the second step in propensity score matching model. The aim of matching is finding the closest comparison group to the participant group in the sample. Closeness in matching is measured in terms of observable characteristics but independent of participation in the program (Khandker *et al.,* 2010 and Caliendo & Kopeinig, 2005). There is no optimal matching algorithm for specific data type. But in this section some most frequently used alternative matching criteria for matching treatment to non-control group based on propensity score is overviewed.

Nearest Neighbor Matching (NN): it is the most straightforward and widely used matching where control and treatment group is matched that have the closest propensity score (Khandker *et al.*, 2010). Individuals form the comparison group is chosen as a matching partner for treated group that have closet propensity score (Caliendo & Kopeinig, 2005). Matching can be done with or without

replacement. Matching with replacement allow to use untreated group as a match more than once. This helps to increase matching quality and reduce bias (Caliendo & Kopeinig, 2005). While matching without replacement consider only once.

Caliper Matching: failure to capture difference in propensity score between treated and untreated group is a flaw of NN matching. This occasion results poor matches and can be avoid by imposing threshold or "tolerance" on the maximum propensity score distance (caliper).

The imposition of caliper in matching is the same as matching with replacement. Applying caliper matching implies individual from the control group chosen as a matching partner for a treated individual lies within the caliper ('propensity range') and is closest in terms of propensity score (Caliendo & Kopeinig, 2005).

Kernel Matching (KM): the risk of matching algorithms discussed above is its applicability for small observation from the comparison group to construct counterfactual outcome of a treated individual (Caliendo & Kopeinig, 2005).

Kernel matching (KM) algorithm will be applied to find out the matching counter factual group by using propensity score (a single number) in terms of observable characteristics (lance et al., 2014; Calvin and Hobbes, n.d; Stuart and Rubin, 2007).

It is the non-parametric matching which use weighted average of all individuals in the control group to construct counterfactual outcome and hence it lower variance by using more information (Caliendo and Kopeinig, 2005).

3.7.3.3. Checking Overlap *and Common Support*

Treatment effect is only defined in the regions of common support. Hence, checking the overlap and the region of common support between treated and control group is preliminary estimating treatment effect. So as to define the treatment effect, region of common support is determined either through the comparison of minimum and maximum propensity score of the treated and control group or estimating density distribution in both group (Stuart & Rubin, 2007 and Caliendo &Kopeinig, 2005).In comparison of Minimum and maximum propensity score, observations with propensity score out of (below the minimum and above the maximum) the common support region is dropped.

3.7.3.4. Testing the Matching Quality

Balancing test is testing whether there is a statistical significant difference in mean values of covariates between treated and comparison groups or not. There are three commonly used alternative tests of matching quality such as standardized bias, t test, Joint significance and Pseudo-R^2 (Caliendo and Kopeinig, 2005). The notion of all test is comparing the situation before and after matching, and check the difference after matching via propensity score(Caliendo and Kopeinig, 2005).If the test indicates significant difference, matching is not complete (success full) which requires remedies such as variable interaction in propensity score estimation model.

3.7.3.5. Estimation of Standard Error

Estimating the standard error of the estimated treatment effect is vital issue in propensity score matching (Austin, 2011). As a result of estimating the propensity score the estimated variance of the treatment effect incorporates the variance, imputation of the common support, and also the order in which treated individuals are matched (Caliendo and Kopeinig, 2005). Know, it is better to use the bootstrapped standard error to test the statistical significances of the impacts of the treatment.

Bootstrapping method is popular in estimating standard errors, when analytical estimates are biased or unavailable (Caliendo and Kopeinig, 2005). Bootstrap estimate standard error by re-sampling of the data in the original sample. In each bootstrap draw re-estimation of the results, including (propensity score, common support, etc.) is included. Repeating the bootstrapping *N* times leads to N bootstrap samples and *N* estimated average treatment effects (Caliendo and Kopeinig, 2005).

3.7.3.6. Sensitivity *Analyses*

Matching on observed variable and some bias resulted from unobserved covariates could affect whether groups receive treatment or not (Keel, 2010). Estimation based on propensity score matching is unbiased if all relevant covariates are incorporated in the estimation model and there is no unmeasured confounders. If there are unobservable covariates which affect treatment assignment and outcome variable, hidden bias might cause non robust matching estimator (Becker & Caliendo, 2007). But in randomized assignment this problem is not because randomization balances both the observed and unobserved covariates (Rosenbaum, 2005).

Hence, checking sensitivity of estimated result on such bias is a basic task in PSM analysis. In sensitivity analysis due emphasis is given to whether inference about treatment effects affected by unobserved factor or not (Caliendo and Kopeinig, 2005).

According to Rosenbaum's (2002) methods of sensitivity analysis, sensitivity analysis is based on the parameter developed by him called gamma Γ that measure the degree of departure from random assignment of treatment. Two comparison groups with the same observed characteristics may differ in the likelihoods of receiving treatment by at most a factor of sensitivity parameterΓ. In a randomized experiment, randomizations of the treatment ensure that sensitivity analysis is not required ($\Gamma = 1$). However, for observational study value of $\Gamma$is unknown which requires several trial to see the change in the conclusions. In most social science studies the magnitude (value) of gamma Γ extends up to 6 (Keele, 2010).

In this study, sensitivity analysis is based on Wilcoxon's sign rank test of Rosenbaum sensitivity analyses. This test gives the upper and lower bounds significant level (p) values based on the proposed sensitivity parameter. However, only upper bound level of significant is interesting since lower bound is always lower than the observed significant level (Guo and Fraser, 2010, and Keele, 2010).

Wilcoxon's sign rank test the null hypothesis of hidden bias in treatment effect due to unobserved confounders against the alternatives. The null hypothesis is rejected if p value is$\leq$ 0.05 (Guo and Fraser, 2010 and Keele, 2010). This implies treatment had an effect and there is no unmeasured bias of magnitudeΓ. If the result is very sensitive, the researcher might care about the validity of the identifying assumption and consider alternative estimation strategies (Guo and Fraser, 2010).

3.8. Definition of Variables and Hypothesis

Propensity score (probability of being treated) is estimated by observable characteristics. Omission of relevant covariates in the estimation results hidden bias in treatment effect and violation of CIA (Guo and Fraser, 2010). In order to have the matching process from observational data equivalent to the experimental dataset one has expected to follow the economic theory, empirical findings to identify key potential covariates for estimating propensity score.

The dependant variable in probability of small scale irrigation technology (pulley and Rope-and-Washer) adoption estimation model is the adoption decision of the farm household. The adoption decision of small scale irrigation technology is a discrete outcome with a dichotomous decision of farmers to adopt and / not to adopt the irrigation technology. The adoption decision has a value of 1 if the household adopt either or both of the technology and 0 otherwise.

3.8.1. Covariates

Following the adoption literature (such as: Gebregziabher et al., 2014; Asante, 2013; Adeoti, 2008) the decision to adopt small scale irrigation technology depends on various factors including socio-economic factors, demographic character (sex), farm household asset bundle and financial capability and access to finance. An asset bundle consists of physical and human asset. In this study the effect of factors in the adoption of small scale irrigation technology is hypothesized as follows:

Household head sex (sex): This is a dummy variable with value 0 if the household head is male and 1 if the head is female. Often, women have specific role within the farm household, men and women are different in asset holding and decision making (Alkier et al., 2012). Mostly, female headed household lack productive resource (Ndiritu et al., 2011 cited in Gebregziabher et al., 2014) and hence it hinders technology adoption. Thus, it is expected that sex of the head affect technology adoption positively.

Household head age (age_h): it is the age of the household head in year. It captures the quality of household labor (the working capacity of farm household head). The effect of age on adoption is dichotomous. In one hand, older farmers are experienced enough and they have accumulated physical and social capital, adaptive expectation which enable to try the new technology. So, they have higher probability to adopt new irrigation technology since he/she knows all the cost and benefit of producing crops solely on one season (rain-dependant). On the other hand, younger household head has low position of owning productive resource and they are exposed to farm risk but they are more capable to work than older head. Therefore, young households can cop farm risk like drought with technology adoption. Thus, it is difficult to prioritize the effect of age on small scale irrigation technology adoption before observing the empirical result.

Adult household member (Add_hh): it is the number of adult members in the given household. This variable indicates the quantity of household labor that can assist in operating the irrigation technology. Small scale irrigation technologies are labor intensive, which requires adult labor to operate it. Farm households with higher adult family size offer extra labor for assisting irrigation technology. Therefore, it is it is hypostasized that households with large adult family size are higher probability to adopt small scale irrigation technology.

Household head education level (Educ_h): it is the maximum schooling level (grade) that the household head completed. This indicates household capacity to adopt technology. More education

enables farm households to manage and operate the complex technology. In many adoption study, like Getacher et al. (2013) and Adeoti (2009), it was found that more educated household have higher tendency to adopt irrigation technology. Thus, it is expected that more educated household are more interested to adopt irrigation technology.

Land holding (Land_size): it is the continuous variable measured in hectare, which measures the wealth status of the household. In agricultural activity land is the prime input for both dry and rain feed production. In technology adoption research large land holding encourages the adoption of irrigation technology (Bagher and Ghorbani, 2011; Adeoti, 2009). Accordingly, it is hypothesized that farmers with grater land holding have greater probability to adopt irrigation technology.

Extension service (Ext_service): it is a continuous variable, which indicates the frequency of farmers visited by extension workers per year. Extension service enables farmers to identify problems related to farming activity, crop, Soil and over all farming activities. Hence, access to this service is important to adoption of technology. Therefore, it is hypothesized that households who is frequently visited by extension workers have higher tendency to adopt irrigation technology than less frequently visited farmer households.

Market distance (Mkt_dista): this is the distance in kilometers from household's dweller to nearest market at which farmer's exchange. Nearness to market center helps to farm household to have alternative income source other than farming (irrigation) activity. On the other hand, farmers far from the market have less opportunity to have off arm activities like petty trade, which encourages irrigation in dry season and adoption of irrigation technology. Therefore, the effect of farm households' village distance to the market on adoption of small scale irrigation technology is ambiguous.

Access to credit (Credit_acces): this is the dummy variable with value of 1 if the household has access to credit and 0 otherwise. Investments on farmers (credit provision) facilitate the diffusion of irrigation technology. Empirical evidences confirm that household with credit access are more probable to adopt irrigation technology than their counterpart (Adeoti, 2009). Likewise, it is expected that access to credit positively affect the adoption of irrigation technology.

3.8.2. Outcome variables

Outcome variables are variables which results from participation in technology adoption. In this study, household consumption behavior, women empowerment and welfare of the household were impact indicator variables of irrigation technology adoption.

Household consumption behavior: is the behavioral intent of farm households on the acts of using their current income for today and their future life. Their behavioral intent is measure through the habit of spending the proportion of current income on current use (consumption) which is the Average propensity to consume (APC). Adoption of technology helps to use available productive resource economically. Therefore, it is hypothesized that technology non-adopter household are more exposed to habit of unsparing relative to adopter household. As a result, adoptions of technology improve the consumption smoothing habit of technology adopter household.

Women empowerment: it is the empowerment of women in activities they run. Their empowerment is measured by the latest innovative measure of women empowerment in agricultural activity called Women Empowerment in Agricultural Index (WEAI). The index is developed from two sub index (such as 5Des and GPI). The five domain of empowerment is also developed from ten (10) indicators. A woman is treated as empowered in all domains of empowerment if her WEAI score is 80% and above. Households who adopt irrigation technology enhance decision and leadership power of the women. Hence, it is predicted that, participation in technology adoption improves the empowerment of women.

Welfare of the household (WI): welfare in this paper is material well-being of the household, which is obtained from consumption. Welfare of farm household is measured by annual consumption of the household adjusted to living cost (CPI) and household need (adult equivalent and consumption economies of scale). In computation of welfare indicator consumption expenditures on funerals, health and education were not included. Expenditures for funerals can increase welfare of an individual who consumes but not the welfare of the household who prepare the funerals (Deaton and Zaidi, 2002). Likewise, health expense is not included in consumption aggregate because first, even though health expenses for household fallen in sick confirm its welfare, welfare loss for sick could not measure (Deaton and Zaidi, 2002:30-31). Second, in Ethiopian health care are freely subsidized and covered through community based health insurance. Hence, the household expenditure could not indicate the actual health situation for the following two reasons. (1) Household health care requirement may above or below insurance premium paid

for health sector. (2) Vaccination for children, women and other offer freely. Adoption of technology improves production and productivity of farm household which enhance the consumption capacity. Therefore, it is intuitive to hypothesize that adoption of technology improves welfare of the adopter household.

CHAPTER FOUR

RESULT AND DISCUSSION

In this section, descriptive statistics, inferential statistics and econometric results are presented and discussed. Socioeconomic and demographic characteristics of sampled household are presented via statistical tools including mean, percentage and standard deviation. Moreover empowerment and nutritional analysis were also presented. In addition to descriptive statistics, inferential statistics such as t-statistics and chi-square tests were also employed to compare treatment (technology-adopters) and control (technology non-adopters) by different variables. Propensity score matching econometric models is employed to evaluate the significant difference between treatment (technology adopter) and control (non-technology adopter) groups in terms of consumption behavior, women empowerment, nutritional status and welfare status of the household in the study area.

4.1. Sample Household Characteristics

4.1.1. Covariates

Descriptive statistics and mean difference test results of continuous covariates are summarized in table 4.1. The result show that small scale irrigation technology adopter and non- adopter are heterogeneous in terms of education level of the household head, number of adult household member and land holding of the household. All difference is statistically significant at 1% level of significant. Moreover, the result also shows that statistically there is no significant difference between technology adopter and non-adopter in terms of household head age, extension service (number of days visited by the agricultural extension worker, DAs, per year) and distance to the nearest market. Unlike non-technology adopter sample household, technology adopter sample household have large adult household member (who can assist the technology), high education level and large land holding. On average, technology adopter households have 13.05 percent higher adult family size than their counterpart. Likewise, technology adopter household have higher education attainment by about more than one years of schooling than non-adopters respectively. On average, the landholding of technology adopters is higher than their counterparts by 0.58 hectare. The result implies that the household who has higher household member that can assist the technology, higher educational attainment, and large land holding size has higher tendency to adopt irrigation technology.

Table 4.1: Summery Statistics and Mean Difference Test of Continuous Variables.

Covariates		Technology Adopter (N=79)	Technology Non-Adopter (N=122)	Total (N=201)	Mean difference	T-value
	Unit	Mean	Mean	Mean	Mean	
Age_h	No.	44.61 (12.41)	43.62 (14.0)	44.00 (13.27)	0.99	-.0517
Educy_h	Year	3.04 (3.47)	1.67 (2.64)	2.21 (3.01)	1.37	-3.16*
Add_hh	No.	3.87 (3.47)	3.426 (1.098)	3.60 (1.118)	0.45	2.8*
Land_size	Ha	1.95 (1.1)	1.36 (0.78)	1.59 (0.96)	0.58	-4.404*
Ext_service	day	7.33 (8.03)	6.06 (9.13)	6.56 (8.71)	1.27	-1.01
Mkt_dista	km	5.06 (1.85)	4.43 (5.27)	4.67 (4.27)	0.63	-1.03

Remark: Numbers in bracket are standard deviation and * indicates significant at 1%.

Source: Survey Estimation Result

The descriptive statistics of Pearson's chi-square proportion test between technology adopter and non-adopter for categorical variables is presented in table 4.2. The survey result shows that there is no significant difference between adopters and non-adopters in terms of household head sex. From the total sample household about 90.55 percent are male headed and the remaining 9.45 percent are female headed household. However, it was found a significant difference in access to credit between technology adopters and non-adopters and the result is significant at 1% level of significant. This result indicates that access to credit has an effect on technology adoption decision. Overall, 75.62 percent of sample households have credit access, technology adopter household are highly likely accessible to credit service than non-adopters.

Table 4.2: Summery Statistics and Mean Difference Test of Categorical Covariates

Variable	category	Adopter		Non-adopter		Total		X^2
		N	%	N	%	N	%	
Head_sex	Male	69	87.34	113	93.62	182	90.55	1.56
	Female	10	12.66	9	7.38	19	9.45	
Credit_acces	Yes	72	91.14	80	65.57	152	75.62	17*
	No	7	8.86	42	34.43	49	24.38	

Remark: * indicate significant at 1%

Source: Survey Estimation Result.

4.1.2. Outcome Variables

In this study the potential outcome of interest are proportions of income spent on household consumption (APC), women empowerment measured by women empowerment in agricultural index (WEAI) and welfare of the household measured by consumption (WI). The descriptive statistics and the mean difference test of those variables are presented in table 4.3 below.

The survey result shows that the consumption behavior of technology adopter and non-adopter was statistically significant. As compared to non-adopters, the portion of income spent on consumption by technology adaptor household was lower by about 10.89% and it is significant at 1%. This

implies that technology adopters have consumption smoothing habit and they put their income either for saving or repaying their loan if there is any.

The result also show, technology adopters and non-adopters are different in the empowerment of women across the five domains of empowerment (such as: production, resources, income control, leadership and time). Women in adopter household were more disempowered in 8.05 % of the domain (at most in 1 domain out of 5 domains); it is statistically significant at 5%. Furthermore, the result regarding on gender parity indicates that, women in the adopters household were more inadequate (disempowered) relative to their counterpart (husband), which is statistically significant at 5%. Thus, on average women in technology adopter household are more inadequate (disempowered) in both sub indices of empowerment in agricultural index and it is statistically significant at5%. This might be due to the fact that cultural, educational impacts on their active participation and control in any resource.

However, technology adopters and non-adopters have no significant difference in terms of their welfare status. This might be the case because the technology has no significant deference between the two groups or due to the health condition of the children and their mother.

Table 4.3: Summary Statistics and Mean Difference Test of Outcome Variables.

Variables	Technology Adopter (N=79)		Technology Non-adopter (N=122)		Total (N=201)		Mean difference	T-value
	Mean	SD	Mean	SD	Mean	SD		
APC	0.92	0.239	1.033	0.198	0.989	0.0221	-0.112	3.623*
5Des	0.657	0.174	0.715	0.175	0.692	0.176	-0.058	2.28**
GPI	0.904	0.013	0.90	0.013	0.902	0.013	0.004	-2.10**
WEAI	0.68	0.15	0.73	0.16	0.713	0.16	-0.051	2.27**
WI	869.34	406.91	826.89	877.15	843.57	728.34	42.91	-0.55

Notice: * and ** indicates significant at 1% and 5% respectively.

Source: Survey Estimation result

4.1.3. Small Scale Irrigation Technology Adoption in the Study Area

Small-scale irrigation technologies mainly: Pulley, and Rope and Washer are used to lift water from different sources so as to grow vegetables including Onion, Tomato, Fodder, Pepper and Chat (Table 4.4). In the study areas, mover than 55 percent households adopt pulley, 40.51 percent of the farmers adopted Rope-and-washer, and the remaining 6.25 percent adopt both pulley and motor pump irrigation technology. As compared to Robit counterparts, farm household in Dengeshita mainly adopted Rope-and-washer irrigation technology. Contrary, most of Robit farm households (about more than 83 percent) adopt pulley irrigation technology. The survey result also revealed that in both sites well is the main source of water for irrigation. Overall, about 93.67percent of the household lift water for irrigation from their well and the remaining 6.33percent got water for irrigation from both river and well.

Table 4.4: Technology Adopted and Water Source by Sampled Households

Adopted Technology type	Sites					
	Dengeshita (N=31)		Robit (N=48)		Total (N=79)	
	N	%	N	%	N	%
Rope-and-washer	27	87.1	5	10.42	32	40.51
Pulley	4	12.9	40	83.33	44	55.69
Pulley and motor pump	0	0	3	6.25	3	3.80
Water source for irrigation						
Well	30	96.77	44	91.67	74	93.67
Well and river	1	32.23	4	8.34	5	6.33

Source: Survey Result

4.1.4. Constraints to the Adoption of Small Scale Irrigation Technology

The main reason farm households fail to adopt small scale irrigation technology is presented in table 4.6. According to the result, out of the total non-technology adopter 50.82 percent, 88.52 percent 18.85 percent and 3.28 percent of them report that shortage of land, lack of water for irrigation (e.g. well), lack of labor and lack of awareness are the main constrained to adoption of small scale irrigation respectively. Lack of water for irrigation and shortage of land used for irrigation are found more dominant factors that hinder adoption of small scale irrigation technology.

Table 4.5: Constrained of Small Scale Irrigation Technology Adoption

Reason Of Not Adopting	Dengeshita		Robit		Total	
	N	%	N	%	N	%
Shortage of land	41	33.61	21	17.21	62	50.82
Lack of water	60	49.18	48	39.34	108	88.52
Lack of labor	14	11.48	9	7.38	23	18.85
Lack of awareness	2	1.64	2	1.64	4	3.28

Source: Survey Estimation Result

4.1.5. Consumption and living Situation of the Sample Household

This section provides an empirical result with the interpretation of the descriptive statistics result for the living situation of the sample household. A summery statistics is provided here to give a clue on average consumption of the group in each category.

The result shows technology adopter household has higher total consumption expenditure per adult equivalent than non-adopter by about 7.34 percent.

In both district, there are some households that have zero consumption of some goods such as protein foods (Meat, Eggs, and Milk), and health. The explanation of such null expenditure is provided as follows: the very nature of too be poor may constrain households to spend on well nutritious food and human capital investment. Mainly, those poor household have health care service based on community based health insurance scheme or there was no anyone in the household member needs any health care during the survey time.

By looking at the average per adult equivalent consumption of total food and non-food consumption, it was found that the average consumption of food always exceeds over non-food consumption in all groups. The result is consistent with the empirical finding of Rahman (n.d) on Bangladesh household and Deaton's (2002) Proposition of the poor spent more of their budget on food. Although the lion share of the consumption budget is allotted for food consumption, it was

found consumption per adult equivalent share of food for non-adopter is 7.9 percent higher than the adopter household. In addition to this, food consumption share of adopters in Dengeshita is higher than their counterpart in Robit, but the converse is true for non-food consumption share. Overall, adopter spending on non-food consumption item (it may durable and service) is 8.07percent higher than non-adopters. Moreover, Percentage of non-food consumption is higher for non-adopters in Robit site by 0.96 percent than in Dengeshita.

Unlike technology non-adopter, technology adopter household spent higher portion of their consumption budget on funeral /festive activities (such as wedding, tezkar and holyday). Likewise, Robit farmers are exposed to spend more for funereal activities than their counterpart in Dengeshita. Finally, among the sites Robit is better off in terms of all consumption (both food and non-food consumption).

Table 4.6: Descriptive statistics of annual consumption per adult equivalent scale

Consumption type	Over all sample			Adopters			Non-adopters		
	Total (N=201)	Dengeshita(102)	Robit (N=99)	Total (N=78)	Dengeshita(N=31)	Robit (N=48)	Total (N=79)	Dengeshita (N=71)	Robit (N=51)
	Mean	Mean	mean	Mean	mean	mean	Mean	Mean	Mean
Cons	8921.2	7782.24	10094.6	9307.40	8502.4	9827.31	8671.07	7467.80	10346
Food	5787 (64.87)	5113.18 (65.70)	6488.21 (64.27)	5602.55 (60.20)	5334.01 (62.74)	5779.66 (58.81)	5904.84 (68.1)	5016.76 (67.18)	7141.2 (69.02)
non-food	2313.8 (25.94)	1904.66 (24.47)	2739.72 (27.14)	2860.13 (30.73)	2473.27 (29.1)	3115.3 (31.7)	1964.57 (22.66)	1656.4 (22.18)	2393.6 (23.14)
Ceremony	2883.0 (9.47)	2740 (9.23)	3030.4 (9.71)	3420.9 (10.24)	2834.3 (8.44)	3799.8 (11.41)	2534.7 (8.89)	2698.83 (9.65)	2306.2 (7.88)

Note: all consumption except ceremony is per adult equivalent scale. Numbers in bracket shows percentage

Source: Survey Estimation Result

As shown on table 4.7 below the proportion of the household who is not capable to feed their member all over the year is higher in Robit than Dengeshita (16 %Vs 12.74 %). And more than one in ten household is partially capable to feed their household member over the year. Moreover, the incapability of feeding the member is severe in technology adopter than non-adopter.

Table 4.7: Feeding Capacity of the Household over the Year

	Total	Site		Technology adoption status	
		Dengeshita	Robit	adopter	Non-adopter
Feeding capacity	percentage	Percentage	Percentage	Percentage	Percentage
Capable	85.64	87	84	84.81	86.18
Didn't capable	3.96	6.86	1	5.06	3.25
Partial	10.4	5.88	15	10.13	10.57
N	202	102	100	79	123

Source: Survey Estimation Result

4.1.6. Empowerment Analysis

This section presents the result of women empowerment in agricultural index (WEAI) and its sub-indexes such as the 5DEs and the GPI in the study area. So as to identify the areas that contribute most to women's disempowerment, decomposing the women's disempowerment index (M_0) by dimension and indicator is vital. Moreover, for comparison purpose M_0 and its component for the men are also presented in the table below.

As presented on the table 4.8 below, the WEAI for women in the study area is 0.713. It is the weighted average of 5DEs sub-index value of 0.692 and the GPI sub index value of 0.902. The head count ratio in table 4.8 shows overall, 79.0 percent of women in the sample are disempowered. The proportion of disempowered women in the study area is much higher as compared to developing countries; Bangladesh (61 percent), Guatemala (71.3percent) and Uganda (56.7 percent) (Alkier et al., 2012), but less than what rural Pakistan women experienced (83 percent) (Ahmad and Khan, 2016).

Table 4.8: Amhara Region WEAI and its sub index

Index	Women	Men
Disempowered headcount(H)	0.790	0.680
Empowered headcount(1-H)	0.21	0.381
Average Inadequacy score(A)[11]	0.390	0.335
Average Adequacy score(1-A)	0.61	0.619
Disempowerment Index(M0=HxA)	0.3081	0.228
5DEs index (EA=1-M0)	0.692	0.7408
No. of observations used	196	
Total observation	201	
% of data used	97.03%	
%of women without gender parity(H_GPI)	48.94%	
%of women with gender parity(1-H_GPI)	51.06%	
Average empowerment Gap(I_GPI)	20.11%	
Gender parity in Empowerment index (GPI)	0.902	
No. of observations used	201	
Total No. of dual households	185	
% of data used	92.04%	
WEAI= [0.9x5DE+0.1xGPI]	0.713	

Notes: WEAI=women empowerment in agricultural index; 5DE= five domains of empowerment.

Source: Survey Result Estimation

The overall disempowerment index of women (M_0) is 0.308, which is much higher than the comparable measure of disempowerment of countries like Bangladesh and Uganda but lower than women's disempowerment index of Guatemala (Alkier et al., 2012).The 5DEs show that 30.81 percent women were disempowered in five domains of empowerment (see table 4.8).

11 This is the average score of disempowered women.

In the study area the empowered head count ratio was found 21 percent among women and 32 percent among men.

On average, the women who are not yet empowered have inadequacy achievement in 39.0 percent of the domains. In the same way, the average inadequacy of disempowered men in the study area is 33.5 percent. Hence, the men's disempowerment index is 22.8 percent.

Table 4.9 presents the censored disempowerment headcount and the contribution each domain and indicator to women's disempowerment. The censored head count ratio (in table 4.9 and figure 4.2) show that women are more disempowered in terms of indicators like, control over use of income, leisure and access to and decision on credit. Over 71percent, 36 percent and 53 percent of women are disempowered in indicators of control over the use of income, leisure, and access to and decision on credit respectively. Other indicators contribute low to the level of women disempowerment (see figure 4.2). Compared to other indicators fewer women are disempowered in terms of ownership of asset (6.97percent) and group membership (7.43percent) indicators. Only 3.5 percent of women are disempowered in terms of autonomy in production, comparatively the result infers that in terms of this indicator woman are empowered. The result is consistence with the pilot empirical finding in southern Bangladesh (Alkier et al., 2013).

Based on the decomposition of the disempowerment measure (see table 4.9 and figure 4.1), in the study area control over the use of income and time dimension (domain) contribute most for the disempowerment of women. All this domain contribute for disempowerment of women more than their respective share of 20 percent in the calculation of disempowerment index, which advocates women are deprived mainly in these domain.

According to the survey result, about 71.3 percent of women are not empowered and lack power to sole or joint control over the use of income and expenditure, and 53.3 percent of women do not have a manageble work load. This finding is inline with the pilot result in uganda(Alkier et al., 2013). Despite women involved in all agricultural activity, their power over control and decision on income is lower in these study area.

Table 4.9: Women's and Men's Disempowerment Decomposed by Domains and Indicators

	Production			Resource		Income	Leadership		Time	
Statistics	Input in productive Resource	Autonomy in production	Owner ship of asset	Purchase, sale& transfer of asset	Access to & decision on credit	Control over use of income	Group member ship	Speaki ng in public	Wor k load	leisur e
Indicator weight	0.1	0.1	0.0667	0.0667	0.0667	0.2	0.1	0.1	0.1	0.1
Women										
Censored head count	0.139	0.03465	0.0693	0.0796	0.3663	0.7129	0.0743	0.2723	0.24 3	0.535
%contribut ion	4.52	1.13	1.51	1.72	7.97	46.50	2.42%	8.88	7.91	17.44
Contributio n	0.0421	0.0128	0.0140	0.0160	0.0806	0.4785	0.0212	0.0848	0.07 6	0.174
%cont. by dimension	5.65			11.2		46.50	11.3		25.35	
Men										
Censored head count	0.1040	0.0149	0.0050	0.0149	0.2871	0.5545	0.0644	0.1139	0.40	0.272
%contribut ion	4.55	0.65	0.15	0.44	8.38	48.56	2.83	5.00	17.5	11.92
Contributio n	0.0433	0.0052	0.0009	0.0032	0.0868	0.5089	0.0199	0.0421	0.17	0.113
%cont. by dimension	5.2			8.97		48.56	7.83		29.44	

Source: Survey Estimation Result

The remaing domain contribute to disempowerment of women bellow their share in calculation of the over all disempowerment index. Forexamle, only 5.65 percent of the women are disempowered in the production domain.

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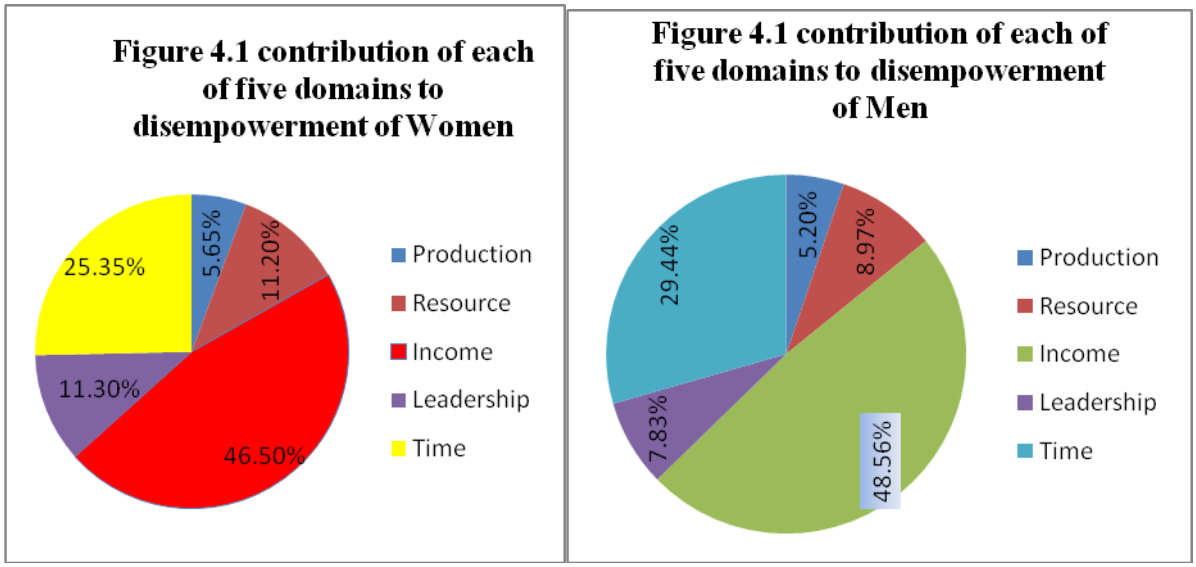
Figure **4.1: Contribution of domains to disempowerment of women and men in the study area**

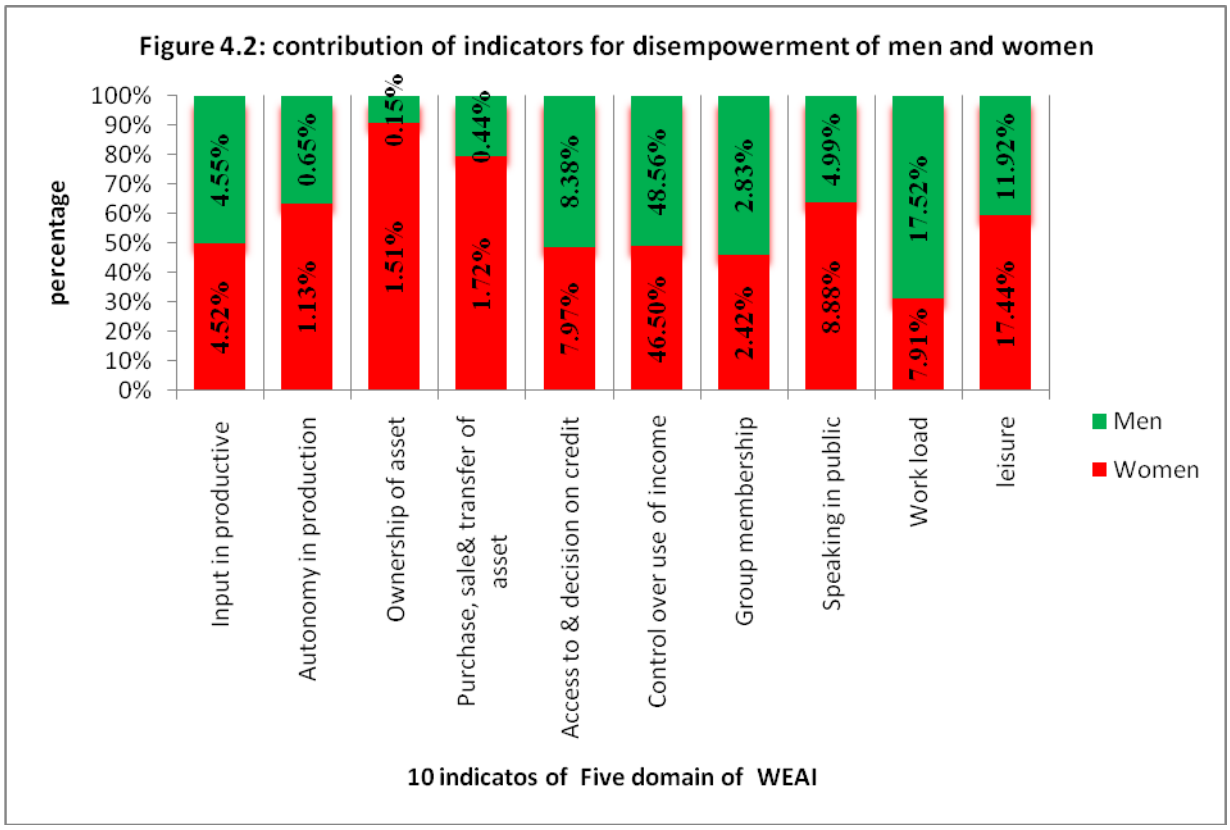


Source: Survey Result Estimation

The gender parity analysis based on the sampled household with meal and female respondent in the household. The disempowerment head count, Gender Parity Index, average disempowerment scores, and the empowerment gaps are presented in table 4.8 (see appendix 2 for methodology of calculation). The result shows disempowerment head count of women and men reflects huge disparity in the level of disempowerment among women and men and it indicates 79percent of women and 68 percent of men are disempowered. The 79 percent women who are not yet empowered have an average empowerment achievement in 61 percent of the domain (dimension). The result helps to deduce that, the average disempowerment score (39 percent) of the disempowered women is higher than that of the men in the sample (33.5percent). The gender parity index (GPI) was found 0.902 the result reflect higher gender parity (inequality between the

empowerment level of male and female within the same household) in the study area compared to other countries like Pakistan (Ahmad and Khan, 2016).

Figure 4.2: Contributions of Indicators for Disempowerment of Men and Women



Sources: Survey Estimation Result.

The headcount result (table 4.8) shows 49 percent of the household have no gender parity and women have higher disempowerment scores than the men in their household. For those women without parity the empowerment gap between women and their men counterpart in their households is 20.11 percent.

In comparison of headcounts across domains and indicators (table 4.9, figure 4.1&2) women have higher headcount in all indicators and all domains except income and time domain. Comparison of disempowered headcount depicts that the highest disempowerment headcount for both women and men is control over use of income. Likewise, the lowest head count for women is autonomy in production; while for men ownership of asset contribute more to their disempowerment level (see table 4.9).

Income and time domain are the only domains that contribute more to disempowerment of men than women (48.56%Vs46.5 %) and (29.44%Vs 25.35%) respectively. The contributions of all other domains are substantially higher for women than men.

4.1. Econometric Analysis

In this section econometric estimation results is presented and discussed. As noted earlier for accounting the impact of small scale irrigation technology on farm household welfare, propensity score matching estimation technique was employed. The method consists of propensity scores estimation, appropriate matching algorithm choose, common support region, balancing test and sensitivity analysis.

Before estimating the econometric model, testing for checking model specification, data reliability and consistency were conducted. Likely, Multicolinearity among continuous covariates and association between categorical covariates were tested via Variance Inflation Factor (VIF) and Pearson contingency coefficient respectively. The VIF test result (appendix 3) show that, there is no serious problem of co-linearity among continuous covariates in probability estimation model (VIF<10). Likewise, the contingency coefficient (appendix 4) shows weak association between categorical covariates (contingency coefficient< 0.75). Furthermore, link-test for model specification (Appendix 5) show that the model fitted for estimation of technology adoption probability is correctly specified since the predicted is significantly explains the model but the predicted square has no much explanatory power(p-value for predicted < 0.01, but p-value for predicted square > 0.1).

4.2.1. Estimation of Propensity Scores

For matching treated household with control household propensity score matching were estimated by the binary logistic regression. In this study, participation in adopting small scale irrigation technology is the dependent variable with value of 1 if the household adopt the technology and 0 otherwise. Table 4.10 reports the estimation results. The result indicates that, jointly, all estimated coefficients are statistically significant since the LR statistic has a p-value less than 1%. The pseudo-R^2 value is 26.25%, which is good for cross sectional data. Likewise, the model specification test (link test) show that the probability estimation model of technology adoption is correctly specified, since the link-test rejects the hypothesis that the model is not correctly specified (appendix 5).This shows the explanatory variables are relevant in explaining the adoption decision

model. The sign of all explanatory variables except extension service agree with a priory expectation.

The estimated result revealed that factors such as sex of the household head, education level of the head, adult household member, and land holding size, distance to the nearest market and access to credit (dummy) are significant predictors of small scale irrigation technology adoption. Accordingly, those household with female household head have a 42.1% greater chance of being technology adopter than the household with male head, other things remain constant.

The results also indicate that, education level of the household head positively affects the probability of technology adoption and is significant at 1%. More educated farm household have better knowledge on the importance of technologies. This is expected since literacy enhances the capacity to adopting and understanding the technology (know-how). The estimation result shows, cetries paribus, additional years of schooling of the household head increases the probability of adopting small scale irrigation technology by 5.6%. The finding is in line with the finding obtained in Kenya (Godfrey et al., 2014) and in Alamata District, Tigray, Ethiopia (Wehabrebi, 2014).

Increasing adult family size of the household was found relevant to increase the likely hood of technology adoption and is significant at 1%. This is because small scale irrigation technology is labor intensive, which needs labor to assist the irrigation technology (Adeoti, 2009). And the household with more members requires more production to sustain their life, which requires augmentation of their productivity via technology. Other things remain constant; a unit increases in adult family members of the household results an increase in the likelihoods of technology adoption by 11.3%. The result is intuitive because more adult members in the household imply cheap labor availability in the household, who can assist the technology. This seemingly encourages small scale irrigation technology adoption of the household, which is labor intensive and requires joint decision making

The result also shows that households with large land holding have higher likelihoods of adopting technology, which is statistically significant at 1%. This might be, since irrigation is the activity in the dry season and land for irrigation is prepared at the end of summer season where rain fed crops is not yet harvested. Thus, the household should left the land waiting for irrigation. Therefore, having large land holding may permit households to allocate part of their land for irrigation and adopt technology so as to lift water and irrigate in the appropriate season. This result is in line with the finding obtained in Gahanna (Asante, 2013).

It was also found positive and significant relationship between distances to the nearest market and probability of technology adoption. Lack of market access and distance to it restricts access to vegetables and other agricultural products. This shows that, those farm households far from the market center highly likely adopt technology than households near to the market center. This might be due to the fact that the nearest household to the market may access products in the market; have better market information (regarding risk, price and value of time) and higher opportunities of market sensitive income generating activities (such as trade) within short period of time even a day than households far apart from the market center. Thus, one more kilometer distance of household's home from the market center increase the likelihood of farm household adopting small scale irrigation technology by 1.8%, other things remain constant.

Finally, household access to credit strongly encourages the probability of adopting irrigation technology and is significant at 1%. The result is intuitive, investment in irrigation technology requires investment fund (liquid asset), which is the main constraint for most rural farm household (Godfrey et al., 2014). Thus, provision of either cash credit for technology or the technology in kind encourages farmers to adopt the technology. The econometric result of this study revealed the probability of adopting irrigation technology for households with credit access is higher than households without credit access by 42.3%. The finding is in line with the finding obtained from Kenya (Godfrey t al., 2014), Tharaka Nithi county (Musyoki, 2006).

One the contrary, the result shows that age of the household head and extension service (number of days visited by extension worker per year) has no significant impact on the probability of adopting irrigation technology. To sum up, land holding and access to credit are variables which most strongly induce probability of technology adoption.

Table 4.10: Logistic Regression Result for Propensity Score Estimation.

Variables	Coefficients	MEF(dy/dx)	Standard error	Z-value
_Constant	-6.88	1.223		-5.62*
Sex++	1.745	0.421	0.1248	3.29*
Age_h	0.003	-0.006	0.0032	-0.18
Educy_head	0.25	0.056	0.0145	3.86*
Add_hh	0.504	0.113	0.0381	2.97*
Land_size	0.792	0.178	0.0467	3.13*
Ext_service	-0.001	-0.0003	0.0046	-0.32
Mkt_distance	0.080	0.018	0.00832	2.16**
Credit_acces++	2.568	0.423	0.599	7.07*
Number of obs.	= 201			
LRchi^2 (2)	= 70.72			
Prob>chi^2	= 0.0000			
Pseudo R^2	= 0.2625			
Log likelihood	= -99.327028			

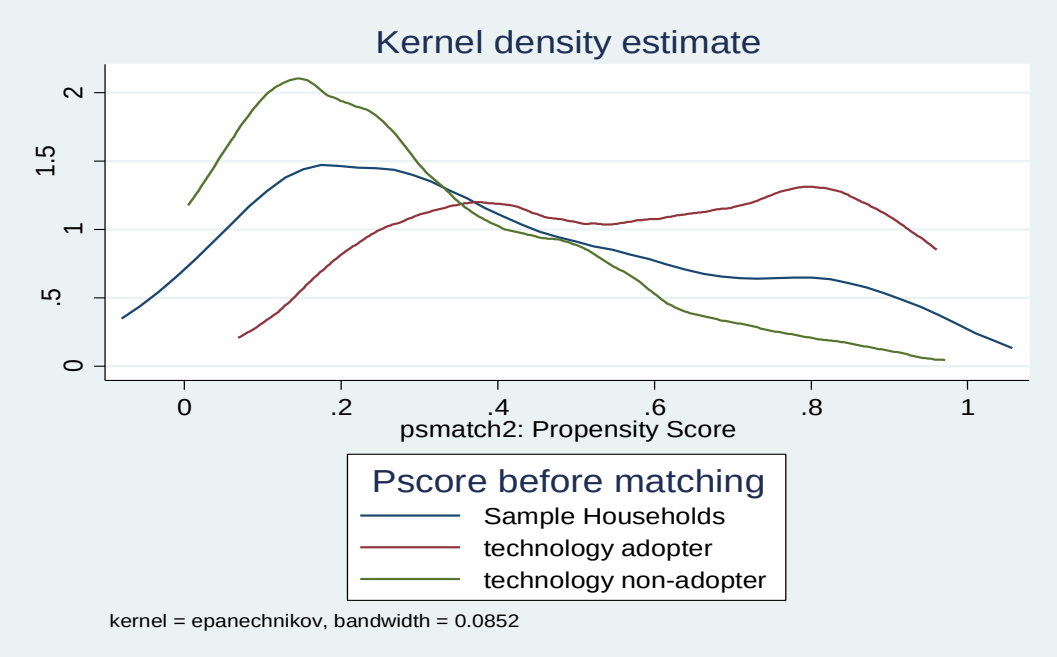
Remark: ++ indicates dy/dx is for discrete change of dummy variable from 0 to 1; and *, and ** indicates significant at 1%, 5% and 10% significance levels, respectively.

Source: Survey Estimation result

4.2.2. Distribution of Propensity Score Matching

Even though the propensity score distribution of technology adapter and non-adopter was skewed to right and left respectively, it is possible to see a substantial wider area of common support region (distribution of propensity score of both group shares in common) (see figure 4.3).

Figure 4.3: Kernel Density Distribution of Propensity Scores



Source: Survey Result Estimation

As indicated in table 4.11, the propensity score of adopters vary from 0 .0688023 to 0 .960054, with mean of 0.581589 and among non-adopters, the predicted propensity score vary from 0.0049739 to 0.9713063 with mean of 0.2709383. Therefore, the common support assumption satisfied in the region [0 .0688023, 0.960054].

This imposition of the common support region implies that, observations with the propensity score matching below 0 .0688023 and above 0.960054 were discarded out of the matching sample. Based on the min-max criterion of determining the common support region, out of 201 household, 55 household (35 control and 20 treated households) were lies out of the common region (support region) and were discarded from the analysis.

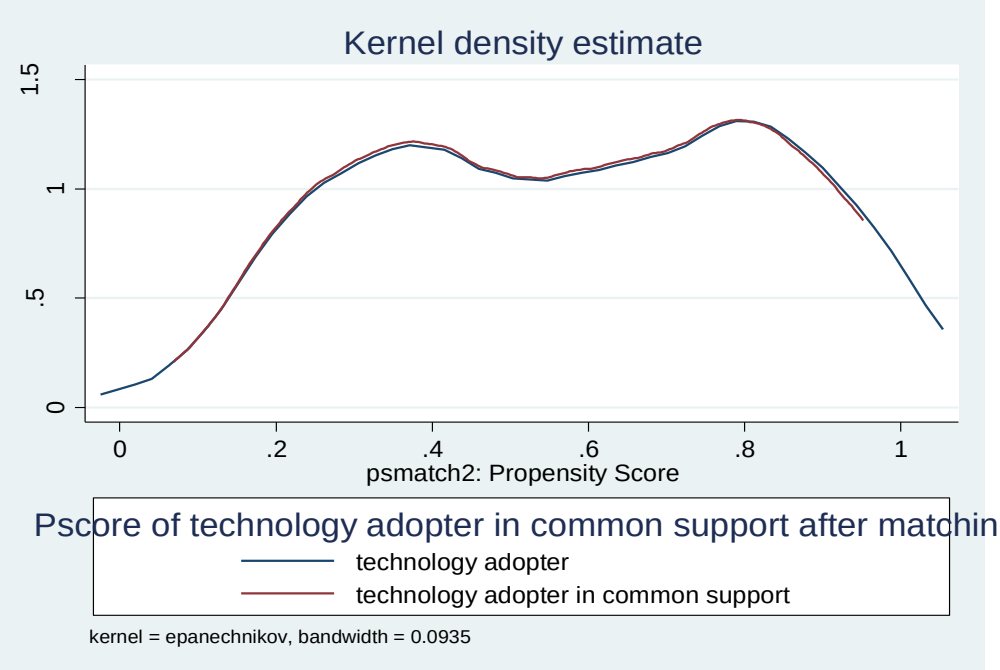
Table 4.11: Distribution of Estimated Propensity scores

Groups	Obs.	Mean	Sta.dev.	Min	Max	Off support
All sample	201	0.393	0.273	0.0049739	0.9713063	55
Adopter	79	0.581589	0.2488892	0 .0688023	0.960054	20
Non-adopter	122	0.2709383	0.2128262	0.0049739	0.9713063	35

Source: Survey Result Estimation.

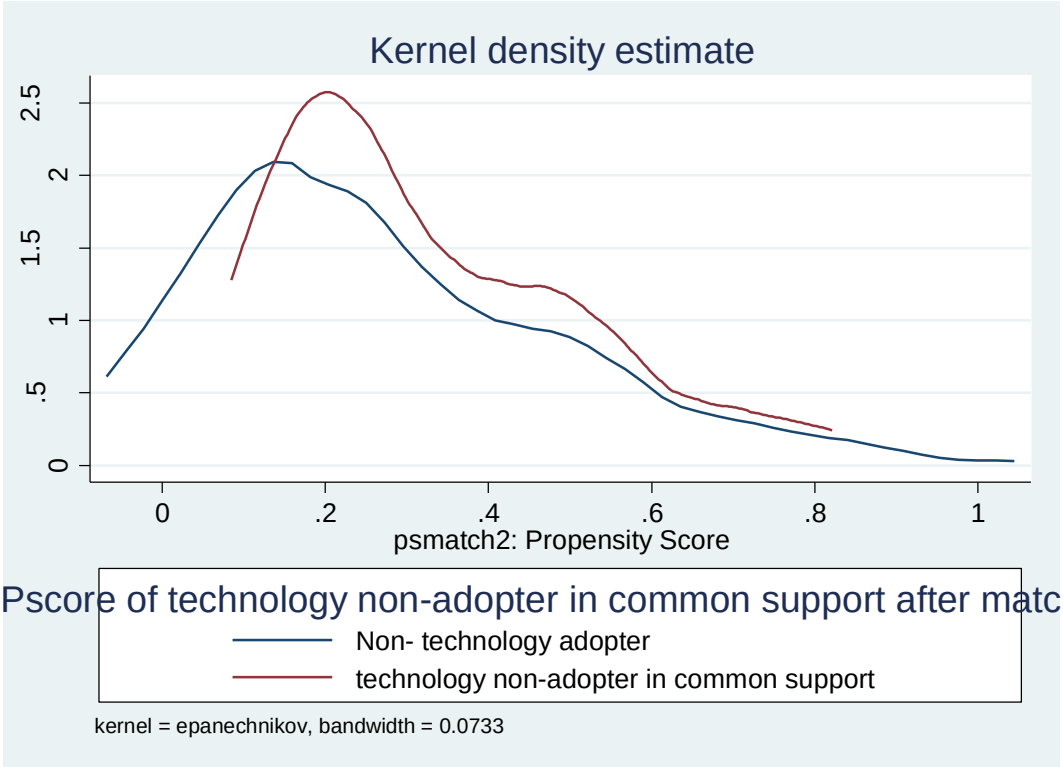
The distribution of propensity score matching for treated and control group after matching is portrayed in figure 4.4 and 4.5 respectively. The figures indicate that the propensity scores of the majority treated household were around 0.8, while their counterfactual group have a propensity score around 0.2.

Figure 4.4: Kernel Density of Propensity Scores of Technology Adopter Household.



Source: Survey Estimation Result

Figure 4.5: Kernel Density of Propensity Scores of Technology Non-Adopter Household.



Source: survey estimation result

4.2.3. Matching Algorithm

The challenge in employments of propensity score matching is the absence of definite techniques of choosing the appropriate algorithm for matching from the algorithm techniques mentioned in the literature, but mostly it is recommended based on theory and simulation. The best algorithm for the pertinent problem is exposed to uncertainty though the merit and demerits of each algorithm is known theoretically (Lance et al., 2014). But all matching algorithm compare the outcome of treated individual with the outcome of its counterpart (Lance et al., 2014 and Khandker et al., 2010).

Quality identification of the matched sampled result is the core steep in matching method. The matching method is treated as qualified matching if all covariates in the matched sample household (treated and control group) is balanced. Likewise, a matching method with high imbalanced sample is discarded and an alternative method is detected till a well balanced sample is attempted (Stuart, 2010 cited in Addis, 2014).In literature, matching quality is checked and appropriate matching algorithm for a given data is selected via the three dominant criterions such as equal mean test, low pseudo-R^2 value and large matched sample. By inspection method, the matching algorithm which

bears insignificant mean difference of covariates and low pseudo-R^2 with large matched sample is chosen as the best matching algorithm for this study. Based on the above mentioned criterion (table 4.12), caliper matching with 0.02 distances from the propensity score value of the individual observation fit the entire three criterions. Hence, caliper matching with 0.02 distance is the best matching algorithm for this study. Therefore, the estimation result of this study is based on caliper matching algorithm with 0.02 distances from propensity score of the individual household.

Table 4.12: Matching Quality of Different Estimator.

Matching estimator	Performance criterion		
	Balancing test	Pseudo-R^2 value	Matched sample size
Caliper Matching			
0.01	9	0.2625	124
0.02	9	0.2625	146*
0.5	7	0.2625	175
Kernel Matching			
Bandwidth 0.01	7	0.2625	117
Bandwidth 0.025	8	0.2625	130
Bandwidth 0.5	8	0.2625	135
Nearest Neighbor Matching			
N=1	6	0.2625	175
N=2	7	0.2625	175
N=3	7	0.2625	175
N=4	7	0.2625	175
N=5	7	0.2625	175

Remark: * indicates for nutritional analysis out of 135 child only73 (29 treated and 44 control) child were matched via caliper 0.02.

Source: Survey Estimation Result

4.2.4. Balancing Test of Propensity Score and Covariates

The main objective of matching is balancing treated and control groups on the bases of observable characteristics (Khandker et al., 2010 and Baker, 2000). Balancing test is aimed to check (verify) the independence of treatment from any characteristics after conditioning on observed characteristics (Lance et al., 2014). The quality of matching algorithm is checked through balancing test of covariates (equality of mean test between treated and control group after matching) by the commonly balancing test like T-test and standardized bias test.

The mean difference test (T-test) in table 4.13 shows before matching, including propensity score several covariates such as education level of the household, adult household member, land holding size and access to credit are balanced. Before matching, most of the standardized bias difference in covariates is above 20 which indicate differences in this covariate between treatment and control group. However, after matching through caliper there is no significant difference of covariates and propensity score between treated and control group. Moreover, the standardized bias difference become below 20.

The low pseudoR^2 and insignificant likelihood ratio test of joint test for mean equality between treated and control group in table 4.14 shows both groups have the same covariates after matching. Hence, based on partial and joint test of covariate and propensity score balance, there is no significant mean difference between adopters and non-adopters. Therefore it is trustworthy to estimate treatment effects based on the available data and the chosen matching algorithm (caliper with 0.02 distances from propensity score).

Table 4.13: Balancing Test for Propensity Score and Covariates

Variables	Mean			%reduction		T-test	
	Sample	Treated	Control	%bias	|bias|	T-value	p> |t|
_Pscore	Unmatched	0.582	0.271	134.2		9.45*	0.00
	Matched	0.483	0.484	-0.6	99.6	-0.03	0.973
Sex	Unmatched	0.139	0.074	21.2		0.52	0.131
	Matched	0.136	0.153	-5.5	74.1	-0.36	0.795
Age_h	Unmatched	44.608	43.615	7.6		0.52	0.606
	Matched	44.898	44.119	6.0	21.5	-0.36	0.723
Educ_h	Unmatched	3.038	1.672	44.3		3.16*	0.002
	Matched	2.217	2.373	-6.6	85.1	-0.35	0.724
Add_hh	Unmatched	3.038	3.426	40.7		2.82*	0.005
	Matched	3.814	3.678	12.3	69.7	0.62	0.534
Land_size	Unmatched	1.947	1.365	61.3		4.4*	0.000
	Matched	1.632	1.446	19.6	68	1.27	0.206
Ext_service	Unmatched	7.739	6.057	14.8		1.01	0.341
	Matched	7.322	5.593	20.1	35.9	1.34	0.182
Mkt_dista	Unmatched	5.058	4.425	16.0		1.03	0.306
	Matched	4.875	7.776	-73.4	357.9	-1.55	0.123
Credit_acces	Unmatched	0.911	0.656	65.0		4.29*	0.000
	Matched	0.898	0.864	8.6	86.7	0.57	0.573

Remark: * implies significant level at 1% significant level.

Source: Survey Estimation Result

Table 4.14: Chi-Square Test for Joint Covariate Balancing Test

Sample	Pseudo-R^2	LR-chi^2	P>chi^2	Mean bias	Med bias
Unmatched	0.262	70.71	0.000	45.0	40.7
Matched	0.038	6.27	0.713	17.0	8.6

Source: Survey Estimated Result

4.2.5. Impacts of Small Scale Irrigation Technology

The ultimate goal of propensity score analysis is ensuring comparison of treatment and control group in the same economic environment via balancing in order to get more accurate treatment effect (average treatment effect on the treated) of the treatment (Austin, 2011). If so, ATT can be estimated to measure the difference on the outcome variables.

The propensity score matching result (Table 4.15) shows there is a significant difference in consumption behavior between adopters and non-adopter households. The proportion of treated household current income spent on consumption by far is less than its counterpart. On average, the average proportion of income spent on consumption by technology non-adopters was more than a unit (1), which implies that non- adopter household cannot afford to finance their consumption. The result implies more than 0.3% of their consumption is autonomous[12] and they did not have longing the luxury of being able to save.

The result is consistent with relative consumption theory of Dusenbery, "people do not want to show to their neighbors that they no longer afford to maintain their standard of living". Unlike non-adopter, adopter household induce their consumption with their current income. More concisely, the proportion of the total amount of goods and services demanded by adopter households originated from the demand for consumer goods is lower than non-adopters by about 11.69 percent. The survey result shows there is a significant difference in consumption behavior between technology adopter and non-adopter. Non-adopter households spent higher even more than their income on consumption and smooth their consumption either through borrowing or using their previously saved or accumulated asset. But adopter household save part of their income for smoothing their future consumption. From the survey result it is possible to infer that, irrigation technology adoption

[12] Autonomous consumption is the consumption level of the household at zero level of their current income.

helps to improve the consumption smoothing habit of adopter households. The result is consistent with descriptive statistics result prior to matching. The noteworthy mentioning impact of small scale irrigation technology on consumption behavior of adopter household might result from cutting the spendthrift habit of households and their investment decision on their future life.

The PSM result in Table 4.15 shows empowerment status of women in adopter and non adopter households are significantly different. Women in technology adopter households suffered more disempowerment than non-adopter household by about 12 percent of the empowerment domain (above 1 domain out of 5 domains). The possible explanation for this might be empowerment of women as a result of irrigation treatment depends on the situation whether women in the household are farm decision maker or simply family laborer. As provided in the descriptive statistics result women in the study area are inadequate in decision making, so adoption of technology did not offer enjoyment of empowerment for women in technology adopter households as compared to women in non-technology adopter households. Moreover, empowerment of women might be determined by environmental and social factors like religion and culture. The result is consistent with the descriptive statistics result and the empirical finding of Bryan et al. (n. d) for comparison of Ethiopian irrigator and non- irrigator women and (Van Kopen et al., 2012).

The result also shows welfare of adopters and non-adopter households is significantly different. Glance in to the welfare indicator, on average, the welfare indicator score of technology adopter households is higher than non-adopter households by about 154.381.

The reason might be due to the fact that technology adopter household have produce more both in rainy and dry season which might improve their production and productivity to grow crop for market and own consumption.

Those opportunities enable them to improve their welfare via consumption of goods and services of both purchased goods including manufacturing goods (through exchanging) and own production. The result is in line with the descriptive statistics result and empirical findings of Munongo and Shallon (2013) estimating welfare role of agricultural technology on welfare rural Masvingo.

Table 4.15: Impacts of Small Scale Irrigation Technology Adoption on Households

Outcome variables	Treated	Controls	Difference	S.E[B]	T-value
APC	0.888	1.0031	-0.117	0.039	-3.42
WEAI	0.668	0.787	-0.12	0.0452	-3.00
WI	834.815	680.43	154.381	324.831	2.24

[B] Standards for bootstrapped error which is obtained after 100 replication.

Source: Survey Estimation Result.

4.2.6. Sensitivity Analysis

In this section, sensitivity analysis is conducted as the last stage of propensity score matching process. Sensitivity analysis helps to check the sensitivity of estimated treatment effects to hidden bias (Caliendo and Kopeinig, 2005). Rosenbaum bounding approach of sensitivity analysis allow to identify how robust finding cause hidden bias as a result of an unobserved confounder. Rosenbaum's bound p-values from Wilcoxon's signed rank test result are presented in table 4.16. The significant level (P-value) corresponds to value of sensitivity parameter Γ and outcome variable is the upper bound P values from Wilcoxon's signed rank test.

The estimation result of this study shows that the upper bound significance level (p value) is significant (i.e. $p < 0.05$) at different sensitivity parameter Γ. This lower significant level shows the estimated result is insensitive to hidden biases.

Therefore, the sensitivity analysis result shows even though the comparison groups (adopters and non-adopters) have the same covariates (after matching), they may differ in chances of receiving treatment at least by a sensitivity parameter up to $\Gamma=6$, the inferences on the impacts of small scale irrigation technology adoption on the household consumption behavior, empowerment of women and household welfare results are insensitive to unobservable characters (covariates).

Table 4.16: Sensitivity Analysis Result of Rosenbaum Bounding Approach

Gamma	Outcome Variables		
	APC	WEAI	WI
Γ=1	0	0	0
Γ=1.5	0	0	0
Γ=2	0	0	0
Γ=2.5	3.8e-15	3.6e-15	3.8e-15
Γ=3	6.4e-13	6.1e-13	6.4e-13
Γ=3.5	2.5e-11	2.4e-11	2.5e-11
Γ=4	4.0e-10	3.8e-10	4.0e-10
Γ=4.5	3.4e-09	3.3e-09	3.4e-09
Γ=5	1.9e-0 8	1.9e-08	1.9e-08
Γ=5.5	7.9e-08	7.8e-08	8.0e-08
Γ=6	2.6e-07	2.5e-07	2.6e-07

Notice: Γ (gamma) is the log odds of differential assignment as a result of unobserved factor.

Source: Estimation result

CHAPTER FIVE
CONCLUSION AND RECOMMENDATION

5.1. CONCLUSION

The ultimate motive of this study was to evaluate the impact of small scale irrigation technology on farm household welfare in the study area. To do so, household consumption behavior, women empowerment and household welfare impact evaluation was under taken on 201 household (122 control and79 treated) in Dengeshita and Robit, Amahara region, Ethiopia. It was hypothesized that small scale irrigation technology adoption has a positive effect on household welfare. To analyze the impact of technology adoption on the intended treatment outcome both descriptive and econometric analysis were employed. Moreover, women empowerment analysis was also under taken.

The empowerment analysis showed women in the study area were disempowered (empowered only in 0.713 percent) of the empowerment domains. The head count ratio implies 79 percent of women are disempowered in five domains of empowerment. Moreover, women who are not yet empowered are inadequate in 39 percent of the domain (which is in 2 out of the 5 empowerment domains). The disempowerment of women is highly influenced by two domains (income and time) and three indicators (such as income control, leisure and speaking in public) of empowerment.

Descriptive statistics analysis result revealed that there is statistically significant heterogeneity between adopters and non- adopters in terms of consumption behavior and empowerment status of women. Adopter household have consumption smoothing habit as compared to non-adopter household. Adopter women are more disempowered in 5.1% of the empowerment domain, which is in one domain out off the five domains. However, the difference between technology adopter and non-adopters in terms of nutritional status and welfare were found statistically insignificant.

The PSM result show that the likelihoods of the household to adopt small scale irrigation technology was influenced by covariates sex of the household head, education level of the household head, number of adult family size, land holding size, distance to the nearest market and credit access. The result implies that, those households whose head is female have higher probability to adopt irrigation technology than the male headed household. Likewise, households with highly educated head, large adult family size and large land holding are more likely to adopt small scale irrigation technology than their counter part. In addition to this households who live far

from the market center are more probable to adopt the irrigation technology. Moreover, households who have credit access have higher probability to adopt irrigation technology. Access to credit allows farmers to invest more on irrigation technology and irrigation. Hence it promotes the technology adoption probability of farm household.

The Propensity score matching estimation result also shows significant difference between adopters and non adopters in terms of the outcome variables such as consumption behavior, women empowerment and welfare of the household. The effect of small scale irrigation technology on consumption behavior of the household revealed that on average technology adopter household are sparing and they are prepared for their retirement age and contingency. On the contrary, non adaptor households are lavish and are not prepared to smooth their future life consumption via saving. Technology adopters save only 8.6 percent of their income while non-adopters spend on their consumption more than their current income with 2.3 percent autonomous consumption. Therefore, non-adopter household were found more spendthrift than adopter household.

The effect of small scale irrigation technology on women empowerment show that on average women in small scale irrigation technology adopter households enjoy empowerment only in 66.8 percent of the empowerment domain, which is by 12 percent lower than the empowerment enjoyment of women in non-technology adopter households. This might be woman in the technology adopter households has no role other than family labor. Beside, all women in the study area were empowered in the domain less than in 4 domains (80 percent of the empowerment domain), which implies all are disempowered.

Although technology adopters and non-adopter have the same socio-economic characteristics, the welfare of technology adopter household was found better than their counter parts, the effect is statistically significant. On average, technology adopter household enjoy welfare indicator score of 834.815, which is by 22.69 percent higher than the welfare indicator score of non-technology adopter households. Hence, the propensity score matching method indicate that small scale irrigation technology adoption plays a vital role in improving the household welfare in the study area.

Result of sensitivity analysis test shows that the treatment effects were insensitive to the hidden biases. This implies that the estimated impacts of small scale irrigation technology on women empowerment and household welfare were based on observed covariates.

To sum up, econometric result shows that adoption of small scale irrigation technology has a significant impact on household consumption behavior, women empowerment and welfare status of the household.

5.2. Recommendations

Evaluating the impact of small scale irrigation technology has a supreme importance to identify sensitive area of intervention by designing and redesigning policy and project intervention.

This study shows adoption of small-scale irrigation technology enable farm households to improve their saving habit and welfare status. Based on the empirical the following possible recommendations are suggested.

Education level of the household improves the probability of small scale irrigation technology adoption. This implies that proper utilization of irrigation technology requires special technical and managerial skills. So, in order to widen the adoption of irrigation technology and sustain the improvement of farm household welfare, special education such as vocational education of farmers, farmers training (training on operation and maintenance of technology and awareness creation of farm household) need to be provided for farmer.

The empirical result also shows that, land holding of the farm household significantly affects technology adoption decision. The land own by the farm household usually allot for several purposes including production of crops in dry and rainy season. Hence, farmers with large land holding are capable to grow the crop in all season. Therefore, focus has to be given for transforming non-arable land to arable land for improving the arable land size and increasing productivity of the available arable land via land management system. Beside, small farmers prefer to adopt technology that is more capital saving with less risky but large farmers need to adopt technology which are labor saving. As a result small farmers fail to adopt the technology due to the technology cost. So, due attention should be given for provision of low cost labor saving technology.

Likewise, distance to the nearest market positively affects the likelihoods of technology adoption by farm household. Long distance to the market discourages non-agricultural activity, reduce price at farm level and increase transportation cost for both input and output marketing. Therefore, attention should be given to create market integration (chine) between farmers (producers) and consumers (buyers).

Furthermore, access to credit has also positive impact on technology adoption. Access to credit either in the form of cash or in kind fortune the decision of farm household to invest in irrigation and increase the likelihood of farmers to adopt technology. So the concerned body such as micro finance institutions, multipurpose cooperatives, government development agencies and NGOs should give due attention on provision of credit for farmers for promoting investment in irrigation and expanding small scale irrigation technology adoption.

Women's overall empowerment, control over income, leadership and time are particularly significant to improve nutritional well-being of the household generally, nutritional status of the child particularly, which is pillar for future human capital formation. Moreover, women often considered as caregivers of children, therefore, their empowerment influence their child nutritional status directly through care practice and indirectly through their nutritional status. As a result, disempowerment of women is directly associated with poor child and maternal malnutrition. So, policy makers and intervention should aimed to empower women (by closing gender gap, ensuring access to productive resource use and control of income) and women's child-care responsibility should take in to consideration.

Generally, small scale irrigation technology had brought significant impact on improving saving behavior and welfare status of technology adopter households in the study area. Therefore, due attention should be given for expanding the adoption of small scale irrigation technology in the study area and other parts of the region. Government and other development agencies that intervene in irrigation activities should focus on cross cutting issue such as gender, nutrition, and over all wellbeing of the household. Emphases also have to be given for establishing market chine and farmers cooperative so as to improve the bargaining power of the farmers to get good price and optimize the benefits of the farm household.

Since adoption of small scale irrigation technology improve the welfare of farm household, policies and interventions of development agency quest to eradicate poverty in rural area should incorporate strategies of expanding small scale irrigation technology adoption as part of it aim.

5.3. Study Limitation and Future Research

Evaluating the impact of technology adoption on women empowerment, nutritional status is so vital and this study can evaluate it. The researcher could not investigate all the issue interrelated with. As a result, further research on the area should focus on the issue which this study cannot reach

because of time, budget and data constraint. The issues are: 1. Identify factors that hinder the empowerment of women and the nutritional status of the farm household 2. Examine the Link between empowerment indicators and nutritional status. 3. Cost effectiveness of the impact.

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APPENDICES

Appendix 1: Ten Indicators of Women Empowerment in Agricultural Index and Their Weights

Domain	Indicator	Weight
Production	Input in production decision	1/10
	Autonomy in production	1/10
Resource	Ownership of assets	1/15
	Purchase, sale ,or transfer of assets	1/15
	Access to and decisions on credit	1/15
Income	Control over use of income	1/5
Leadership	Group member	1/10
	Speaking in public	1/10
Time	Workload	1/10
	Leisure	1/10

Source: Alkier et al. (2013)

Appendix 2: Methodology for Calculating Disempowerment index and Gender parity.

To compute the WEAI and its sub-indices identification of indicators that contributes for empowerment is the preliminary activity. To do so, computation of disempowerment index across the five domains (M0) helps to compute 5Des (1-M0).

Coding the disempowerment indicators

The inadequacy score (C_i) of disempowerment indicators are coded value of 1 for an individual who is inadequate in all 10 indicators and 0 for an individual who has no inadequacy on any indicator. . The inadequacy score (C_i) is computed by:

$$(C_i) = W_1 I_1 + W_2 I_2 + \cdots + W_i I_i \quad (1)$$

Where I_1 = inadequacy achievement of a person in indicator "i"; $I_i = 1$ for inadequacy and 0 otherwise.$W_i$is the weight attached to indicator "i"

Identification of the disempowered

A cutoff 0.20 is used to identify the disempowered (Alkier et al., 2013). This cutoff is the share pf weighted disempowerment an individual must have to be considered as disempowered, which is denoted by (k). Hence, it is the way to compute the censored score. C_i (k) Denotes censored score and C_i is non censored score. If$C_i > k$, the $C_i(k)$=C_i and if$C_i < k$, then $C_i(k)$=0 where $C_i(k)$ is the disempowerment score of the disempowered.

Computing five domains of empowerment (5DE)

Steeps of computing 5DE:

Computation of 5DE has two components:

1st steep: (i) Disempowered head count ratio (H): it is the incidence of the individuals (within a given population) whose share of weighted inadequacies is more than the cutoff *k.*

$H = \frac{q}{n}$ Where q = number of disempowered individual, and n is the total population.

2nd steep: (ii) Intensity of empowerment (A): it is the average inadequacy score of disempowered individual.

$$A = \frac{\sum_{i=1}^{n} C_i(k)}{q} \qquad (2)$$

Where $C_i(k)$=the censored inadequacy score and q is the number of disempowered individual.

3rd steep: Computing five domains of disempowerment

The disempowerment of and individual in five domain of empowerment is the product of disempowerment headcount and the average inadequacy score. Symbolically:

$$M0 = H * A \qquad (3)$$

Finally, empowerment in five domains:

It is the empowerment score of an individual in a weighted five domains of empowerment.

$$5DE = 1 - M0 \qquad (4)$$

Equivalently, $5DE = H_e + H * A_e$ (5)

Where: $H_e = (1 - H)$ is empowered headcount ratio and $A_e = (1 - A)$ is the average adequacy score.

Breaking of disempowerment index by domain and indicators:

This is important to see the disempowerment of women in different context via decomposing M0 in to its component-censored indicators. The censored headcount in each of the indicators is calculated by adding up the number of disempowered people who are deprived in the indicator and dividing by the total population. The censored headcount ratio for an indicator implies the proportion of deprived people in that indicator.

The overall M0can be computed as:

$$M0_t = w_1 CH_1 + w_2 CH_1 \ldots + w_{10} CH_{10} \qquad (6)$$

Where $CH_i$is the censored headcount ratio of the indicator "i" and w_i is the weight attached ti indicator "i", the sum of each weight is equal to one.

The percentage contribution of each indicator for the overall disempowerment is computed as:

$$\%contribution\ of\ indicator\ i\ to\ M0 = \frac{w_i CH_i}{M0} \qquad (7)$$

The contributions of all indicators will sum up to 100 percent. And the percentage contribution of each domain to the overall disempowerment of women is the sum of percentage contribution of each indicator in their respective domain.

Calculating Gender Parity in Empowerment Index

Gender parity index indicates the inequality in the five domain of empowerment between primary male and female adult in each dual household. A household enjoys parity if the woman is empowered or not, her adequacy score is greater than or equal to her male counterpart in her household. The GPI has two pillars of information:

(i) **Percentage of women without gender parity (H_GPI):** is the proportion of women who lack gender parity relative their male counterpart in her household.

$$H_{GPI} = \frac{h}{m} \qquad (8)$$

Where h = number of households classified as without gender parity and m= total population of dual- adualt household in the population.

(ii) **Average Empowerment Gap (I_GPI):** is the extent of the inequality in empowerment between women without gender parity and men in the household. In other words, it is the average percentage gap between the censored inadequacy scores of women and men living in the household that lack gender parity.

$$I_{GPI} = \frac{1}{h}\sum_{j=1}^{h} \frac{c'j(k)^{w} - c'j(k)^{M}}{1 - c'j(k)^{M}} \qquad (9)$$

Where $c'j(k)^{w}$&$c'j(k)^{M}$ are the censored inadequacies scores of the primary women and men respectively, live in household$j$, and h is the number of household with gender parity inadequate.

Therefore, $GPI = 1 - (H_{GPI}\ x\ I_{GPI})$ (10)

Finally, $\text{WEAI} = 0.9\ \text{x5DE} + 0.1\text{xGPI}$ (11)

Appendix 3: Multicolinearity Test of Continuous Variables

Variables	VIF	1/VIF
Age_h	1.09	0.9167
Educ_h	1.08	0.927
Ext_service	1.07	0.931
Add_hh	1.04	0.96
Land_size	1.03	0.974
Mkt_distance	1.01	0.986
Mean VIF	1.05	

Source: Survey Estimation Result

Appendix 4: Contingency Coefficient for Categorical Variables

Variables	Sex_head	Credit_acces
Sex_head	1	0.015
Credit_acces	0.015	1

Source: Survey Estimation Result

Appendix 5: Linktest Model Specification Test of Propensity Score Estimation Model

Tchno_adoptio	Coefficient	Std.err	Z	p>|z|
_hat	0.983	0.157	6.22	0.000
_hatsq	-0.107	0.096	-1.12	0.263
_const	0.134	0.217	0.62	0.538

Source: Survey Estimation Result

Appendix 6: Household Survey Questionnaire

Informed consent:

Thank you for the opportunity to speak with you. I am a Post graduate student from Bahir Dar University. This questionnaire is prepared for the purpose of collecting information in Dengeshita and Robit to assess the welfare impacts of small scale irrigation technology. The study is conducted for academic purpose. These questions in total will take approximately 35 minutes to complete and your participation is entirely voluntary. If you agree to participate, you can choose to stop at any time or to skip any questions you do not want to answer. And your responses are confidential. I will interview other household in your community and other parts of Amahara region, Ethiopia. The collected data will use for how irrigation technology benefits the household in the study area. Therefore, you are kindly requested to give your honest responses for the provided questionnaire.

Thank you

Household survey questioner

Bahir Dar University

Post graduate office

Department of Economics

Household Survey Questionnaires to Study

Impacts of Small Scale Irrigation Technology on Farm Household Welfare

•Enumerator's name_____ Signature _____

Questionnaire Code _____ Date of interview _____

Section I: General Information

REGION	ZONE	WOREDA	KEBELE
Amhara			

ZONE CODE
1. W/ gojam
2. Awi zone

WOREDA CODE
1. Dangla
2. Bahir darzuria

KEBELE CODE
1. Dengeshia
2. Robit Bata

1. Household Characteristics

1.1. Type of household: 1) Male and Female adult 2) Female adult only 3) child headed

1.2. Sex of Household head…… 0) male 1) female

1.3. Age of the household head in years ----------. Age of the spouse in years ----------

1.4. Size of the household including the heads ……..

1.5. Marital status of the household head…: 1) Married 2)Never married 3) Divorced 4)Widowed

1.6. Educational status of the head…… and spouse……..
1) attend formal education 2) read and write from informal education 3) Illiterate

1.7. If the head and or spouse attend formal education, what are their maximum years of schooling? Head-----and spouse ……..

1.8. What is the role of the household head in the community: 1) Local administration 2) model farmer 3) chair or member of social services (such as idir, equb, mahiber, religious institution).

Detail information about the member (consider a member who live in other than gusts)

Child live in household	Sex	Age in years	Maximum completed year of school
1st child			
2nd child			
3rd child			
4th child			
5th child			
6th child			
7th child			
Other member specify			

1.9. What is/ are the main economic activities of the household?

1) Farming (crop production and animal husbandry) 2) petty trade
3) Off farming (hand craft include pottery, black smiting) 4) other specify----

1.10. What is your farming experience? ---------- Year.

Section II: Resource Ownership

2.1. Do you have your own land? 0) no 1) yes

2.2. how much land size do you have?---------- timad or----------gemed----------kada

2.3. How do you express your land quality (fertility)? 1) Good 2) medium 3)poor

Livestock ownership

2.4. Livestock owned by members of the household

Livestock type					
Cattle	**Qty**	**Equine**	**Qty**	**Small ruminant**	**Qty**
Ox		Horse		Sheep	
Cow		Donkey		Goat	

Bull		Mule		Poultry	
Heifer		Horse		Beehive	
Calf					

Section III: farm and irrigation activities

2.5. Do you practice irrigation? 1) yes 2) No

2.6. If your answer for question 4 is yes, how long you are experienced? ---------- Year.

2.7. Which crop did you irrigate in the last 12 month? Use any combination if there is 1) tomato 2) onion 3) pepper 4) Fruit 5) chat 6) fodder

2.8. Which technology you employ to lift water? 1) Rope and washer 2) pulley3) drip irrigation technology 4) water pump 5) Bucket/hose 6) motor pump 7) other

2.9. What is the source of water for irrigation? 1) well 2) river 3) lake 4) other

2.10. How far the well from the plot? ----------k.m

2.11. Are you willing to pay for this technology? 0) No 1) yes

2.12. How much you are willing to pay? ----------

2.13. Do you have used modern agricultural inputs in the in the production season 2007/08 E.C May 2007- April 2008)?1) Yes 2) No

2.14. If you do not irrigate what is/ are the main reason/s? pleas rank (**non-irrigators only**)

Reason for not to irrigate	**Rank**	**Remark**
1. Shortage of land		
2. Seed and/or seedling shortage		
3. Lack of water for irrigation		
4. lack of labor		
5. Inappropriate slope of the land		
6. Resting the land		
7. Lack of knowledge on irrigation		

Section IV: Infrastructure and service

4.1. Do you have access to market in the last 12 month? 0) No 1) yes

4.2. Have you ever take any agricultural training in the past 12 month? 0) no 1) Yes

4.3. Have you got any extension service from Keble DA in the past 12 month? 0)no 1) Yes

4.4. If yes how often you were visited by the expert from May 2007 – 2008 E.C? ---------- Days /year.

4.5. Did you get extension advises and trainings on irrigation practice practices last year 0) Yes 1) No

4.6. If you had got have you practice according to their advice? 0) Yes 1) No

Section V: Household income and Expenditure

I. Income

Please tell us about all the work that members of your household have done and how much income they earned from doing that work during the previous production season.

Livelihood Activity	*Unit*	Total harvest	Total annual net income earned *(Birr)*
Farm income			
Farm income (rain fed)			
Farm income (irrigation)			
Selling Livestock / animal			
Livestock products:			
Milk, butter			
Honey ,wax			
Egg			
Poultry and poultry products			
Other farm income (e.g., sell of hide and skin, manure, etc.)			
EMPLOYMENT			
Public works (food-for-work, cash-for-work)	Birr		
Agricultural laborer on others farm	Birr		
Daily laborer on non-farm activities	Birr		
Domestic work for others	Birr		
Other employment (specify):	Birr		
TRADING (buying and selling)			
Trading in food crops (grains, pulses, vegetables)	Birr		
Trading in livestock or livestock products	Birr		
Trading in other commodities	Birr		
SALE OF NATURAL PRODUCTS	Birr		
Selling firewood or charcoal or selling wild fruits, etc.	Birr		
Selling grass or fodder (for livestock)	Birr		
Selling construction materials (sand, wooden poles, etc.)	Birr		
Other (specify)	Birr		

Livelihood Activity	Unit	Total annual net income earned *(Birr per annum)*
CRAFTS / SMALL INDUSTRY		
Making baskets or mats	Birr	
Spinning or weaving cloth (cotton or wool)	Birr	
Making or repairing clothes (tailoring)	Birr	
Pottery/ Blacksmithing or metal-work	Birr	
Traditional healer	Birr	
Other (specify)	Birr	

RENTS		
Land rent	Birr	
Renting out oxen for farming	Birr	
Renting out pack animals for transport (e.g. donkeys)	Birr	
Housing rent	Birr	
Other (specify)	Birr	
FOOD & DRINK PROCESSING AND SELLING		
Selling drink (both soft and alcoholic)	Birr	
Selling cooked food	Birr	
Other (specify)	Birr	
OTHER		
Remittances	Birr	
Pension	Birr	
Food aid	Birr	
Compensation	Birr	
Other (specify)	Birr	

I. Consumption expenditure

Agricultural items	Consumed last week (last seven days)		
	Quantity	unit	Total value (Birr)
Cereals			
Teff			
Maize			
Wheat			
Barley			
Sorghum			
Millet			
Rice			
Bread			
Pasta, macaroni, and biscuit			
Infant feeding cereal			
Other (specify)			
Pulses			
Beans			
Peas			
Chickpea			
Vetch			
Lentil			
Vegetables			
Cabbage			
Onion			
Garlic			
Tomato			
Pumpkin			
Green leafy vegetables			
Row pepper			
Other (specify)			
Oilseeds			
Noug			
Sesame			
Rapeseed			
Linseed			
Other (specify)			
Fruit			
Banana			
Orange			
Mango			
Avocado			
Papaya			
Ayton			

Agricultural items	Consumed last week (last seven days)		
	Quantity	unit	Total value (Birr)
Fruit juice			
Roots			
Potatoes			
Tuber and root crops			
Other (specify)			
Behaverage& stimulant			
Coffee			
Sugar, Tea			
Alcohol (birra, Ozo,)			
Local beer (tela, arki) at home			
Tela ,arki (commercial)			
Sweet candy			
Hopes/ Gesho			
Chat			
Soft drink (coca, penpsi)			
Other (specify)			
Animal products			
Milk			
Butter			
Cheese			
Meat			
Fish			
Eggs			
Honey			
Other (specify)			
Cooking additives			
Spices			
Yeast			
Pepper			
Salt			
Baking powder			
Oil			
Other (specify)			
Energy sources			
Kerosene			
Fire wood			
Dung			
Other (specify)			

NON-FOOD EXPENDITURES

List of consumed item	Consumption over the last 12 month? In birr		
	quantity	Unit price	Total value
Cloth and foot wear			
Infant clothing			
Baby nappies/diapers			
Boy's & Daughter's clothing			
Men's and women's clothing			
Boys' & Girls Shoes			
Women's and men's Shoes			
towels, sheets, blankets, matters			
Umbrella			
Matt, rug			
Other (specify)			

Non consumption expenditure over the last 3 month

List of consumption item	Consumption over the last 3 month? In birr		
	Quantity	Unit price	Total value
Charcoal			
Firewood			
Kerosene			
Electric and gas Stove			
Other (specify)			
Laundry and dry			
Laundry soap(OMO/endod, detergents)			
Hand soap			
dry cleaning, tailoring fees			
Others			
Other utilities			
Matches			
Batteries			
Candle			
Transport			
Education (for school fees, stationary e.t.c.)			
Health (treatment, drugs, e.t.c)			
Other personal care goods (incl sendel, matent)			
Other (scissors, needle, razor)			

Kitchen equipment over the last 12 month

List of Kitchen equipment	Consumption over the last 12 month? In birr		
	Quantity	Unit price	Total value
Plate			
Pot			
Knives, Spoon			
Boiler, Basin			
Other personal care goods (incl sendel, matent)			

Durable good consumption over last 12 month

List of consumed items	Consumption over the last 12 months? In birr		
	Quantity	Unit price	Total value
Furniture			
Bed			
Table , Chair , Desk			
Box /cupboard			
Coffee table			
Beer-brewing drum			
Media and light			
Radio			
Television			
Tape or CD/DVD player			
Solar light			
Clock			
Other (specify) ----------			
Ceremonial expenses			

Nuptials/ Weeding			
Funeral			
Holyday			
Contributions to IDDIR			
Donations to the church			
Tezikar			
Zikir			
Fines/ legal fee			
Others			

Section VI: Subjective wellbeing of the household

5.1. How do you perceive about your household's wellbeing status as compared to an average household in your community? 1) very rich 2) rich 3) self-sufficient 4) poor 5) very poor/destitute

5.2. Is your wellbeing seasonally varying? 1) yes 2) no

5.3. If you say yes for 2, why is seasonally varying? ----------

5.4. Are you capable to feed your own household? 0) No 1) yes 2) partially

5.5. Types of the house the household dwelling: 1) corrugated iron roof with mud wall 2) Grass roof with wood wall 3) plastic roof 4) other specify ……..

5.6. What is the principal material used for the floor of your house? 1) Dirt or dung 2) Sand 3)Cement 4) asphalt 5) Wood plank 6) polished wood 7) carpet 8) other specify …..

5.7. How many people are there for each sleeping room in your household? ---------- Person per room.

5.8. How do you express your family's sleeping situation?

1) All slept on bed 2) Only the head and spouse get sleep on bed 3) All sleep on floor 4) other specify……

5.9. How the living situation of the livestock and the household member in your house?

1) Separate 0) joint

5.10. What is the principal source of drinking water: 1) Piped water 2) covered well in dwelling 3) open well 4) hand well public 5) River 6) canal 7) surface water 8) open spring 9) covered spring 10) rain water 11) others.

5.11. What is the principal source of fuel for cooking use of your household?

1) Electricity 2) gas 3) biogas 4) kerosene 5) Charcoal 6) Wood 7) dung / manure 8) other

5.12. What is the principal toilet facility used by your household?

1) Private foolish 2) private latrine 3) VIP latrine 4) bush 5) field as latrine

5.13. How do you describe your household living standard before and after irrigation? (only irrigator)

i. **Before irrigating :**

1) _____
2) _____
3) _____
4) _____

i. After irrigating:

1) _____
2) _____
3) _____
4) _____

Section VII: Women empowerment

Enumerator: ask only the household either Male and Female adult or Female adult only

1. Production

Role in Household Decision-Making on Production and Income Generation

Activities	Did you participate in [Activities] over the last 12 month **1= yes, 0= No**		Who participate in decision on product type and input for the activities over the last 12 month **1= men, 2= women, 3=heads Jointly,4= other hh member, 5= others non-hh member**	How much input did you have in making decisions about [Activity]? Code1		How much input did you have in decisions on the use of income generated from [Activity]? Code1	
	men	Women		**men**	**women**	**men**	**women**
Food crop farming: (hh food consumption)							
Cash crop farming (for sale in the market)							
Livestock raising							
Non-farm economic activities: Small business, self-employment, buy-and-sell							
Wage and salary employment: in-kind or monetary work both agriculture and other wage work							
Fishing or fishpond culture							

Code 1:input in to decision making:
No input=1, input into very few decisions=2, input into some decision=3, input into most decision=4, input into all decision =5, No decision made=6.

Motivation for Decision Making (Autonomy)

Aspects	My actions in [aspects] are partly because I will get in trouble with someone if I act differently. [**Read Options**: **always true, Somewhat true, Not very true, or Never true]**		Regarding [aspects] I do what I do some others don't think poorly of me. [**Read Options**:**always true, Somewhat true, Not very true, or Never true]**		Regarding [aspects] I do what I do because I personally think it is the right thing to do. [**Read Options**:**always true, Somewhat true, Not very true, or Never true]**	
	A1		A2		A3	
	Men	Women	Men	women	men	women
Getting inputs for agricultural production						
The types of crops to grow for agricultural production						
Taking crops to the market (or not)						
Livestock raising						

A1, A2, A3: **motivation for activity:**

Never true =1, not very true=2, somewhat true=3, Always true=4, the hh is not engaged in the activity=0

2. Resource

i. Asset Ownership

Productive Capital	Did your household own the [items] in the last 12 month 1= yes 0=No	Who own the [ITEM]?	Who decide whether to sell out or rent [ITEM] most of the time?	Who decide whether to transfer [ITEM] most of the time?	Who contributes most to decisions regarding a new purchase of [ITEM]?
		R1	R2	R3	R4
Agricultural land (pieces/plots)					
Large livestock (oxen, cattle)					
Small livestock (goats, pigs, sheep)					
Chickens, Pigeons					
Fish pond or fishing equipment					
Farm equipment (non-mechanized)					
Farm equipment (mechanized)					
Nonfarm business equipment					
House (and other structures)					
Large durable consumer good (fridge, TV, sofa)					
Small consumer durables (radio, cookware)					
Cell phone					
Other land not used for agricultural purposes (pieces, residential or commercial land)					
Means of transportation (bicycle, motorcycle, car)					

R1, R2, R3, R4: 1) men, 2) women, 3) heads jointly, 4) only meal member, 5) only female members, 6) all member, 7) others non-household member

ii. Access to and decisions about Credit

Source of borrowing	Did anyone in your household borrowed from [**SOURCE]** in the last 12 month? **1=yes, 0=No**	Who made the decision to borrow from **[SOURCE]?**	Who made decision about what to do with the money/ item borrowed from [SOURCE]?	Who made decision about what to do with and how to use the money/ item borrowed from [SOURCE]?
		C1	**C2**	**C3**
Non-governmental organization (NGO)				
Informal lender				
Formal lender (bank/financial institution)				
Friends or relatives				
Group based micro-finance or lending including ACSI, RUSA				

C1, C2, C3: decision making and control over credit

1) Men 2) women 3) heads jointly, 4) only meal member, 5) only female members, 6) all members, 7) others non-household member

3. Income

	When decisions are made regarding the following aspects of household life, who is it that normally takes the decision?		To what extent do you feel you can make your own personal decisions regarding these aspects of household life if you want(ed) to	
	CODE 1		**CODE 2**	
	Men	**Women**	**Men**	**women**
Agricultural production?				
What inputs to buy for agricultural production?				
What types of crops to grow for agricultural production?				
When or who would take crops to the market?				
Livestock rising?				
Non-farm business activity?				
Your own (singular) wage or salary employment?				
Major household expenditures (like durable goods)				
Minor household expenditures (like food for daily consumption or other household needs)				
Whether or not to use family planning to space or limit births?				

Instruction :

Code 1: Decision making

husband = 1
wife = 2
Husband and wife jointly = 3
Husband & Boy jointly in the hh = 4
Wife & boy Jointly inside the hh = 5
Wife & girl Jointly with the hh =6
Someone outside the household = 7
Decision not made = 0

CODE2:

Not at all =1
Small extent =2
Medium extent =3
To a high extent =4

4. Leadership

1. Group Member

Group membership	Is there a [GROUP] in your community? **Yes=1 No =0**	Are you an active member of this [GROUP]? **Yes=1**	How much input do you have in making decisions in this [GROUP]?	**Instruction:** **Code 1** No input = 1 Input into very few decisions

		No =0		Code 1		=2 Input into some decisions = 3 Input into most decisions = 4 Input into all decisions =5 **Code 2** Not interested =1 No time =2 Unable to fund entrance fees =3 In convenient group meeting location =4 Family dispute/unable to join =5 Not allowed because of sex = 6 Not allowed because of other reason = 8 Other, specify = 9
		men	women	Men	women	
Group Categories						
Agricultural / livestock/ fisheries producer's group (including marketing groups)						
Water users' group						
Forest users' group						
Credit or microfinance group (including SACCOs/merry-go-rounds/ VSLAs)						
Mutual help or insurance group (including burial societies)						
Trade and business association						
Civic groups (improving community) or charitable group (helping others)						
Local government						
Religious group						
Other women's group (only if it does not fit into one of the other categories)						

2. Individual leadership and influence in the community (comfortable felling in public speaking)

Question	Response		Response code : **1=** No, not at all comfortable **2=** Yes, but with a great deal of difficulty **3=**Yes, but with a little difficulty **4=** Yes, fairly comfortable **5=**Yes, very comfortable
	men	women	
Do you feel comfort when you speaking up in public to help decide on infrastructure (like small wells, roads, water supplies) to be built in your community?			
Do you feel comfort when you speaking up in public to ensure proper payment of wages for public works or other similar programs?			
Do you feel comfort when you speaking up in public to protest the misbehavior of authorities or elected officials?			

5. Time allocation

1. Work load

Activities	How much time is spent on [activity] in the last 24 hours?	
	Men	Women
Sleeping / resting		
Eating and drinking		
School		
Work as employed		
Own business work		
Farming / livestock		
Shopping /getting service		
Weaving ,sewing		
Cooking		
Domestic work (fetching water & wood)		
Care for children/ adult/ elders		
Traveling and communicating		
Watching TV/listing radio		
Exercising		

Social activities and hobbies		
Religious activities		
Other		

2. Leisure hour

	Response	Response options/Instructions
Was yesterday a holiday or nonworking day?		Yes =1 No = 0
Regarding the amount of sleep you got last night, was that: [READ RESPONSES]:		Less than average = 1 Average = 2 More than average = 3
How satisfied are you with your available time for leisure activities like visiting neighbors, watching TV, listening to the radio, seeing movies or doing sports?		**READ**: Please give your opinion on a scale of 1 to 10. 1 means you are not satisfied and 10 means you are very satisfied. If you are neither satisfied or dissatisfied this would be in the middle or 5 on the scale.

Thank you for all!!!