CONTRIBUTION OF SMALL SCALE IRRIGATION TO LIVELIHOOD AND ADAPTIVE CAPACITY TO CLIMATE VARIABILTY OF SMALLHOLDER FARMERS AT WOLISO DISTRICT, OROMIA REGION, ETHIOPIA.

M.Sc. THESIS

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A THESIS SUBMITTED TO THE

DEPARTMENT OF AGROFORESTRY,

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REQUIREMENT FOR THE

DEGREE OF

MASTER OF SCIENCE IN CLIMATE SMART AGRICULTURE LANDSCAPE ASSESSMENT

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APPROVAL SHEET-1

This is to certify that the research thesis entitled " Contribution of small scale irrigation to livelihood and adaptive capacity to climate variability of smallholder farmers at Woliso District, Oromia Region, Central Ethiopia" submitted in partial fulfillment of the requirements for the degree of Master of Science with specialization in climate smart agricultural landscape assessment of the graduate program under the department of Agroforestry, Wondo Genet College of Forestry and Natural Resources and is recorded of original research carried out by *Getahun Chala Id.No M.Sc /CSAL/R012/10*, under my supervision, and no part of the research has been submitted for any other degree or diploma.

The assistance and help received during the course of this investigation have been duly acknowledged. Therefore, I recommended it to be accepted as fulfilling the thesis requirements, hence hereby can submit the thesis to the department.

Yemiru Tesfaye (PhD)	____________________	________________
Name of Main Advisor	Signature	Date

APPROVAL SHEET-II

We, the undersigned, members of the Board of examiners of the final open defence by Getahun Chala have read and evaluated her thesis entitled "Contribution of small scale irrigation to livelihood and adaptive capacity to climate variability of smallholder farmers at Woliso District, Oromia Region, Ethiopia" and examined the candidate. This is therefore to certify that the thesis has been accepted in partial fulfilment of the requirements for the degree of Master of Science in Climate Smart Agriculture and Landscape Assessment.

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DECLARATION

I, Getahun Chala, hereby declare that the thesis entitled "Contribution of small scale irrigation to livelihood and adaptive capacity to climate variability of smallholder farmers at Woliso District, Oromia Region, Ethiopia" submitted for the partial fulfillment of the requirements for the Master of Science in Climate Smart Agriculture Landscape Assessment is the original work done by me under the supervision of Yemiru Tesfaye (PhD). This thesis has not been published or submitted elsewhere for the requirement of a degree program to the best of my knowledge and references are listed at the end of the main text.

Getahun Chala Gurmessa

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Signature Date

ABBREVIATIONS AND ACRONYMS

AD	Adaptive Capacity
CSA	Central Static Agency of Ethiopia
DAs	Development Agents
ENMA	Ethiopia National Meteorology Agency
FAO	Food and Agriculture Organization
FGD	Focus Group Discussion
FHHs	Female Household Heads
IPCC	Intergovernmental Panel on Climate Change
KI	Key Informant
LSI	Large Scale Irrigation
MHHs	Male households
MoANRM	Ministry of Agriculture and Natural Resource Management
MoFED	Ministry of Finance and Economic Development
MoWR	Ministry of Water Resource
MSI	Medium Scale Irrigation
NAPA	National Adaptation Program of Action
NGOs	Non-government Organizations
PANE	Poverty Action Network of civil society organizations in Ethiopia
SNNPRS	Southern Nation Nationality and Peoples Regional State
SPSS	Statistical Package for Social Sciences
SSI	Small Scale Irrigation
TIP	Traditional Irrigation Practice
UNFCCC	United Nation Framework Convention on Climate Change
WWRDAO	Woliso Worade Rural Development and Agricultural Office
MRV	Measuring Reporting and Verification

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CONTRIBUTION OF SMALL SCALE IRRIGATION TO LIVELIHOOD AND ADAPTIVE CAPACITY TO CLIMATE VARIABILITY OF SMALLHOLDER FARMERS AT WOLISO DISTRICT, OROMIA REGION, ETHIOPIA.

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ABSTRACT

Small scale irrigation is one of the most useful practice designed to increase production and productivity while reduces risk related with climate variability and improving livelihood of rural farm households indeed. So, the main objective of this paper is to investigate the contribution of Small Scale Irrigation to improve livelihood and enhancing adaptive capacity to climate variability of smallholder farmers in the study area. In study area available irrigation potential but still know this practices poorly managed by smallholder farmers. This study was initiated to investigate whether SSI practice contributes to improving lives and enhancing the adaptive capacity of climate variability to smallholder farmers or not. A multi-stage stratified sampling procedure was used to select 156 samples household from both irrigation user and non-user living within the three kebeles. Quantitative data analysis through descriptive statistics, degree of adaptive capacities household index and qualitative study were used to reach reliable results as well as data gathered from both primary and secondary sources. The survey results revealed that, mean annual income of the irrigation users and non-users were found to be 27,959.11ETB; 18,667.40ETB respectively and minimum 3,500ETB; 1,500ETB and maximum 126,500ETB; 20,840ETB respectively. The average annual income of both groups are significant different at 95% level. This indicates that irrigators have better attainment annual income from agricultural production and high adaptive capacity as compare to non-irrigators. Irrigation users have more use selective valuable adaptation strategy gotten output on short period of time and more asset holding, besides the evidence has ensured that poor grown of agricultural production during climate variability. The logit model revealed that household family size, age, education level, number of livestock, credit service, market information, farm distance, access to non-farm activity and annual income were found significant determinants of SSI use. However, to enhance the adaptive capacity impact and livelihood improvement of SSI was constrained due to lack of access to and distance from irrigable water sources, poor canal, initial capital, presence of disease and pests, lack of an effective marketing system. Thus, improving institutional support towards capacitating, training, and improved irrigation technology would play an inevitable role in enhancing the effect of irrigation on livelihood improvement, asset building and enhancing the adaptive capacity of household farmers towards climate variability.

Key words: Adaptation strategy, annual income, climate variability, physical Asset, traditional river diversion canal.

1. INTRODUCTION

1.1 Background of the study

Climate change-related exposures are likely to affect the agriculture productivity of rural communities, particularly those with low adaptive capacity, through increases in malnutrition and consequent disorders, with implications for livelihood and development among other things (IPCC, 2007). In Africa, agriculture forms the backbone of most of the continent's economies, providing about 60% of all employment (Desale Kidane, 2015). Recent estimates show that only 4% of the production area is under irrigation in sub-Saharan Africa, compared with 39% in South Asia and 29% in East Asia (UNCTAD, 2015).

The area under irrigation development to-date is estimated to be 640,000 hectare for Ethiopia which is less than 5% of the potential irrigable 3,731,222 hectare (Desta Damena, 2012), so there is considerable scope for expansion.

It is critically important to consider small scale irrigation as a conventional practice in smallholder agriculture that improves: farm productivity, enhancing adaptive capacity of climate variability extremes while achieving of livelihood and country goals. Small Scale irrigation has served as one of the key drivers behind growth in agricultural productivity, increasing household income and alleviation of rural poverty, thereby highlighting the various ways that irrigation can impact poverty (Eneyew Adugna *et al.*, 2014).

To meet food requirements by 2020, (FAO, 2005) estimated that food production from irrigated areas are needed to increase from 35% in 1995 to 45% in 2020. Irrigation use in

Ethiopia dates back several centuries, and continues to be an integral part of Ethiopian agriculture. Local communities had already practiced irrigation by diverting water from rivers in the dry season for the production of subsistence food crops by traditional irrigation practice (Woldeab Teshome, 2006).

In spite of all this, agricultural growth still contributes to the improvement of food security conditions and household empowerment in the country. Irrigation would therefore have to be introduced in a significant way for a sustainable achievement of food security and rural transformation at the national level (Kidena Desale *et al.*, 2012). Small scale irrigation in the Ethiopian context refers to smallholder farms to the size of practice amounting to small hectare and practices can be adapted easily to suit local socioeconomic and environmental conditions (Sokoni Cosmas, 2005).

The adoption of sustainable water management and small scale irrigation development programs as well as strong linkages with private sectors and markets with institutional support is essential; these could provide plenty of opportunities in terms of a coping strategy for climatic variability, growth of economy and reducing the environmental impact of agricultural expansion to marginal land under rapid population growth (Awulachew *et al*., 2010). For in Ethiopia, irrigation is increasing agricultural productivity, enabling households to generate more income, increasing their resilience as well as transforming their livelihood stands out as the most pressing agenda now and for the coming decades (Napa, 2007).

Small scale irrigations is a policy priority in Ethiopia for rural poverty alleviation, climate change adaptation and growth (MoFED, 2010). The principal feature of rainfall in most parts of the study area is seasonal character, poor distribution and variability from year to year (Solomon Tekalign. 2015) and affecting household livelihood and failure agriculture productivity. Thus, designing SSI practice is necessary and could bring socioeconomic importance to the beneficiaries.

1.2 Statement of the problem

In Ethiopia, irrigation development is a priority for agricultural transformation, but poor practices of irrigation management discourage efforts to improve livelihood and expose people and the environment to risks (Desale Kidena, 2015). Moreover, the poor performance of irrigation in the country, systematic and holistic evaluation of irrigation management in general and of small-scale irrigation in particular is lacking (Getaneh Kebede, 2011). In most parts of Ethiopia, production from rain-fed agriculture has been highly fluctuating, corresponding to the amount and distribution of rainfall.

A distinctive feature of agriculture production in the study area is the level of risk due to climate variability, which is more depend on rain fed and lack of use modern technology. The livelihood and production shocks which rural farmers are exposed to cause farm profits to vary hence affects the livelihood of rural farmers. Fluctuations in agriculture production and particularly the adaptive capacity to climate variability of small holder farmers decrease, may present difficult livelihood problems for rural farmers.

To respond to climate variability towards enhancing adaptive capacity through agricultural production should increase; SSI has the potential to sustainable development as well as help offset some of the negative effects of rapid population growth in Ethiopia (Ethiopia CSA, 2013). Despite Small-scale irrigation has immense potential to improve the incomes of poor rural households in developing countries like Ethiopia, it is never free from problems.

In some parts of rural area, short term climate variability affects agriculture productivity. So, smallholder farmers' which are in weaker positions to adopt alternative strategies to cope with the face of changes around them. In the study area, SSI practice is mainly based on a traditional river diversion canals so, water shortage during cropping season due to the high seepage of irrigation water through the canal.

The systems were developed by farmers for a long time, particularly to enable timely sowing of crops with the onset of rainfall and to protect against dry periods. Hence, there is a need for a better understanding of the socio-economic benefit of these traditional irrigation activities to smallholder farmers for livelihood improvement as well as enhancing adaptive capacity to respond to climate variability.

This depicts the fact that if we maximize our efforts to utilize the untapped water resources for irrigation development, we will be able to improve the household livelihood and overcome the challenges of adaptive capacity within the shortest time possible (Awulachew *et al.*, 2010). SSI practices in the study area to date; there are no recent studies on the contribution to refused climate variability extremes and factor influences of its practices. This study was investigated of the effect of the practices and recommendations for improving the systems. Therefore, the objective of this study was to examine the contribution of Small Scale Irrigation to livelihood improvement and adaptive capacity to climate variability of smallholder farmers in the study area.

1.3 Objectives of the Study

1.3.1 General objective

The general objective of this study was to investigate the contribution of Small Scale Irrigation to improve livelihood and enhancing adaptive capacity to climate variability of smallholder farmers in the study area.

1.3.2 Specific objectives

The specific objectives of this study are:-

1. To assess the contribution of small scale irrigation to smallholder farmer's livelihood improvement and asset building;
2. To compare the adaptive capacity to climate variability between Small Scale Irrigation users and non-users smallholder farmers in the study area;
3. To identify the major constraints of the small scale irrigation practice in the study area;
4. To identify the determinant factors of small scale irrigation practice by households in the study area.

1.4 Research Questions

1. How a significant difference asset building of smallholder farmers with access to small scale irrigation and those without access?

2. How a smallholder farmers' adaptive capacity to climate variability higher among irrigators compared to non-irrigators?

3. What are the major factors that constraint irrigation practices and limit its contribution to the adaptive capacity to climate variability of smallholder farmers to climate Variability?

4. What are the determinant factors that influence smallholder farmers to practice small scale irrigation?

1.5 Significance of the Study

Understanding the factors that cause farmers to partially or fully use or drop the use of small-scale irrigation is crucial for an improved design and transfer of the recommended practices. It is also important for researchers, extension workers and policymakers to know the pattern, intensity, and dynamics of adoption and abandonment of improved small-scale irrigation packages. The generated information was also help extension to design proper strategies for removing barriers to higher adoption of improved production technologies by smallholder, and policymakers to increase adaptive capacity, sustainable agricultural productivity without seasonal problems and improving livelihood smallholder in the study area.

1.6 Scope and limitations of the Study

This study was limited by different factors such as time, resource and availability of secondary data, limited area coverage concentrates to examine the contribution of SSI on smallholder farmers to livelihood and enhancing adaptive capacity to against climate variability to one district. The study used the cross-sectional design so that data collection was made at one time, due to dynamic changes in the livelihood, socioeconomic diversity of smallholder farmers and adaptive capacity indicators may difficulty to measure and hinder concluding. These shows during a household survey challenge to gather information and the absence of secondary data. Not willingness to respondents share necessary information because they engaged in different social duties and shortage of irrigation experts within the worade office for detail information obtained, inaccessibility of roads so, the researcher was enforced to walk long distances on foot; this made the data collection process longer than it was planned.

2. LITERATURE REVIEW

Climate Change: Is a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer (UNFCCC, 2007).

Climate Variability: Is the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events (IPCC, 2007).

Adaptive capacity: Is the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damage, to take advantage of opportunities, or to cope with the consequences (IPCC, 2007).

2.1 Theory of small scale irrigation

Irrigating households reported an average 20% increase in annual income since adopting irrigation due to cultivation of higher value crops, intensified production and reduced losses (Belay Mehretie *et al.*, 2013) and most successful households have increased their assets, particularly livestock which is an important form of saving and wealth accumulation. Some have bought new farming equipment to further increase productivity. In this way irrigation can lead to an upward spiral of increased production and income, and some households say that their livelihoods have been 'transformed'.

The Government of Ethiopia has identified small-scale irrigation as an important component of adaptation (GoE, 2010). The study found that small-scale irrigation is a potentially valuable component of adaptation strategies as it increases agricultural productivity and households' ability to cope with climate variability. However, accompanying measures are required to ensure that; water sources themselves are resilient to a variable climate and the design is proofed against extreme events. However, in

Ethiopia most irrigation is currently supplied by surface water. There is a low level of knowledge about the groundwater resource and little monitoring of groundwater levels, making it difficult to assess the sustainability of abstraction.

2.2 Climate Change

Climate change as “a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere, and that is in addition to natural climate variability over comparable time periods”. Climate change is a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer (UNFCCC, 2007).

It is a trend in one or more climatic variables characterized by a fairly smooth, continuous increase or decrease of the average value during the period of record, such as, increasing trend in air temperature and the frequency of drought, increase in frequency of flood and decreasing trend in rainfall with a statistical significance (IPCC, 2007). By contrast, the IPCC, 2007 takes a broader view on ‘climate change’ and states that climate change can occur as a result of natural variability and human activity.

2.3 Vulnerability of smallholder farmers to climate change

Vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes (IPCC, 2007). It is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity to climate change, and its adaptive capacity. According to the (Ungtae Kim *et al.*, 2008) long-term climate change in Ethiopia is associated with changes in precipitation patterns, rainfall variability, and temperature, which could increase the country's frequency of both droughts and floods.

Low economic development, inadequate infrastructure, and lack of institutional capacity all contribute to the country's vulnerability to the adverse impacts of climate change. In addition, Ethiopia's economy is heavily dependent on agriculture and faces increasing population growth. Negative climatic impacts on crop and livestock production could result in a nationwide food shortage and greatly hinder the economy. If appropriate steps are not taken, food insecurity, deepened poverty, and increased incidence of disease, such as malaria and yellow fever, would be likely consequences.

The farming community was identified as the most vulnerable because of its dependence on agricultural production for its livelihood. Within the farming community, small-scale, rain fed subsistence farmers as well as pastoralists were identified as more vulnerable to changing climatic conditions than others. In addition, farm households without assets and financial resources were identified as especially vulnerable, as their limited resources restrict them from easily adapting to the changing climate (Aemro Tazeze *et al*., 2012). These changes will impact natural and human systems directly or in synergy with other determinants to alter the productivity, diversity and functions of many ecosystems and livelihoods around the world.

Limited capacities and resources for responding to stresses such as droughts and floods, constrain their ability to meet basic needs and move out of poverty. These new vulnerabilities may include loss of livelihood through increased extreme events, food insecurity due to changes in temperature and rainfall patterns and falling crop yields, increasing morbidity and mortality associated with a rise in water and vector-borne diseases, and a deepening poverty cycle associated with the diversion of livelihood assets towards recovery and coping. According to the Third Assessment Report (TAR) of the Intergovernmental Panel on Climate Change (IPCC), vulnerability is described as a function of exposure, sensitivity and adaptive capacity.

2.4 Adaptation to climate change

According to UNDP, 2007 defines adaptation to climate change as an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Adaptation often occurs in the community and local level. Action and policies by governments, international organizations and other stakeholders can often influence the self-governing adaptation action undertaken directly, for example by increasing the resources available on the ground, or indirectly through measures that shape the incentives, knowledge sharing and capacity available for self-governing adaptation. Adaptation is a process by which strategies to moderate, cope with and take advantage of the consequences of climatic events are enhanced, developed and implemented.

2.5 Resilience to climate change on smallholder farmers

The capability of a social and ecological system to absorb a range of perturbations and to support and build up its central structure, function, character, and responses through either a bounce back or reorganisation in a new situation (Folke Carl, 2006). Climate change impacts necessitate responses and adjustments to the biophysical and social conditions which together determine exposure to climate hazards. Resilient systems avoid, absorb, or adapt and transform around the disturbance in order to maintain their fundamental identity or operate within critical thresholds.

These responses may occur in form of adaptation action or through public as well as private planned, individual and institutional mechanisms. As a global community, we need to reduce agriculture's contribution to climate change while building farmers' resilience to climate shocks and preserving our natural resource base for the future. Increasing system resilience is directly related to increasing the adaptive capacity of farmers. In order to be resilient, a system's resilience capacity must match the severity of the threat.

When resilience capacity matches the threat level, a system can "bounce back" to its original state or even "bounce forward" to an improved state after a disturbance. When resilience capacity does not match the threat level, the system will not have the capacity to respond effectively to the threat and will "backslide," ending up worse than before the disturbance. And also the ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a potentially hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions.

Resilience depends on ecological dynamics as well as human organizational and institutional capacity to understand, manage and respond to these dynamics.

2.6 Adaptive capacity

Is the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damage, to take advantage of opportunities, or to cope with the consequences (IPCC, 2007). Thus, the adaptive capacity of a system or a community describes its ability to modify its characteristics or behaviours so as to cope better with changes in external conditions. Adaptation to climate change is very crucial in order to reduce the impacts of climate change that are happening at present time and increase resilience to future impacts.

The capability of a system, institutions, individuals and other organisms to adjust to potential harm, to exploit opportunities, or to react to outcome of hazards (IPCC, 2014). In the field of vulnerability analysis, extensive research has been done on the elements of exposure and sensitivity, while adaptive capacity has only recently begun to be explored (Vincent *et al.,* 2010). Like vulnerability, adaptive capacity has been defined many different ways, by numerous scholars. For example, sometimes adaptive capacity is considered a separate entity from vulnerability, instead of a component of vulnerability, and sometimes the term is used interchangeably with resilience or social vulnerability.

Smit *et al.*, 2003 defined adaptive capacity as the potential or capability of a system to adjust to climate change, including climate variability and extremes, to moderate potential damages, to take advantage of opportunities, or to cope with the consequences. While adaptive capacity exists at varying scales, it is fundamentally dependent on access to Social, human, institutional, natural and economic resources (Cassidy Lin *et al.*, 2012).

At a household or community level, adaptive capacity to climate change depends on "factors such as knowledge base, which may enable households to anticipate change and identify new or modified livelihood opportunities; and their access to further resources required to achieve this" (Vincent *et al.*, 2010). One thing is for certain, adaptive capacity is a critical element in determining the impact of climate change (Vincent *et al.,* 2010).

If a population is exposed to significant changes in climate but is not negatively affected by those changes, they are not vulnerable to climate change (Smit *et al*., 2003). In contrast, even small changes in climate can have significant negative effects on populations where the capacity to adapt to those changes is low or non-existent, making it crucial to consider adaptive capacity when assessing vulnerability.

2.7 Livelihood

A livelihood comprises the capabilities, assets (stores, resources, claims and access) and activities required for a means of living; a livelihood is sustainable which can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, both now and in the future (Diana Carny, 2003), while not undermining the natural resource base and provide sustainable livelihood opportunities for the next generation; and which contributes net benefits to other livelihoods at the local and global levels and in the short and long-term,(Chambers *et al.*, 1992).

Whiles it can be viewed as assets and resources that can be assessed and used to make means to an end, others see it as having access and control to resources. This view is implicitly supported by (Diana Carney, 2003) in his argument that livelihood comprised the capabilities, assets (including both material and social resources) and activities required for a means of living. The emphasis on access and control is influenced by the cultural, political, social and economic settings of the society in which the individual is found. Frank Ellis, 2000 agrees with this assertion when in his definition of a ‘livelihood’ he has placed more emphasis on the access to assets and activities that is influenced by social relations (gender, class, kinship, belief systems) and institutions. The significances of this study are assessing the role of small scale irrigation practices and access to irrigable land

and service delivery by institutions and agencies to livelihood improvement. Things that people do to earn a living or revenue can be said to be livelihood strategies.

Livelihood strategies are composed of activities that generate the means of household survival (Frank Ellis, 2000). These strategies change as conditions of the environment change and culture also changes. This study will assuming that peoples' livelihood is considered secure and normal if they have access to five basic assets or capitals of livelihood (social, human, natural resource, financial, and physical capital). Moreover, in the next section, each livelihood capital is described briefly.

2.7.1 Social Capital

The social capital consists of resources (networks, membership of groups, relationships of trust, access to wider institutions of society) upon which people draw in pursuit of livelihoods. Moreover, social capital can be defined at different levels and for distinct units of analysis: Individuals (micro level), organizations (intermediate level) of the whole society (macro level). Roughly speaking, social capital refers to social relations among persons generating productive results (Ramírez *et al*., 2010). Social networks are valuable resources since they facilitate economic activity (Nahapiet Janine *et al*., 1998) allows SSI to be more efficient and access adaptive capacity opportunities (Abreu Maria *et al*., 2010) and improve innovation (Duan, 2010).

2.7.2 Human Capital

Human capital represents the skills, knowledge, and ability to labour and good health as important to the ability to pursue different livelihood strategies and achieve their livelihoods objectives. At a household level human capital is broadly a factor of the amount and quality of labour available (Diana Carney, 2003). Similarly (Frank Ellis, 2000) characterize human capital as the labour available to the household: its education, skill, and health. Education can help to improve people's capacity to use existing assets better and create new assets and opportunities while being healthy and access to health facilities are essentials. Therefore, this study will be considering ability to labour, knowledge and good health as human capital for SSI use, enhancing adaptive capacity and livelihood improvements.

2.7.3 Natural-resource Capital

Natural resource capital is the term used for the natural resource stocks from which resource flows and services (e.g., nutrient cycling, erosion, land protection, water, wildlife, biodiversity, environmental resources) useful for livelihoods are derived (Diana Carney, 2003). This study will be considering the source of water and land protection that is used for SSI purposes and is natural capital for smallholder farmer's livelihoods improvement and in enhancing adaptive capacity.

2.7.4 Financial Capital

The financial capital is determinant of livelihood that shows peoples' access to hard cash in term of savings, availability of credit, remittances or retirement allowances (Diana Carney, 2003). These financial resources available to us SSI can contribute to livelihoods as well increasing crop production of people as an employee on availability of cash may fulfil their desired livelihood necessities. Percentage of households having debt and percentage of households having savings was used as indicators of financial capital of farmer's to coping climate related risks and taking adaptation measure options.

2.7.5 Physical Capital

Physical capital comprises of infrastructures and producer goods needed to support livelihoods. (Diana Carney, 2003) defines physical capital as the basic infrastructure (transport, shelter, water, energy, milk collection plants, and communications) and the production equipment and means which enable people to pursue their livelihoods.

Transportation, water, energy, and communications are major components of physical capitals are considered as essentials for SSI practices and livelihood outcomes.

2.8 Relationship between Adaptive Capacity and livelihood Assets

Measuring adaptive capacity is difficult, since adaptive capacity is essentially measuring the 'potential' to respond to changes in climate or climate related disasters. An asset based approach is often taken as a way to measure the potential. Despite the uncertainty in assessing adaptive capacity, there remains a policy need for empirical assessment so that policy makers can turn assessment into practical measures (Vincent *et al.*, 2010).

Much of the work done on adaptive capacity to date, has favoured national level assessments that utilize indicators and indices; however, there has been research on identifying adaptive capacities at various scales (Cassidy Lin *et al.*, 2012).

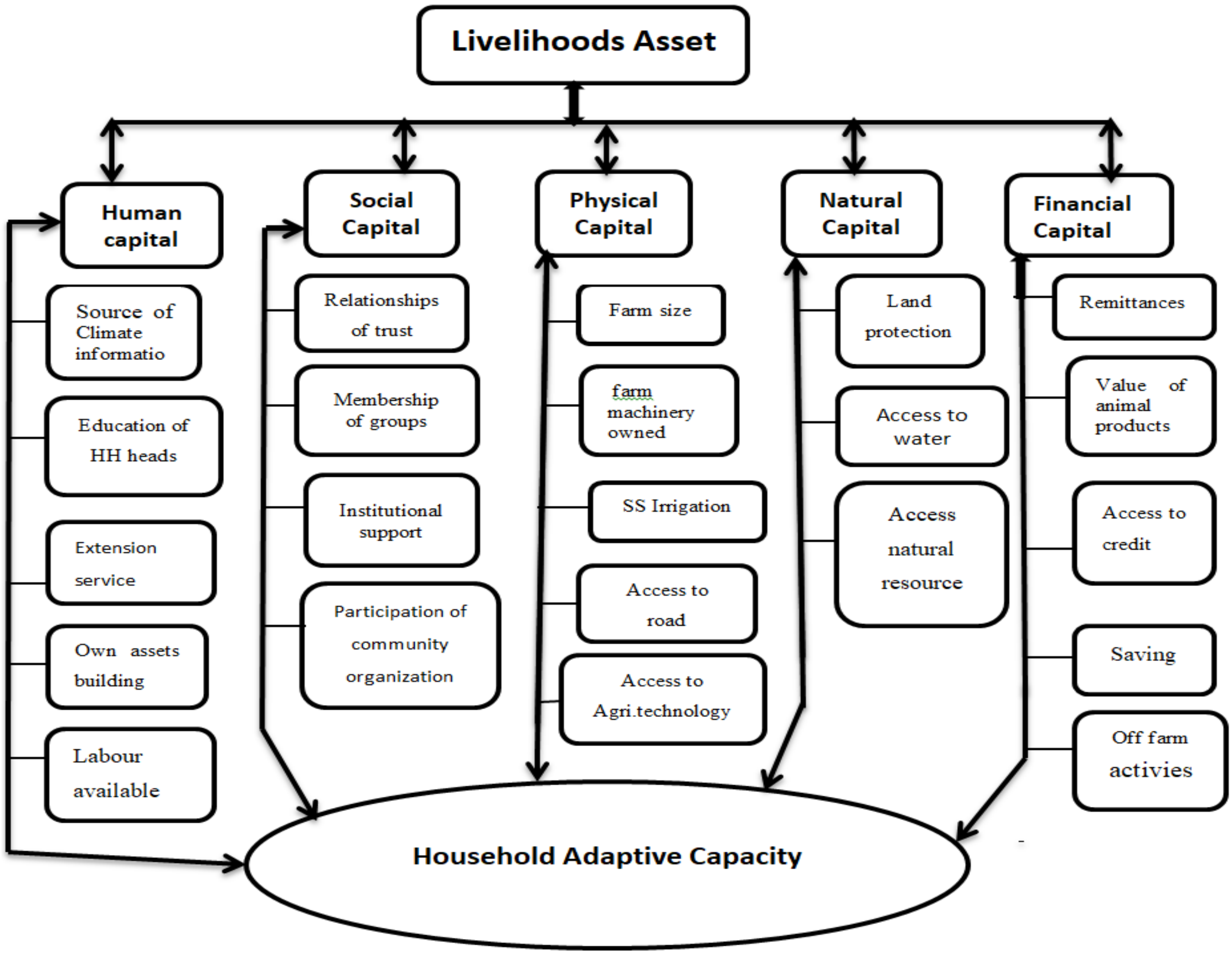

Figure 1 : Livelihood framework

Source: own survey data, 2019

2.9 Empirical Review of the study

Small-scale irrigation increases mean annual household income, irrigating households have lower probability of being poor than non-irrigating households. A much higher proportion of those who are poor are non-irrigating rather than irrigating households. Though small-scale irrigation has those mentioned roles, the study also identified many problems in irrigation development such as: lack of access to surface water, loss of water through seepage, problem of irrigation water distribution, lack of spare parts for water pumps, high cost of fuel for water pumps, lack of market transparency and marketing facilities, crop disease, and the perceived high cost of inputs (Getaneh kebede, 2011).

Irrigation user households are in a better position when compared to those that are non-users. For example, users have high crop income, higher level of education of the household head, large size of livestock holding, better labor man-day equivalent and all these contributed significantly to high total income for users than nonusers.

Accordingly, access to small scale irrigation can significantly improve (about two fold) income level of beneficiary households. This implies, in addition to surface water, the use of ground water for small-scale irrigation is likely to be valuable for future economic growth and improvement livelihood. As a result, access to irrigation increases the opportunity for crop intensity and diversification which increase cropping income. Therefore, in order to increase the rural households' income expansion of small scale irrigation by using available water resource is a crucial factor. Therefore, access to irrigation has got a significant and positive contribution to income (Hamda, 2014).

Animal forage should be given equal treatment with the crop production be it as hedgerows or intercropped with the food crops. Canals should be cemented for the prevention of water logging and percolation. Irrigation have both positive consequences on asset ownership and income of households. Increased in agricultural production through diversification and intensification of crops grown, increased household income because of on/off/non-farm employment, source of animal feed. Moreover, irrigation utilization greatly supports the livelihood of the non-users through employment opportunity (Asayehegn, 2012). Irrigation improved household income and enhancing adaptive capacity. Irrigation use has a positive impact on households earning from crop, and livestock.

In general, the above reviewed empirical studies revealed that, small scale irrigation practice is an important tools for the improvement the households' livelihood and tangible asset. This is also a best mechanism that leads to the use resources more efficiently.

2.10 Farmers perception of Adaptive capacity

Adaptive capacity is higher near local rivers and streams of rural and urban areas, which all provide opportunities for small scale irrigation, transport, and marketing. Whether the shock takes the form of drought, floods, or price fluctuations, access to markets and services affect adaptive capacity. Thus, adaptive capacity tends to be highest near major urban centres where road, health, and market infrastructure are dense.

Inaccessible markets, poor road infrastructure, and insufficient market information to increase transportation costs etc are these factors limit recover the farmers' ability to successfully negotiate fair prices and find adequate markets, especially for cash crop production. Training and market linkages significantly aided ruler farmer adoption of new technology, use small scale irrigation and resulted in increased resilience. Resilience also increased for those who had more diversified incomes. In most cases, diversifying income means producing surplus food crops or producing higher value products for sale, such as vegetables, fruit, livestock products and all crop products. As farmers gain access to markets and can invest in production systems, they increase their ability to recover from shocks.

Community member focus-group discussions revealed that the ability to generate income during the dry season is one of the most important indicators of resilience, non-farming activities (e.g., agricultural products) which are both a primary and a secondary source of income help poor households and vulnerable individuals, especially women, diversify incomes, smooth consumption, and cope with shocks and stresses.

Off-farm income diversification supports resilience capacities by helping households fill gaps in seasonal agricultural incomes and adapt to changing conditions in the rural economy and environment. Aemro Tazeze *et al.,* (2012) found that farm income, nonfarm income also significantly increases the likelihood of using different crop varieties, changing planting dates, and using small scale irrigation as adaptation options. Most parts of Ethiopia are struggling to climate change impact, which already faced through the introduction and/or modification of different adaptation mechanisms. Of which, small scale irrigation uses the one of enhancing adaptive capacity option.

Currently, much attention has given to climate change adaptation and it becomes as integral component of major policies and strategies in Ethiopia. The priorities of the national policies, sector strategies and programs of the government are primarily targeted at promoting rural and agricultural development and poverty reduction. As a result, climate change and adaptation issues are often treated indirectly in sector specific policies and programs since climate impacts are considered as a subcomponent of the overall development goal, particularly in relation to natural resources and environmental protection (Belliethathan *et al*., 2009).

2.11 Small Scale Irrigation Farming

Small scale irrigation is on small plots where farmers have the majority control, using technologies which they can effectively operate and maintain as well as controlled and managed by the users themselves. This type of irrigation has proved successful where large primary government controlled projects have failed. Small scale irrigation is preferred because of the easy adaptability of the options to local community and socioeconomic conditions. But more importantly, small scale irrigation has become important because of the recent shift in the development paradigm to ‘development from below’, an approach subsumed under ‘sustainable development.

Furthermore, smallholder farmer’s small scale irrigation is attractive because of the low capital investment required and the demonstrated capacity of the beneficiaries to manage, operate and maintain the systems to easy. Small scale irrigation can be highly productive in terms of yield per hectare of land. The energy input into large scale irrigation can be up to fifteen times greater than that required in small scale irrigation to produce the same output of crops (FAO, 2005), it not to say that small scale irrigation is without challenges and difficulties.

2.12 Small Scale irrigation Categories and features

According to Awulachew *et al*., 2010), defined, SSI as: Farmer-managed irrigation practices of a few hundred square meters to a several thousand hectares, developed, operated and maintained by individuals, families, communities, or local rulers and landowners, independently of government, and generally for the production of basic food or fibre crops and vegetables for local markets. Indeed, small-scale practices are defined as those are controlled and managed by the users themselves. Irrigation practices differ considerably in size and structure. In the Ethiopian context, irrigation types are categorized in to three classes. They are three types of irrigation practices. These are: small, medium and large-scale irrigation practices. Small-scale irrigation (SSI) practices are those which have less than 200 hectares of area. Medium- scale (MSI) practices cover an area of 200-3000 hectares while large-scale irrigation (LSI) practices cover an area greater than 3000 hectares (Napa, 2007).

SSI types are the responsibility of the MoANRM and regions, while MSI and LSI are the responsibility of the (Awulachew *et al*, 2010). Small scale irrigation practices can be classified as traditional and/ or improved types. Traditional irrigation practices are usually initiated, implemented and managed by the small holder farmers, while modern types of various categories are usually initiated and assisted by the government, NGOs and other donors (MoANRM, 2011). Some types of the different categories of SSI are described as follows.

2.12.1 Traditional SSI

Traditional types of small-scale irrigation are reconstructed after every flood season and they are managed by beneficiary farmers through their own water users associations. The farm size of such irrigated plots is usually in the range of 0.25 ha - 0.5 ha per household (MoANRM, 2011). The traditional water users associations in the form of water committees are well organized and successfully operated by farmers who know each other and are devoted to cooperate closely to achieve common goals. A typical association comprises up to 200 users who share a common main canal or its branches may be grouped into several teams of 20 to 30 farmers each. These water associations handle construction, water allocation, and operation and maintenance functions of irrigation systems.

2.12.2 Modern diversion SSI

Modern diversion SSIs are usually built on permanent rivers and/ or springs with sufficient base flow. Due to the fact that these structures do not have storage on the stream, they are not capable of regulating the flow (MoANRM, 2011). These diversion structures help in efficient and sustainable diversion of the flow and stabilizing banks. Usually, rivers with large width and deep alluvial material are costly to be handled by small scale irrigation. Consequently, intakes on the banks are used instead of complete barrier across the river.

2.12.3 Micro/medium dams SSI

In response to the erratic nature of the rainfall, flow regulation is very important for complementary irrigation and increased intensity of small scale irrigation. The construction of small- to medium-scale dams is undertaken in the mid- and highlands of the country where there is high population pressure and sever food security problems (MoANRM, 2011). The construction of such dams and irrigation infrastructures is undertaken in response to controlling seasonal flows and storing more water in areas with insufficient base flows.

2.12.4 Pumped types of SSI

These types of SSI with pumping plants implemented when water must be lifted from the water source and / or when sufficient head or pressure is not available to operate the farm irrigation practice. The adoption, operation and maintenance of such types is relatively costly and sometimes credit arrangements deem essential to finance such irrigations (MoANRM, 2011). Due to the high financial requirements, pumped systems are successful in areas with good market access, better service delivery and more demand for high value crops. Depending on the size of the pump, such types can be privately owned or communal.

2.12.5 Micro-irrigation

Relatively speaking, micro irrigations are recent developments in the area of SSI. Micro-irrigation refers to individual small-scale irrigation technologies for lifting, conveying and applying irrigation water on farms. These micro irrigations use treadle and small- power pumps to lift water and irrigation application practices such as smallholder drip irrigation, micro- sprinklers and trickle systems (MoANRM, 2011).

In terms of financial requirements, micro irrigation technologies are more reasonably priced to be used by smallholder farmers. Nowadays, low-pressure drip irrigation practices such as bucket, family drip and family nutrition kits are being used in areas where there is acute water shortage. The development of low-head emitters and simple filtration system has reduced a large amount of the initial capital investment which makes low-pressure drip systems less expensive for the smallholder farmers.

2.12.6 Shallow ground water harvesting

Shallow ground water is usually used for household water supply. Nevertheless, in areas where large volume of shallow ground water is accessible, it is promising to use suitable water lifting technologies to broaden its use for irrigation purpose. These are appropriate for an individual holding due to access to low-cost drip irrigation technologies (MoANRM, 2011).

2.12.7 Traditional river diversion small scale irrigation and its practices in the study area

Farming communities in the study area are largely involved in construction and use of traditional river diversion canal irrigation through constructing physical diversions and gully crossing structures built with local materials while sloppy area water easily flows and the differences from other small scale irrigation is an integral part of local indigenous farming systems and simply managed by farmers without external support, characterized by poor infrastructure and water management.

Over the last decade, an increase in traditionally irrigated areas has been observed due to the growing pressure to intensify agricultural production as a result of high population growth and a shortage of arable land. For example, the area irrigated with the traditional river diversion in four regions of Amhara, Oromia, SNNP and, Tigray while modern irrigation practices in the same regions (MoANRM, 2011).

In many places, the technique can be seen also in hilly sites irrigating 0.25 to 25 ha and more. Generally, with the growing need to intensify farming systems in food-insecure areas and climate variability, traditional irrigation plays an important role in increasing agricultural production and improving local food. They are usually temporary or semi-permanent dams and earthen canals that divert surface water from rivers.

The study more focuses on the contribution of this activity for smallholder farmer's improvement livelihood and enhancing adaptive capacity during climate variability. There is traditional small scale irrigation practiced by many households using rivers and streams in the area. The district has a long history of traditional small scale irrigation practices and indigenous knowledge.

2.13 Rural livelihood and adaptive capacity to climate variability

Agriculture is the backbone of the country's economy and it is mostly small- scale, rain-fed, traditional and subsistence farming with limited access to technology and institutional support services (Desta Demana, 2012). Ethiopia is alone believed to have the potential of 5.1 million hectares of land that can be developed for irrigation through the river and spring diversion, pump, gravity, pressure, underground water, water harvesting and other mechanisms (Tedros Tsehaye. 2014).

It has also potential to increase both yields and cropping intensity (Awulachew *et al*., 2010). Rural farmers are among the most vulnerable to the impact of climate variability. Hence, using small-scale irrigation and other forms of agricultural water management to cope climate change impact and to ensure sufficient water is a priority for their livelihoods improve.

These means, small scale irrigation can reduce poverty in rural smallholder farmers through improvements in the levels and security of productivity, employment and incomes for irrigating farm small households and farm labor; linkages in the rural economy; increased opportunities for rural livelihoods diversification. SSI helps to reduce the risks of crop damage by allowing cultivation at times of year when climatic conditions less risky. It has a key role to stabilize agricultural production and mitigate the negative impacts of variable or insufficient rainfall (Getaneh Kebede *et al*., 2013). Profit from irrigation has often been re-invested in household improvements, such as tin roof, painted walls, and greater expenditure on household possessions.

3. MATERIAL AND METHODS

3.1 Description of the study area

3.1.1 Geographical location

This study was undertaken in Woliso District, which is one of the 11 Districts of South West Shoa Zone, Oromia Region, Central Ethiopia. It is located at a latitude and longitude of 8^{o} 32′ 23.0″ N and 37^{o} 58′ 16.3″ E, respectively, in the Southern West part of the country along Addis Ababa to Jimma main road, extending from 114 km from the capital city of the country. Woliso District is boarded in the North by Bacho District, in the west by Wonchi District, in the southwest by SNNP, in the south by Goro District and in the east by Sadden Sodo District. The total area of the District is approximately 681.8 sq.km and a total of 37 rural kebeles of the district were divided into two agro-ecology (Dega, 7 kebeles and Woinadega, 30 kebeles) and 7 urban kebeles administrative (WWRDAO, 2019).

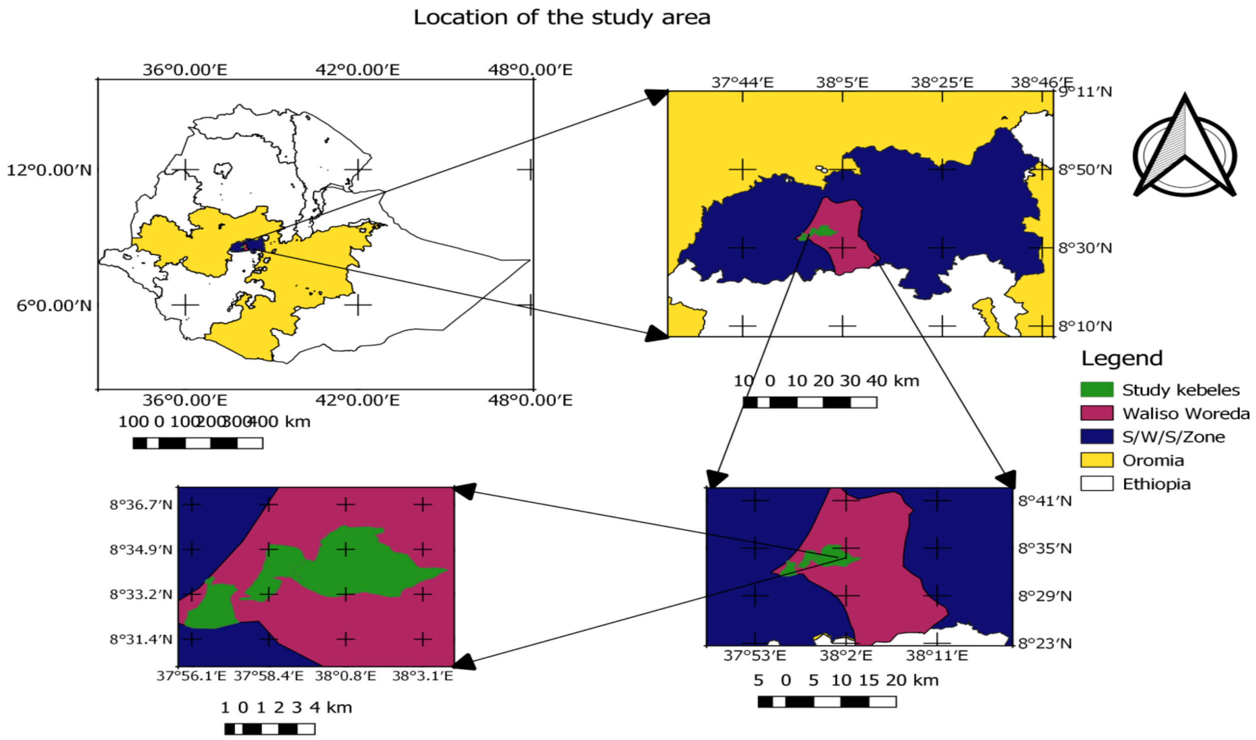

Figure 2 : Map of the study area *source: drawn by authors, (2019)*

3.1. 2 Topography

Based on information from the District rural development and agricultural office (2019) the area topography is characterized by plateaus, mountains, hills, and plains. Altitude wise, the district lies between 1600 and 2880 meters above sea level. Simela, Karfefe, and Rogda are the major mountains found in the district. Several perennial rivers are Walga, Rebu, Kono, Manisa, Dedebo, kalia and intermittent streams are Gute, Osole, Boye, Dergu, Atabela found in the district (WWRDAO, 2019).

3.1.3 Climate

According to the district of rural development and agricultural office, 2019 Agroecology, of the study area is classified into woinadega (70%) and dega (30%) zones. The average annual rain fall of woliso 1149 mm and the average Minimum, Maximum and mean annual temperature of the District lies on 17.8℃, 20.2℃ and 19.1℃ respectively. Its dry sub-humid area (Solomon Tekalign, 2015). The major rainy season occurs in the month of June - September (Kiremt) and ranges from 800 to 1200mm. The other seasonal rainfall amounting to 400 to 600mm occurs in the months between February and May (National Atlas of Ethiopia). The hottest months are from April to May and the coldest months are from June to October (WWRDAO, 2019).

3.1.4 Soil type

Based on information from the District rural development and agricultural office, 2019 predominantly three types of soil formations cover in the study area it includes black, clay and reddish-brown clay. There is serious water erosion problem along several sections of the study area; the main causes of the problems are lack of erosion control and intensity of cultivating farmland (WWRDAO, 2019).

3.1.5 Population

According to Ethiopia CSA, (2007) the national census reported Woliso woreda had a total population of 205,751 of which 100,914 (49.05%) were male while the other 104,837 (50.95%) were female in sex. The majority of religious composition (77.8%) of the population practiced Ethiopian Orthodox, Muslim 16.9%, Protestant 4.7%, Catholic 0.3%, Traditional 0.1%, and others 0.2% of respectively. It is the most densely populated in the districts. Population distribution by Ethnic Oromo 80%, Gurage 13.7%, and others 6.3% Woliso Woreda are consisting of heterogeneous people in terms of ethnic and religious composition.

3.1.6 Farming system and existing irrigation practices

Agriculture is the mainstay for the majority of the population in the study area and it provides the largest share for the livelihood of the population. Mixed farming is a common practice in the area involving dominantly crop production and livestock rearing though both are carried out at a private level in a traditional way. Nonetheless, Woreda Agriculture and Rural Development Offices are aspiring to acquaint farmers with modern production systems by distributing input and giving training via extension package.

Smallholder subsistence agriculture is the main character of crop production in the area, which of course is the case for other parts of the country. Crop production is mainly rain-fed and practiced in traditional style. The study area and its surroundings are relatively free from meager/enough/ and erratic rainfall distribution. However, the production is characterized by a lack of access to modern technology, dependency on rainfall, traditional irrigation practice and the productivity is still less as compared to the potential. The agro-climatic condition of the area is very suitable for the production of cereals, pulses, and oilseeds.

Thus, teff, wheat, barley, maize and sorghum for cereals and field pea, house bean, Chickpea, and lentil from pulse and chat and enset, is also cultivated in the district. The major livestock feed along the study area includes open pasture, bushes, hay and crop residues. There is a gradual declining of grazing land, there has been no forage development in regular extension services. The livestock dominantly in the study area were cattle, equine, small ruminant, and poultry. There is traditional small scale irrigation practiced by numerous families using rivers and streams.

The district has a long history of traditional small scale irrigation practices and have indigenous knowledge. According to data obtained from Woliso Woreda rural development and Agricultural Office (2019), there is about 8,935 ha irrigated farm currently by the number of 13,399 families. Onion, tomato, potato, cabbage and other types of vegetables are produced by irrigation. As many reports have shown, there is low institutional support for both irrigation users and non-users (WWRDAO, 2019).

3.1.7 Land Use

Land use pattern is usually the function of the existing socioeconomic features and farming system of the people dwelling in the study area. Land use pattern is dominantly utilized for cultivation in the specified district as crop production is the major means of livelihood. Each land use pattern was covered 66% cultivated, 7% grazing, 6% vegetation and 21% for other purposes. However, as a result of human interference due to population pressure, conversion of the vegetation land to farmlands, clearing and cutting natural trees for fuel wood, charcoal and construction purposes so, the vegetation cover of the area is extremely declining (WWRDAO, 2019).

3.2 Methods of Data Collection

3.2.1 Primary data sources

Key informant interviews: The key informants were individually interviewed on the overall information on the existing trend of small scale irrigation farming focus on the difference between adaptive capacity and the socioeconomic status of respondents as well as livelihood activities of in the area. Like most qualitative data collection, key informants were asked repeatedly in order to explore issues in-depth based on open-ended questions (See Appendix Table 6). It included 2 agricultural office experts, 2 irrigation experts, 1 cooperatives expert and 2 DAs from the district.

Focus group discussions: In a focus group discussion, a group of people having similar concerns and experiences regarding a subject is encouraged to participate. The FGD considered 8-10 individuals per group (Elder S, 2009). Therefore, two FGDs involved: one group from user 8 members and another group from non- user 9 members were carried out within respondents. The discussion was facilitated by the researcher together with the enumerators so that group members were encouraged to talk freely during the discussion. The main issues that were raised during the group discussion were adaptation measures and its constraints, the existing small scale irrigation practices and its contribution. The checklist of questions was used to facilitate all FGDs (See Appendix Table 7).

Household's survey: The household survey was undertaken involving households simple randomly selected from the list of stratified in the two groups' user and non-user. The structured questionnaire contained; adaptation strategy and its constraints, income-generating activities, the existing small scale irrigation practices, finally, the major factor that constraints influences irrigation practices.

In the process of HHs survey was stage involved; translation of the questionnaire to the local language (Afan Oromo), recruitment and depth training of data collector, selection of field assistants and key informant, prepared questionnaire were protested (12 HHs from each sample kebeles) and feedback was obtained before actual fieldwork and finally the administration of actual fieldwork. The survey was undertaken based on open and close-ended questions (See Appendix Table 5). The data upon which this study based was collected using a structured questionnaire and administered through a face to face interview with the households.

3.2.2 Secondary data sources

The secondary data sources in the study were obtained through collecting relevant literature from both hard copies and online materials (published and unpublished) and also some data were also obtained from the electronic media. Information from these sources was useful for reviewing relevant literature and for validating the findings. Data were also collected from institutions such as District Rural Development and Agricultural office and irrigation authority from the Oromia bureau. Information regarding districts is: - irrigable farmland size and crops grown types, yield of the area per hectare, adaptation measures and constraints, and district profile were obtained from these institutions.

3.3 Data Collection and Analyses

3.3.1 Sampling Techniques and Sample Size Determination

Woliso worade was selected purposively among districts found in south west shoa zone Oromia region, Ethiopia. The Woliso worade was selected for this study because of presence contribution of small scale irrigation to livelihood and adaptive capacity to climate variability of smallholder farmers and the major constraints of the small scale irrigation practices in the study area. The two-stage sampling procedure was followed; in the first stage, three kebeles where the SSI practices are found were selected purposively.

Before selecting households to be included in the sample, the sampling frame was stratified into irrigation user and non-user households. The sample households were then selected simple randomly from both SSI user and non-user groups. In this regard, the sample populations were categorized into irrigators and non-irrigators and they were listed by name to use a simple random sample technique and then the appropriate sample size was determined.

Based on population concentration in the district, the type of SSI they used, and the recommendation of the Agricultural office of the district, three SSI Practicing Kebeles namely, Badessa koricha, Hobi Koii, and Fudo Gora were purposively selected. For every selected sample size of irrigators, proportional sample sizes of non-irrigators was selected based on representativeness to the major irrigation user of the district and proximity to the source of water, i.e. their irrigable farmland is close to the river that used as the major irrigation practice and personal experience in an irrigated farm in the area.

Therefore, irrigation user sample households were obtained from comparable areas in terms of access to irrigation water sources and farmlands. The total sample was distributed proportionally among the sample kebeles among user and non-user households (Table 1).

In this study, a simplified formula provided by (Yamane Taro, 1967) is used to determine the required sample size at a 95% confidence level and 8% (0.08) level of precision. Therefore, to select the sample household the researchers used the following formula (Equation 1):

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

Where: n = the number of required sample of each irrigation kebeles;

N = total households of each irrigation kebeles; confidence level (95%) and (e = is the level of precision 8% (0.08); and $\sum N$ = total households of the three irrigation kebeles. The required sample households of each kebeles were calculated used the following formula (Equation 2):

$$n1 = \frac{N1(n)}{\sum N} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

The proportional sampling technique was used to develop the overall sample size; accordingly, 78 irrigators and 78 non-irrigators with a total of 156 sample households were taken respectively as shown in the table below.

Table 1: Number of Sample Households in each kebeles

Sample kebeles	HH Irrigation user		HH Non irrigation user		Total samples HHs
	Total HHs	Samples HHs	Total HHs	Samples HHs	
Badessa Koricha	273	31	271	30	61
Hobi Koji	203	23	220	25	48
Fudo Gora	219	24	211	23	47
Total	695	78	702	78	156

Source: computed data obtained from own survey, (2019)

3.4. Methods of Data Analysis

3.4.1 Descriptive statistics

The data were analysed through descriptive statistics and one way ANOVA. The quantitative data to be analysed and described through opinion interpretations after being organized and categorized. Means that exhibited significant differences were compared using at 95% confidence interval levels. As descriptive statistics, frequency and percentage distribution, mean, maximum and minimum, and standard deviation were employed to analyse the quantitative data. As inferential statistics, chi-square was used to identify the associations between categorical variables and for continuous variables t-test was also used to compare mean differences between two groups across the study, variables while taking the research objective into consideration. Finally, the summarization of quantitative data with SPSS (Statistical Package for Social Science) version 20 and Microsoft excel 2013 were the packages used in the analysis.

3.4.2 Empirical determination of the degree of adaptive capacities

According to (Franklin Nantui *et al*., 2012) measures the adaptive capacities of farmers by considering five attributes such as knowledge, use, availability, accessibility, and consultation. Adaptive capacities of farmers depend on certain factors or attributes such as their knowledge on and the number of times they use a particular adaptation strategy. Other factors are the availability and accessibility of the adaptation strategy. Also, the number of consultations that a farmer makes on a particular adaptation strategy affects whether the farmer will be lowly or moderately or highly adapted to climate variability. In measuring the adaptive capacities quantitatively, farmers were asked to indicate their degree of attainment of each attribute. The highest degree of attainment of each of the attributes or factors affecting adaptive capacities scored 1 whereas the lowest degree was given a score of 0.25. The score level for a higher degree of attainment of each attribute is 0.75. Lastly, the score level for a high degree of attainment is 0.50. Therefore, the degree of each farmer's knowledge of each adaptation strategy was observed. In terms of knowledge, the higher the degree, the better knowledge the farmer has on a particular adaptation strategy. Table 2 summarizes how each attribute was measured.

Table 2: score levels of farmers' Achievement of Attributes

Degree	Score	Knowledge	Use	Availability	Accessibility	Consultation
Highest degree	1.00	Very well	Several	Very regular	Easily accessible	Several
Higher degree	0.75	Well	Twice	Regular	Accessible	Twice
High degree	0.50	Fairly well	Once	Occasionally	Not easily accessible	Once
Low degree	0.25	Not well	Never	Never	Not accessible	Never

Source: computed data obtained from farmers' achievement attributes

The adaptive capacity (*AdaCap*) of an *ith* farmer to *jth* adaptation strategy is calculated as shown in equation (1) below, according to (Byrne, T.R. 2014; Felix A.A *et al., 2012*).

$$AdapCap_{ij} = \frac{kij+Uij+Vij+Aij+Cij}{NA} \quad \text{..................................} (1)$$

Where $AdapCap_{ij}$ denotes the adaptive capacity of an ith farmer to a jth adaptation strategy; Kij, the knowledge of the ith of farmer on jth adaptation strategy; Uij, the level of usage of the jth adaptation strategy by ith farmer; Vij, the availability of innovations on a jth adaptation strategy to ith farmer; Aij, accessibility of innovations on a jth adaptation strategy to ith farmer; NA, the sum of applicable attributes.

The average adaptive capacity of farmers to jth adaptation strategy $AveAdapCap_j$ is calculated using the equation (2) below, according to (Byrne, T.R. 2014).

$$AveAdapCap_{j=} \frac{\sum AdapCapij}{N} \text{ .... (2)}$$

Where, *N* is the number of observations.

Table 3: Degree of Adaptive Capacity

Degree of adaptive capacities	Range of indices of $AdapCap_{ij}$	Range of indices for $AveAdapCap_j$
Low adaptive capacities	0< $AdapCap_{ij} < 0.33$	0< $AveAdapCap_j < 0.33$
Moderate adaptive capacity	0.33≤ $AdapCap_{ij} < 0.66$	0.33≤ $AveAdapCap_j < 0.66$
High adaptive capacity	0.66≤ $AdapCap_{ij} \leq 1.00$	0.66≤ $AveAdapCap_j \leq 1.00$

Source: computed data obtained from degree of adaptive capacities

3.4.3 Econometric Model Specification

An econometric model was adopted to assess factors influencing farmers' use of small scale irrigation. According to Gujarati, (2004) logistic regression model uses when the dependent variable is a dichotomy (binary) and the independent variables are of any type and also that preferred for the dependent variable which has a binary outcome that is easy to interpret and provides odds ratios.

It is used to identify the determinants of use to irrigation and assess their relative importance in determining the probability of being an irrigation user. The functional form of a logit model is specified as follows:

$$P_i = \text{E (y= 1/}X_i) = \frac{1}{1+ e^{-(\beta o+\beta i\, Xi)}} \text{ .... (1)}$$

For ease of exposition it can write (1) as:-

$$P_i = \frac{1}{1+ e^{-Zi}} \text{ .... (2)}$$

The probability that a given household is irrigation user is expressed by (2) while the probability for non-adopters

$1 - P_i = \frac{1}{1+e^{Zi}}$ .... (3)

Therefore, it can be written as:-

$\frac{Pi}{1-Pi} = \frac{1+e^{Zi}}{1+e^{-Zi}}$ .... (4)

Now $\frac{Pi}{1-Pi}$ is simply the odds ratio in favour of participation in irrigation, the ratio of the probability that will be non-user. Finally taking the natural log of the equation (4) it obtains:-

$L_i = 1\text{n}\left[\frac{Pi}{1-P}\right] = Z_i = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \cdots \beta_n X_n$ .... (5)

Where P_i = is the probability being irrigation user ranges from 0 to 1.

Z_i = is a function of n explanatory variables (x) which also expressed as:-

$Z_i = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \cdots \beta_n X_n$ .... (6)

β_o = intercept,

$\beta_2 X_2$ ... β_n are slopes of the equation in the model

L_i = is log of the odds ratio, which is not only linear in X_i but also linear in the parameters.

X_i = is the vector of relevant household characteristics.

If the disturbance term (U_i) is introduced, the logit model becomes:

$Z_i = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \cdots \beta_n X_n + U_i$.................................... (7)

Multicollinearity test was applied before estimating the model between explanatory variables to meet the assumption of Classical Normal Linear Regression Model (CNLM). Due to this, variance inflation factor for continuous and contingency coefficient test for dummy variables association was tested.

$\text{VIF} = \frac{1}{TOL} = \frac{1}{1-{R_i}^2}$ -- (1)

Where VIF = variance inflation factor, TOL= tolerance which is the inverse of VIF, ${R_i}^2$ is coefficient of determination in the regression of one explanatory (x_i) on other explanatory variable (x_j). As a rule of thumb**,** if the VIF of a variable exceeds 10, which will happen if ${R_i}^2$ exceeds 0.90, or if tolerance close to zero that the variable is said be highly collinear (Gujarati, 2004). To avoid a serious problem of multicollinearity, it is quit essential to omit the variables with VIF exceeds 10 in case of continuous variables.

CC = $\sqrt{\frac{x^2}{N+x^2}}$ -- (2)

Where CC = contingency coefficient, X^2 = chi-square, N = total sample size. If contingency coefficient test value exceeds 0.8 for those dummy variables, there is a multicollinearity problem (Gujirati, 2004).

3.4.3.1 Definition of variables and working hypothesis

Once the analytical procedures and their requirements are known, it's necessary to identify the potential variables and describe the measurements. Accordingly, the variables expected to have an influence on irrigation use are explained below.

Dependent variable

Household use of small scale irrigation was investigated as the dependent variable.

Explanatory Variables

Age of a households: age is a continuous variable measured in years that determine the SSI use and household income. According to Abiyu Abebaw *et al*., (2015) the younger the farmer, the most likely to use new technology early. Hence, the expected effect of age on household decision to use of irrigation could be positive or negative. Gender of the households: gender is a dummy variable with 1 for male and 2 otherwise. In Ethiopia, household head is the decision maker for farm activities. Male household heads are expected to decide for the use of SSI and have higher income compared to female household heads because of better labor inputs used in male-headed households. Hence, it is expected to use of irrigation could be positive or negative.

The education level of a households: It is a continuous variable measured in formal schooling years completed by the household. Households with better education level is believed to have a chance to apply scientific knowledge and better manage their farm activities in good manner, hence boost domestic production through involving in SSI to enhance household income. (Dillon, 2011; Fanadzo, 2012). Hence, education has a positive contribution to household income and use of SSI and.

Households' family size: It is a continuous variable measured in the number of people living in the household converted in to adult equivalent. A household who has more number of family members could share the workload to them and contribute a lot to the income of the specific household. Hence it is expected to influence the use of SSI of the household positively (Zeweld Woldegebrial *et al.*, 2015).

Annual income of the households (Income): this variable is a continuous variable, which is the annual income measured in Ethiopia Birr. Evidences (Kinfe Aseyehegn *et al.*, 2012) show that this variable is positive and significantly affecting the small scale irrigation use of the farmers. The farmers with higher income can cover the irrigation cost easily, can easily buy the inputs required for irrigated farming than lower income households. Therefore, this variable was hypothesized positively influencing the small scale irrigation use decision of the farmers and its intensity.

Access to Credit: This is a dummy variable that takes the value 1 when the household takes loan and 0 otherwise. Credit is very much useful to purchase inputs and staple food (Nelson Mango *et al.*, 2018; Muhammad Lawal *et al.*, 2013). Hence, farmers who have access to credit would have a positive effect on crop production due to use of agricultural inputs which enhance food production and ultimately increase household decision to use small scale irrigation and its intensity.

Total Livestock owned /TLU/: This is a continuous variable refers to the total number of livestock measured in tropical livestock unit (TLU). The sources show that the higher the total livestock owned by the respondent the higher the probability of use in small-scale irrigation practice. Livestock is an important source of draught power for crop cultivation in Ethiopian agriculture would increase significantly the household use to SSI that enables to increase the status of income (Hadush Hailu, 2014; Fanadzo, 2012).

Distance of the nearest market (Market distance): This is a continuous variable measured in hours it takes the farmer to arrive at the nearest market on foot. When transaction cost increases it discourage participation in irrigation. Sources indicate different results, that the farther the distance of the market from the farmers' residence area, the lower the probability of the farmers' participation in small-scale irrigation practice (Kinfe Aseyehegn *et al.*, 2012). Therefore, this variable was hypothesized as influencing the participation decision of the farmers in irrigation practice and its intensity of participation positively/negatively.

Cultivated Land size: This variable is continuous variable measured in terms of hectare. Large size of cultivated land is sometimes seen as social status. Because the status they have in the society may encourage those farmers to participate in irrigated farming to maintain their status in the society. Therefore, this variable was hypothesized as influencing the small-scale irrigation use without predetermination of the direction and influencing the area of land allocated for irrigated farming by the farmers positively (Wang Jinxia *et al.,* 2015; Nokuphuwa *et al.*, 2014).

Distance of plot of land from water source (Farm distance): This variable is continuous variable measured in terms of walking hours on foot. It is found by different scholars as it hampers participation in irrigation practice (Beyan A *et al.,* 2014; Nokuphiwa *et al.*, 2014). This factor leads to the higher cost for the farmers to bring the irrigation water to their plot of land, or even they may be unable to apply the irrigation water to their plot of land because of high cost required. Thus, this may force the farmers having the plot of land far from the source of irrigation water not to practice small-scale irrigated farming at all. Therefore, this variable was hypothesized to influence participation in small-scale irrigation and intensity of participation negatively.

Access to non-farm activity (Non-farm activity): This variable is dummy variable taking on 1 if the respondent has involved non-farm activity or 0 otherwise. The related evidences show that the farmers having access to non-farm income were found participating in irrigation practice than those not having access to non-farm income (Beyan A *et al.,* 2014; Hadush Hailu, 2014). This may be due the reason that the farmers having access to non-farm income may use this extra income on the expenditures required in irrigated farming. Therefore, based on these reasons the variable was hypothesized to influence participation in irrigated farming positively.

Market information: This variable is dummy variable taking value of 1 if the farmers have an information on the market concerning the demand and price issue of the product, or 0 if the respondent does not have an access to market information and undertake every production without market information. This variable is found positively and significantly affected the participation decision of the farmers by several studies (Abiyu Abebaw *et al.*, 2015). This may be reduced that the information on the market, such as input and output price enable the farmers to be benefited from the production under irrigated farming. If the farmers does not have an information on the demand of the product, they may not be encouraged to produce since they do not know that production will have positive return or loss. Therefore, this variable was hypothesized to influence the irrigation use and proportion of irrigated land positively.

4. RESULTS AND DISCUSSION

4.1 Rainfall Variability in Woliso district

The Mann-Kendall (MK) trend test and Sen's slope estimator result showed that significant trend for the long term inter-annual rainfall (Table 5). In general, this result indicated that rainfall remained no constant when averaged over the whole period for the study area and this is in agreement with the national rainfall trend (NMA, 2007). However, annual rain fall statistically significant, there is declining trend of inter-annual rainfall amount at a rate of 7.4 mm per decade, and this partly agree with farmers perception while the outcomes of the FGD and KI are also in agreement with the results obtained from the survey data.

Table 4: Trends of rainfall and temperature in Woliso district for the period 1985-2018.

Trends of rainfall			
Trends of rain fall	Mann-Kendall tau	Sen's slope	P- value
Annual rain fall	-0.34	-0.744	0.004**
Monthly rain fall	-0.34	-8.7	0.004**
Average annual rain fall	1195 mm		

Source: NMA (2019). Slope (Sen's slope) is the change (mm) annual and monthly analysis by the author; *Note **: significant trend at 0.05 level.*

Variability of annual rainfall

The maximum rainfall record for the area was obtained in 1993 with rainfall amount of 1553 mm and the minimum rainfall record was 2017 that recorded 384 mm (table 6). The trend analysis indicates that more or less of rainfall of the study area looks varies when a longer time period averaged over. Thus, this demands to look at its variability and distribution.

According to Amogne Asfaw *et al*., (2018) variability of rainfall can be expressed by many statistical parameters; from thus, to this end the inter-annual rainfall variability and distribution pattern of the available rainfall was seen by deploying CV to check this variability.

Coefficient of variability (CV)

According to William Hare, (2003) CV was used to classify the degree of variability of rainfall events as less (CV<20%), moderately (CV, 20-30%) and highly (CV > 30%) variable. Hence, the CV of annual rainfall in the study indicated the existence of less variability of inter-annual rainfall (CV < 20%) (Table 6). This agrees with the variability of inter-annual rainfall in Ethiopia that varies from 10% to 70% (Wing H, 2008).

Table 5: Annual rainfall in Woliso district (1985-2018)

Number of years	Minimum (mm)	Observed year	Maximum (mm)	Observed year	Mean (mm)	SD	CV
34	384	2017	1553	1993	1149	222	19%

Source: NMA (2019) analysis by the Author.

4.2 Temperature Variability in Woliso district

The result showed that the study area's mean annual temperature was 19.09 °C, maximum and minimum temperature were 20.2 °C and 17.8 °C, respectively (table 8).

Table 6: Annual temperature in woliso district (1985- 2018)

Temperature level	Annual temperature(°C)		
	Minimum temperature	Maximum temperature	Mean temperature
Minimum	10.7	14	12.98
Maximum	24.2	26.4	25.22
Mean	17.8	20.2	19.09
SD	0.79	0.52	0.61

CV (%)	4.4	2.6	3.2

Source: NMA (2019) analysis by the Author.

Annual temperature Variability

The result of Mann-Kendall trend test showed that temperature trend was very clear, unlike rainfall trends. The result for mean temperature revealed that there was a significant increasing trend of inter-annual temperature, which indicates the existence of significant warming trend over the study area (Table 7). The annual mean temperature showed a positive trend at a rate of 0.05°C per decade and this partly agree with farmers perception, which is contributed to the national annual mean temperature rate of change that in fact differ according to different sources. Outcomes of the FGD and KI are also in agreement with the results obtained from the survey data. The national rate of change for annual mean temperature 0.28°C per decade based on 1960 to 2006 data (McSweeney *et al*. 2010). All indicated the existence of a warming trend in the country. This result agrees with the result increasing trends of temperature (Solomon Tekalign, 2015) did trend analysis of temperature records in the surrounding of Woliso district. Moderate of moisture in a given area, even if varies of rainfall amount exists.

Table 7: Trends of annual temperature in Woliso district (1985-2018)

Annual temperature	Mann-Kendall tau	Sen’s slope	P- value
Maximum	0.636	0.041	<0.0001
Minimum	0.638	0.06	<0.0001
Mean	0.694	0.054	<0.0001

Source: NMA (2019) analysis by the Author.

Similar to rainfall variability analysis, CV was used to see the variability of temperature data and in general, temperature was found less variable as compared to rainfall variability. It was observed that the annual minimum temperature was more variable (CV=4.4%) than the mean temperature (CV = 3.2%) and maximum temperature (CV= 2.6%) over the analysis period (table 8). This agrees with the result of Muluken Mekuyie, (2017) doctoral thesis who analyzed temperature data of Amibara and Gewane districts in Afar region. Opposite to the minimum temperature, the result for maximum temperature exhibited the lowest variability compared to minimum and mean temperature during the time period indicating that the maximum temperature in the area were significantly increasing with relatively low variability. Also, it was observed that the maximum and mean temperature trend of increase were more significant and noticeable with lower variability than the trend of minimum temperature that have comparatively higher variability.

This implies that during the year of minimum rain fall recorded and annual minimum temperature was more variable, water supply for both agricultural and domestic purposes should be supplied through small scale irrigation in addition to integrated water harvesting technologies and selective adaptation option should be devised to balance the prevalence of water shortage in the area during these periods. This agrees with the result of (Brown *et al.*, 2017) better water management strategies and small scale irrigation development provide for mitigating the impacts of rainfall deficits during crop season.

4.3 Types of irrigation used

The result of (Table 11) showed that the total irrigation participant sample households, the majority of irrigators use traditional river diversion followed by the Motor pump and micro pond. Traditional river diversion is constructing physical diversions and gully crossing structures built with local materials whereas sloppy area water easily flows, and the differences from other small scale irrigation is an integral part of local indigenous farming systems and simply managed by farmers without external support, characterized by poor infrastructure and water management.

They are usually temporary or semi-permanent dams and earthen canals that divert surface water from rivers. The study more focuses on the contribution of this activity for smallholder farmer's improvement livelihood and enhancing adaptive capacity during climate variability. The low level of motor pump use was because of a lack of supply in the area, technical limitations to maintain motor pumps and consumption of high fuel. The micro pond water storage constructed by the farmers are not made of concrete or sealed by waterproof materials and thus, not effective for irrigation uses.

Table 8: Distribution type of irrigation used for participants

Irrigation type	Frequency	Percent (%)
Traditional river diversion	64	82
Motor pump	6	8
Micro pond	8	10
Total	78	100

Source: own data survey, (2019)

4.4 Contribution of small scale irrigation to livelihood improvement

4.4.1 Increment crop productivity

Small scale irrigation activities are improving the living conditions of their families and promoting the livelihood of the farmers (Nahusenay Teamer *et al.*, 2015). The main objective of any irrigation practices is originated to improve the level of natural production by increasing the marginal productivity of available land. This study was indicated that most irrigation user were derived from their higher income, mostly from irrigated crops, livestock products, and rain-fed agriculture activities.

However, most rain-fed farmers have gained their income, mostly from rain-fed crops, fattening livestock and off-farm activities participation. However, the gross yield of major cereals and horticultural crops by access to irrigation and rain-fed farmers were represented in figure three.

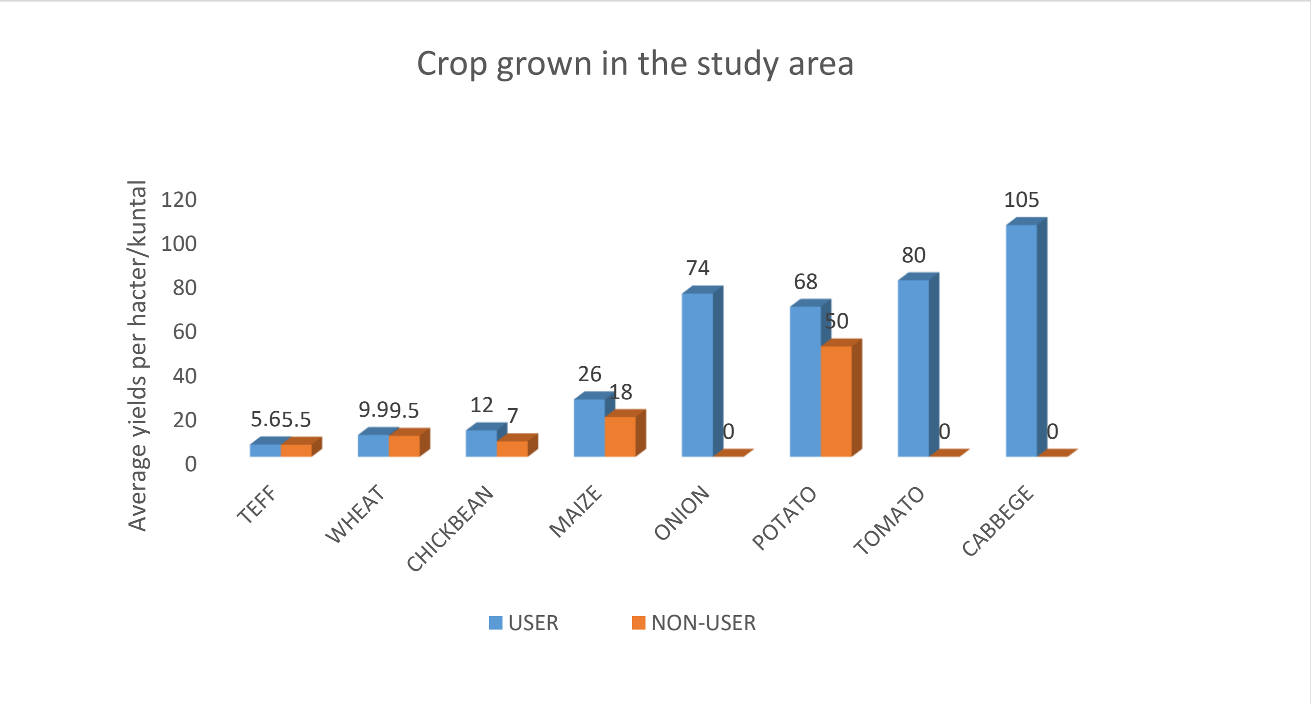

Figure 3 : Average yields per hectare/quintal Note, 1 quintal = 100kg

Source: survey data, (2019) *1ton= 10 quintal*

The result in Figure (3) was shown that indicates, irrigators more producing yields per hectare than non-irrigators, for the reason that irrigators can use more agriculture inputs, improving soil fertility by applying different soil fertility improvement This evidence has ensured that irrigation user has a guarantee of increased agricultural productivity and insured during climate variability extremes poor grown of agricultural production. This is also an indication of the fact that irrigation user increases cropping diversification and intensity, they can increase product quality as well as quantity. The result is similar to reports (Eneyew Adugna *et al*., 2014; Getaneh Kebede *et al.*, 2013; Beyan A *et al.*, 2014).

4.4.2 Household income

Household income is derived from agricultural (crop and livestock) sales and value of crops and livestock products retained for household consumption. The value of retained crop and livestock products was calculated using annual average production prices. In the case of irrigation users, individual household cropping income was computed from both rain fed and irrigated crops but for non-irrigation users, cropping income was derived from only rain fed crops. The off-farm incomes were also computed as part of household income to evaluate the income difference between irrigation and non-irrigation user households due to irrigation.

Income from crops: Total crop income is the amount of mean annual income of a household obtained from both types of cropping systems, rain fed and irrigation. The agricultural input cost such as labor, land rent, fertilizer and seed cost were taking in to account during cropping income evaluation. The major cultivated crop type produced in 2009/2010 production year including irrigated crops and rain fed are shown in table 13 as well as major cropping income of irrigation users was generated, the other hand, cropping income of non- users was listed.

The t-test statistics revealed that there is a significance difference between irrigation users and non-users in maize, chick pea, onion, potato, tomato, cabbage and chat at 5%. Maize and chick pea produced again in dry season and supplement irrigation by users when early offset of rainfall is emerged. The onion, tomato and cabbage was the major cash crops produced in irrigation with farm specific character and management (Table 12). It is also implied that irrigation enhances the cropping income by increasing productivity and cropping intensity as compared to non-users. According to FGDs reports, non-irrigation users earn less cropping income compared to irrigation users since they are poor even they cannot plough their land at a time due to low livestock holding for power.

On the other hand, irrigation users can do because of better asset building due to use of irrigation. Thus, irrigation had enhanced crop production through crop loss reduction, increased production and diversified crop varieties. This finding was in lined with Fitsum Hagos *et al*., 2009; Dereje Mengistu *et al*., 2016; Woldegebrial *et al*., 2015).

Table 9: cropping income of household

Major crop types	Ave. annual price (ETB/quintal)	Irrigation users (n=78)		Non-irrigation users (n=78)		t-value	p-value
		value in ETB	Percent	value in ETB	Percent		
Teff	1746	9841	3.8	9603	8.6	0.312	0.756
Wheat	1430	14165	5.6	13585	12.2	0.582	0.862
Maize	1383	35958	9.2	20745	18.6	3.201***	0.002
Chick pea	1567	18804	4.8	10969	9.8	5.204***	0.000
Potato	631	42908	11	31550	28.3	7.843***	0.000
Tomato	689	55120	14	0	0	34.3***	0.000
Onion	1309	96866	25	0	0	15.4***	0.000
cabbage	580	60900	16	0	0	23.4***	0.000
Chat		45000	11.5	25000	22.4	3.69***	0.000
Tot Gross		379,562		111,452			
Total agricultural input cost		98140	100	27863	100	11.46***	0.014
Net cropping income		281422		83589		18.26***	0.000

Source: own survey result, (2019), ******* *significant at α = 0.05.*

Irrigated crop income: Ethiopian irrigated farm size per household ranges between 0.25 – 0.5 ha (MoANRM, 2011). The average irrigated land per irrigation user in the study area is 0.389 ha with the minimum 0.125 ha, a maximum of 1.5 ha. The result table of 13, mean annual cropping gross income from the sample irrigating households was ETB 30959 with minimum 3500, maximum 126,500. Irrigation input cost such as land renting, seed, fertilizer and labor hiring cost were considered from the survey data. Sample irrigated household incur costs with minimum 450, maximum 10512 ETB. Thus, irrigated households gain net income with the minimum 3050 and maximum 115988, mean of 25099 ETB. The result shows that irrigation users gain income more than the net rain fed income (Table 13). This finding is consistent with Fitsum Hagos et al.(2009); Dereje Mengistu *et al*. (2016); Woldegebrial *et al*.. (2015) as irrigation was a means for household income enhancement.

The results were shown in (Table 13); there is a great difference in household's income between irrigators and rain-fed farmers in the study areas, behind of this they are more productivity of irrigated farms, higher value in the market for irrigated crops, year round production by irrigation users, higher capacity to use intensive agriculture (input) by irrigation user of households. This indicates that using small scale irrigation has a great role in improving the annual income than the abstained rain-fed farming as well as earning higher income from different types of crops grown sources. The result is similar to reports to (Temesgen Hirko *et al*., 2018; Dejene Mengistu *et al*., 2016).

However, the t-test analysis revealed that the mean annual income of the two groups was statistically significant at 5% probability level, confirms that small scale irrigation is considered as one of the best practices for improving the income of households in addition to cope with climate variability extremes and changing life condition of smallholder farmers.

The total income significant difference arises from the both cropping income and livestock income which is enhanced by irrigation access that contribute to households' income. This finding is similar with Fitsum Hagos *et al.*, (2009); Getaneh kebede *et al.,* 2013); Woldegebrial *et al. (*2015). FGDs in three kebeles were reported that irrigation practice increases the user households' purchasing power of agricultural inputs and enable to increase income from rain fed and livestock.

Table 10: Annual Income of respondents

Respondents	Mean	Minimum income/ETB	Maximum income/ETB	Sdt. Deviation	t-test	P-value
Irrigation user (n=78)	27,959	3,500	126,500	19,841.7		
Irrigated input cost	5860	450	10,512	3562		
Irrigated crop net income	22,099	3050	115,988	16,279.7		
Irrigation non-user (n=78)	18,667	1,500	20,840	8,456.25	-9.505	(0.000)**

*Note: ** significant at p<0.05, NS, not significant at p>0.05*

Source: own survey result, (2019)

Livestock income: Livestock plays a significant role as income sources in rural poor Ethiopia. Sale of live animals and their products are main livestock-related income sources in the study area. The livestock income category includes income from the sales of livestock and livestock products. The result Table 13, irrigation user households possess a larger average livestock income (14,084.8) than irrigation non-user households (4,558.9). The t-test analysis revealed that the mean annual livestock income of the two groups was statistically significant at less than 95 % probability level. This indicates that irrigation users were gained more income from livestock than non-users due to maintained the shortage of forage for animal during dry season that enable to increase the quality and stock of livestock and selling the existing stock of livestock in addition to their product

Table 11: Sources of income type of respondents

Income sources	Irrigation user (78)	Irrigation non-user (n=78)	t-test	P-value
	Mean	Mean		
Rain fed farming	12,162.44	6,838.60	-7.9	0.000)**
Irrigated farming	33,692.44	0		
Livestock	14,084.8	4,558.9	-8.6	0.000)**
Off-farm activities	5,685	9,104.2	1.98	0.543NS
Total mean income	65,624.68	20,501.7	3.6	0.000**

*Note: ** significant at p<0.05, NS, not significant at p>0.05*

Source: own survey result, (2019)

Non/off-farm incomes: are important parts of total income in rural households. The mean non/off-farm income of irrigation user households was 5,685ETB while for non-irrigation user households were 9,104.2ETB (Table 13). The result shows that there is insignificance difference of income from non/off-farm activities between users and non-user groups at (p>0.05) level. Irrigation non-user had enabled to diversified livelihood strategy through engaged in different off-farm income generating activities.

This implies that irrigation non-user were used non/off-farm income generation activities to livelihood diversification and important for improving the purchasing power of rural households. It has also described as ‘’ petty trading ‘’ and has become an important off-farm occupation for many poor farmers who have less access to land and water for irrigation (Sokoni Cosmas, 2005).

The data off-farm income of farmers were collected on a monthly basis and converted to estimate annual average. The result implies that engagement in non-farm activities could be more important to increase the annual income of non-user than irrigation user and also purchases food of farm households. This finding is similar to (Eneyew Adugna *et al.*, 2014).

4.5 Contribution of small scale irrigation to asset building

Asset is any resource owned by the persons, anything tangible or intangible that can be owned or controlled to produce value and that is held by the persons to produce positive economic value and built livelihood wellbeing. Simply stated, assets represent the value of ownership that can be converted into cash. This study was revealed that, small scale irrigation practice is an important tools for households' asset building.

The investigated community has perceived that small scale irrigation is a pillar to improve rural livelihood and asset building. According to focus group discussion, more of the irrigation users in their specific localities have improved their livelihood and asset built as a result of access irrigation. Irrigation user being able to educate their children, ability to purchasing input from the market, started local investment like petty trading/ local business.

The result was shown in (Table 15); the study provides a supportive evidence of the statistical effect of the irrigation user has more owned physical asset holding than non-user households, which is significant difference at the 5% level. The finding of this study was consistent with (Ayele Getaneh *et al*., 2013; Dereje Mengsitie *et al*., 2016; Eneyew Adugna *et al*., 2014).

Table 12: Role of small scale irrigation to physical asset building for households

Physical asset	Irrigation user (n=78)				Irrigation non-user (n=78)				Total (n=156)				Chi-square x^2	P -value
	Frequency		(%)		Frequency		%		Frequency		(%)			
	yes	No	yes	No	yes	No	Yes	No	Ye	No	Yes	No		
Chemical sprayer	33	12	73.3	26.7	32	61	34.4	65.6	65	73	47.1	52.9	18.441	(0.000)**
Carts	26	19	57.6	42.2	10	82	10.9	89.1	29	108	21.2	78.8	17.801	(0.000)**
Cars	7	38	15.6	84.4	0	93	0.0	100	7	131	5.1	94.9	15.240	(0.000)**
Bajaj	16	29	35.6	64.4	20	73	21.5	78.5	36	102	26.1	73.9	3.105	(0.078NS)
House from town	15	30	33.3	66.7	7	86	7.5	92.5	22	116	15.9	84.1	15.071	(0.000)**
Grain Mills	6	39	13.3	86.7	1	92	1.1	98.9	7	131	5.1	94.9	9.463	(0.002)**
Shops	13	32	28.9	71.1	5	88	5.4	94.6	18	120	13	87	14.78	(0.000)**
Restaurant	5	40	11.1	88.9	1	92	1.1	98.9	6	132	4.3	95.7	7.344	(0.007)**
Beauty salon	6	39	13.3	86.7	1	92	1.1	98.9	7	131	5.1	94.9	9.463	(0.002)**
Boutique	4	41	8.9	91.1	2	91	2.2	97.8	6	132	4.3	95.7	3.311	(0.069NS)
Saving	19	26	42.2	57.8	1	92	1.1	98.9	20	118	14.5	85.5	41.432	(0.000)**

*Note: ** significant at p<0.05* *NS, not significant at p>0.05* *Source: own survey result, (2019)*

4.6 Contribution of Small Scale Irrigation to Adaptive capacity of climate variability

4.6.1 Degree of adaptive capacity and adaptation strategies of farmers.

Adaptive capacity to climate variability is the ability of a system or an individual to adjust to climate variability so as to minimize the potential damages or cope with the consequences. Therefore, adaptive capacity is the ability to plan and use adaptation measures to moderate the effect of climate variability. Adaptive capacity varies from farmer to farmer based on certain factors that are peculiar to each farmer.

It is assumed that farmers are rational and as such they adapt to climate variability in order to reduce its consequences. Some farmers have higher ability to adjust to climate variability than others. This objective will be achieved by determining the adaptive capacities of each farmer in the study area using qualitative and quantitative indicators described. The degree of adaptive capacity of household heads to climate variability various adaptation strategies were presented in the (Table 16).

The respondents interviewed were to use adaptation strategies to coping with climate variability are; chemical or organic fertilizers, small scale irrigation, soil and water conservation practices, diversification of crop and livestock types and variety, changing planting dates, changing the size of land under cultivation, reduce numbers of livestock, diversify from farming to off-farming activities, use of early maturing crop types, use of drought resistant and needed less water quantity crop variety, crop rotation and integration of tree within crops in the study area.

Table 13: Degree of adaptive capacities and adaptation strategies of households

Adaptation strategies	Irrigation user (n = 78)			Irrigation non-user (n = 78)		
	Adaptiv Capacit (Adapj)	Rank	Degree of adaptive capacities	Adaptive Capacity (Adapj)	Rank	Degree of adaptive capacities
Small scale irrigation	0.85	1	High AC	0.21	13	Low AC
Soil and water conservation practices	0.77	6	High AC	0.42	10	Moderate AC
Diversification of crop and livestock types and varieties	0.82	3	High AC	0.53	8	Moderate AC
Changing planting dates	0.78	5	High AC	0.56	6	Moderate AC
Changing the size of land under cultivation	0.79	4	High AC	0.57	5	Moderate AC
Reduce numbers of livestock	0.57	11	Moderate AC	0.49	9	Moderate AC
Diversify from farming to off-farming activities	0.30	12	Low AC	0.78	2	High AC
Use of chemical fertilizer	0.82	3	High AC	0.81	1	High AC
Use of organic fertilizer	0.62	9	Moderate AC	0.32	12	Low AC
Use of early maturing crop types	0.64	8	Moderate AC	0.54	7	Moderate AC
Use drought resistant and needed less water quantity crop variety	0.83	2	High AC	0.76	3	High AC
Crop rotation	0.65	7	Moderate AC	0.72	4	High AC
Integration of tree within crops	0.60	10	Moderate AC	0.39	11	Moderate AC
Average	**0.695 (High AC)**			**0.55 (Moderate AC)**		

Note: AC: Adaptive Capacity *Source: own survey result, (2019)*

The irrigators interviewed have high adaptive capacity than non-irrigators due to ability use appropriate technology, access water for irrigation to twice agricultural production produced a year; this indicates that their adaptive capacity of irrigators are the average range between of $0.66 \leq AveAdapCap_j \leq 1.00$ (Table 18). So, adaptive capacities of non-irrigators are the average range of $0.33 \leq AveAdapCap_j < 0.66$; thus was shown non-irrigators are moderate adaptive capacity as compared to irrigators due to use lack of new technology and inaccessible water for irrigation those it depends on rain fed farming as well as producing once times in a year; this implies that; averagely the non-irrigators in the area do not have all the necessary resources to aid them for adaptive capacity and effectively to cope climate variability extremes.

This study found that irrigation user in the study area are double cultivate their land; it enables farmers to achieve more reliable, profitable and sustainable production, increase their resilience and in some cases, transform their livelihood and helping to cope with climate variability. The finding of this study was consistent with (Tadesse Getacher *et al*., 2013; Diao Xinshen *et al.,* 2010; Beyan A *et al.,* 2014). While the Government of Ethiopia has identified small scale irrigation as an important one option of adaptation strategy.

The result was shown in (Table 16) all the irrigation user have taken different measurement option for coping with climate variability as compared to non-irrigation user in the study area. However, the result of (Table 17) indicates that the main constraints of adaptation measure of households in the study area are mentioned by respondents where inaccessible irrigation water sources, shortage of input supply, shortage of labour, lack of credit/capital and lack of information are more influences respectively. Therefore, irrigation non-user more affected by climate variability extremes.

Table 14: Constraints to adaptation strategy of cope climate variability

Characteristics	Irrigation user (n=78)		Irrigation non-user (n=78)		Total (n=156)		Chi-squar	p-value
	Frequency	Percent (%)	Frequency	Percent (%)	Frequency	Percent (%)	x^2	
What are the main constraints to adaptation measure?								
Lack of credit/capital	19	42.2	78	83.9	97	70.3		
Lack of information	14	31.1	58	62.4	72	52.2		
Shortage of labour	19	42.2	81	87.1	100	72.5		
Inaccessible of irrigation water sources	24	53.3	93	100	138	100		
Shortage of input supply	32	71.1	73	78.5	105	76.1		
Total							12	0.001**

*Note: ** significant at p<0.05,   Source: own survey result, (2019)*

4.7 Constraints to the Small Scale Irrigation practices

The study result was indicated that small scale irrigation had a great potential to improve incomes, food self-sufficiency, improving livelihood, asset building and enhancing adaptive capacity of rural households. However, use of small scale irrigation is not an easy matter. The study identified several factor constraints during use of small scale irrigation in the study area.

The result was shown in (Table 18) that; more of the respondents were reported that lack of access to and distance from irrigable water sources the main constraint of irrigation practice; especially for non-user households didn't use irrigation as it involves high financial and input costs. This implies that those farmers whose farmland were located in sloppy and water sources far from farmland so, difficult to apply water though gravity forces expect on other water lifting mechanisms and improved irrigation technology.

Table 15: Constraints to small scale irrigation practices

Constraints	Frequency	Percent (%)	Rank
Lack of access to and distance from irrigable water sources	118	85.5	1
Lack of initial capital and irrigating tools	87	63	4
Shortage of human labour	65	47.1	6
Lack of effective marketing system	104	75.4	3
Presences of disease and pests of vegetables	81	58.7	5
Poor canal (water seepage) and free grazing	109	79	2

Source: own survey result, (2019)

The other problems are lack of initial capital and costs of tools, these indicated that farmers with no or little capital to buy irrigation tools and farm inputs they could not engage in irrigation activities. So it need micro credit services to buy inputs and to develop the irrigation infrastructure that brings the water from the feeder canals to their fields. Lack of effective marketing system was another constraint for irrigation practice, farmers would be discouraged to produce as much as they are not getting a rational price for their produce that is prices go down with high supply as result farmers couldn’t store to sell latter because have no storage facilities. Also, the results revealed that the shortage of labor is the other constraints was mentioned respectively.

There was no standardized program and plans to irrigate each cultivated crop. Irrigation water use depends only on spatial location of the farm plot; it does not consider the amount of water required for the type of cultivated crops, the time interval of water application and the size of each plot for irrigation. Based on the respondents' feedback on poor canals 79 % were water seepage is another problem due to the absence of a lined canal. Through all the courses of the diverted river, the water becomes loose because of unlined canal construction.

More irrigation practices in the study area were traditional river diversion canal, so irrigation water flowing in canal cross or excavation; the water loss through by seepage available water doesn’t reach on the farmland and increase. This implies that water shortages during cropping season and reduce crop productivity besides cost of input and others not cover it. Also, the result was shown in (Table 18) presence of pests and diseases were the other constraints of irrigation. This implies that the number of participants and irrigation practices would be reduced as a result crop damage due to pests and diseases as they cannot cover the cost of irrigation use.

4.8 Determinant factors that affect the household small scale irrigation practice

Before using the logit model for hypothesized variables, it is necessary to test the problem of multicollinearity or association among the potential independent variables. A statistical package known as SPSS was employed to compute the VIF values. As a rule of thumb, if the VIF of a variable exceeds 10, there is multicollinearity problems (Gujarati, 2004). To avoid serious problems of multicollinearity, it is quite essential to omit the variable with value 10 and more from the logit analysis. The value of Pearson Chi-square test shows the overall goodness of fit of the model in less than 1% probability level.

Another measure of goodness of fit of the model is based on a practice that classifies the predicted value of events as one if the estimated probability of an event is equal or greater than 0.5 and 0 otherwise. From all sample farmers, 138 were correctly predicted in to SSI user and non-user categories by the model. They correctly predicted user and correctly predicted non-user of the model were 78 (50%) and 78 (50% respectively.

Table 19 indicated that, among the factors considered in the model; seven variables are significantly and positively affected household irrigation use and two variables are significant but negatively affected. Three variables are insignificantly difference but positively influence household irrigation use. In light of the summarized model results possible explanation for each significant independent variable are given as follows.

Table 16: Binary logistic regression model for factors influencing the use of irrigation.

Variables	Coefficient	Standard Error	Wald	Significance	Odds ratios
FARM_DISTANCE	-2.920	0.633	21.269	0.000**	0.54
MARKET_INFOR	1.288	0.563	5.231	0.022**	3.625
NON_FARM	1.143	0.575	3.954	0.047**	3.135
MARKET_DISTANCE	0.518	0.393	1.736	0.188NS	1.679
CREDIT_ACCESS	1.122	0.542	4.292	0.038**	3.071
EDUCATION_LEVEL	0.853	0.212	16.252	0.000**	2.347
LIVESTOCK (TLU)	1.822	0.391	21.761	0.000**	6.193
AGE	-0.077	0.022	11.870	0.001**	0.926
LAND_SIZE	0.308	0.333	0.857	0.354NS	1.361
GENDER	0.322	0.485	0.469	0.494NS	1.394
FAMILY_SIZE	0.858	0.388	4.887	0.027**	2.358
INCOME	0.771	0.179	18.487	0.000**	2.163
Prob>chi-square = 0.0002					
Chi-square (12)	143.981				
Number of observation	138				
Confidence interval level	95.0%		Pseudo R^2 = 0.70201		

*Note: ** significant at p<0.05, NS=not significant at p>0.05*

Source: computed data obtained from binary model output, (2019)

4.8.1 Age of households

The negative relationship implies that older age; household heads have less chance to use small scale irrigation than younger ones. While, the other reason for this finding could be related to the reason that older farmers do not have long term planning and they do not worry about the development on long term and they do not want to invest their time, capital and energy in tiresome job that will bring the long term benefit and improvement in the productivity of their production.

This implies that, increase in the age of the respondents by the one-year probability of becoming irrigation use decreasing by a factor of 0.926. As farmers get older, despite their accumulated experience in farming, they tend to lose energy, have short planning horizons and become more risk-averse and therefore participation in new irrigation practices may be difficult for them. This finding was in agreement with the work of scholars such as Wang Jinxia *et al.,* 2015; Temesgen Hirko, 2018; Nelson mango *et al*.,2018).

4.8.2 Households family size

The family size of the households was found significantly and positively affected the intensity of participation in small scale irrigated farming of farm households at a 5% level of significance. Since households with higher family labor can perform various agricultural activities without labor shortage. This implies that, increase in the family size of the respondents by 0.771 the likely probability of becoming irrigation use increased by a factor of 2.163. This finding was in agreement with the work of scholars such as (Nelson mango *et al.,* 2018; Temesgen Hirko, 2018).

4.8.3 Education level of Households

This variable was found positively and significantly affected the participation decision of the small scale irrigation by the farmer households at a 5% level. It shows that an increase in the year of schooling of the household head by one year leads to an increase in the proportion of land irrigated by the farmer by 2.347 factors. The same finding was reported by scholars such as (Wang Jinxia *et al.,* 2015).

4.8.4 Access to credit services of households

Credit access was also found significantly and positively influencing the intensity of participation in small-scale irrigated farming by the farmers, at the 5% level. The result was shown that the proportion of land irrigated by the farmers, those who used credits exceeds by 1.122 the proportion of land irrigated by the farmers' increases by a factor of 3.071 with those who did not use credit. This finding is in-line with the result reported by (Temesgen Hirko, 2018; Nelson mango *et al*., 2018).

4.8.5 TLU owned of households

This variable was found significantly and positively determined the intensity of participation SSI by the households at a 5% level. This implies that the proportion of irrigated land increased by 1.823 as the number of TLU owned by the household increases by a factor of 6.193. This was because farmers that have a large number of TLU use their oxen as draft power-on time for land preparation, as it is common in the country and they were more easily able to prepare a large area of land than the households that have lower number of oxen and hence more likely involve in small-scale irrigated farming. This finding is in line with the findings of studies by (Temesgen Hirko, 2018; Nelson mango *et al.*, 2018).

4.8.6 Annual Income of households

This variable was also found significantly at the 5% level and positively influencing the use of small-scale irrigation farming by the farmers. The result was shown that the proportion of 0.171 as the farmers have more income annually the proportion of land irrigated by the farmers increase by a factor of 0.631 with that did not have sufficient income owned of households. This finding is in line with the findings of studies by (Nelson mango *et al.*, 2018).

4.8.7 Market information

Market information on the input and output price by the farmers was found to significantly determining the participation decision of the farmers in small-scale irrigation at a 5% probability level. It positively influenced the use decision of the farmers in small-scale irrigated farming. The result of the marginal effect of this variable, 1.288 reveals that the predicted probability of participating in small-scale irrigation increases by 3.625 for the farmers having the market information on input and output price as compared to the farmers who do not have market information. This finding was consistent with the findings of (Kinfe Aseyehegn *et al.*, 2012;Abiyu Abebaw *et al*., 2015).

4.8.8 Distance of plot of land from water source (Farm distance)

This variable was significant at 5% level of significance and have a negative relationship with household use decisions in small-scale irrigation practice. It indicates that as the distance of plot of land from irrigation water source increases by one walking hour on foot, the probability of participating in small-scale irrigated farming decreases by 0.54, holding other factors constant.. This phenomenon is due to the difficulty of bringing water to one's farmland since it involves higher costs as the land becomes more farther from the water source. This finding is in line with the findings of studies by (Beyan *et al.*, 2014; Nokuphiwa *et al.*, 2014).

4.8.9 Access to non-farm activity

This variable was significant at 5% level and have a positive relationship with household use decision in small-scale irrigation practice. This implies that the proportion of irrigated land increases by 1.143 as the access to non-farm activity household increases by a factor of 3.135 of decision use of small scale irrigation of household farmers. This result is concluded that off-farm activities improve income for the farmer and that income can be used to complement agricultural activities. This finding was consistent with the findings of (Beyan *et al*., 2014; Hadush Hailu, 2014).

5. SUMMERY AND CONCLUSION

5.1. Summary

Small scale irrigation is one of the most useful practice designed to increase production and productivity while reduces risk related with climate variability and improving livelihood of rural farm households indeed. The potential of smallholder-irrigated agriculture to enhance adaptive capacity and improve livelihoods has led the government of Ethiopia to invest significantly in irrigation establishment. SSI practices aim to refuse climate variability those are clear increases in agricultural production through diversification and intensification of crops and livestock variety, enables to produce high-value crops grown, improve household annual income and sources of animal feed of participating farmers.

It has played a key role in enabling sustainable agricultural production where it is well managed by lowering the risk of crop failure, helps to prolong the effective crop growing period in areas with dry seasons by permitting multiple cropping per year. Based on this study, various lessons can be learned from the contribution of small scale irrigation and factors constrain to the practice. The average annual income of both groups is statically significance difference at 95% level; this indicates that irrigators are better to attain an annual income from crop production (crop and livestock).

While irrigation user has better to make adjustment options than non-irrigated farmers. The results and discussion parts are revealed that irrigation user has high adaptive capacity, annual income and more asset building as to compare the non-irrigation user So, overall it can be concluded that participation in the small-scale irrigation has robust and positive effect on most of the livelihood improvement, asset building and that an expansion of irrigation practice a good strategy in the water-stressed and drought-prone during cropping season.

The result of the determinants of small scale irrigation use indicates that age of households, family size, education level, credit access, income, farm distance, nonfarm activities, market information, and livestock were the major factors that significantly influence on household small scale irrigation use. Gender, market distance, and landholding size insignificantly but positively affected the household small scale irrigation use but age and farm distance are negatively affected practices.

Furthermore, there are major constraints of the small scale irrigation practices in the study area listed by the households that includes: lack of access to and distance from irrigable water sources, poor canal management to shortage of water during cropping season, initial capital, lack of an effective marketing system and low market price at time of harvest, presence disease and pests of vegetables figured out during fieldwork. Therefore, it needs more supporting different stakeholders to take reducing the constraints and strengthening available enabling factors for respondents. The study revealed that SSI practice is useful for asset building and enhancing the adaptive capacity to climate variability of smallholder farmers.

5.2 Conclusion

Based on the findings of the study, the following recommendations are forwarded to a sustainable improving livelihood and adaptive capacity as well as small scale irrigation practices of smallholder farmers:

- ❖ To remove barriers of using the small scale irrigation considerations should be given on enhancing institutions such as: access to market, improving water loss through sealed canal, making control measures for pests and diseases;
- ❖ Selective adaptation options such as: early maturing crop types, drought resistant and needed less water quantity crop variety, diversification of crop and livestock varieties and Changing planting dates to climate variability should be employed to enhance smallholder farmers' adaptive capacity;
- ❖ To build an asset of smallholder farmers', Government attention should also be given large scale irrigation development, climate smart approach and proper water management;
- ❖ To enhance farmers to use small scale irrigation attention should be given to socioeconomic factors (annual income, improve livestock breed, market information, farm distance) and institutional services such as: credit access and formal education.

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7. APPENDICES

Appendix 1 : **Variance Inflation Factors (VIF) of continuous variables**

Variables	Tolerance	VIF
LIVESTOCK (TLU)	0.505	1.982
EDUCATION_LEVEL	0.713	1.402
AGE	0.683	1.464
INCOME	0.529	1.890
FAMILY_SIZE	0.751	1.331
LAND_SIZE	0.794	1.259
MARKET_DIS	0.631	1.585
FARM_ACCESS	0.582	1.718

Source: Model output

Appendix 2 : **Contingency Coefficients (CC) of Discrete Explanatory Variables**

	CREDT_ACC	OFF_FARM	MARK_INFO	GENDER
CREDT_ACC	1.00			
OFF_FARM	0.064	1.00		
MARK_INFO	0.028	0.062	1.00	
GENDER	0.059	0.049	0.039	1.00

Source: Model output

Appendix 3 : **Conversion factor of Tropical Livestock Unit (TLU)**

No	Livestock Type	TLU	No	Livestock Type	TLU
1	Ox	1.0	6	Donkey	0.7
2	Cow	1.0	7	Horse	1.1
3	Bull	0.75	8	Mule	1.1
4	Heifer	0.75	9	Poultry	0.013
5	Sheep & Goat	0.13	10	Camel	1.25

Source: Yilma, 2005

Appendix 4 : Meteorological data of Waliso district from 1985 -2018

YEAR	MEAN ANNUAL MINIMUM TEM /°C	MEAN ANNUAL MAXIMUM TEM /°C	MONTHLY RF/MM	MEAN ANNUAL RF/MM	MEAN TEM / °C
1985	10.7	24.8	1221	102	17.8
1986	11.7	24.7	1197	100	18.2
1987	13.3	25.4	1271	106	19.4
1988	13.2	25	1448	121	19.1
1989	12.3	24.4	1231	103	18.3
1990	12.2	24.6	1260	105	18.4
1991	12.3	24.8	778	65	18.6
1992	11.7	24.3	1387	116	18
1993	12.3	24.2	1553	129	18.3
1994	12.6	24.8	1083	90	18.7

1995	12.9	25.3	1071	89	19.1
1996	13.2	24.8	1447	121	19
1997	13.5	25.4	956	80	19.4
1998	11.5	25	1381	115	18.2
1999	12.5	25	1217	101	18.7
2000	12.4	25	1136	95	18.7
2001	13	25	1021	85	19
2002	12.9	25.6	1114	93	19.2
2003	13.1	25.4	1175	98	19.3
2004	13.5	25.2	1230	102	19.3
2005	13.5	25.3	1210	101	19.4
2006	13.4	25	1400	117	19.2
2007	13.5	25.3	1170	98	19.4
2008	13.3	25.2	1242	104	19.2
2009	13.5	25.9	979	82	19.7
2010	13.8	25.3	1384	115	19.5
2011	13.5	25.4	1136	95	19.5
2012	13.4	25.7	955	80	19.5
2013	13.1	25.5	864	72	19.3
2014	13.8	25.6	1124	94	19.7
2015	14	26.4	998	83	20.2
2016	14	25.8	1066	89	19.9
2017	13.9	26.2	384	32	20
2018	13.8	26.2	972	81	20

Source: Ethiopia National Meteorological Agency, 2019

Appendix 5 : Household survey questionnaires

Question Code ______________

1. Household head:
Sex: 1 Male 2 Female Age _____________ kebele ___________________
2. Education level: 1 Illiterate 2 Read and Write (1-4) 3 Elementary school (5-8)
4 High school (9-12) 5 Graduate/ College
3. Household Family size: - _____________________?
4. What types of your house? 0 Grass roofed 1 Corrugated iron roofed house 2 both 3 other specify

5. At this time are you able to be self-sufficient in producing food? 0 No 1 yes

If the answer is no, for how many months food shortages faced?

1 3 months 2 6 months 3 8 months 4 1 year and above

6. Livestock production

No	Type of animals	No of animals	How much if you	If there is any sold Animals	Remark

			want to Sell (Nov-June,2011)	Sold Amount (Birr)	Total cost (Birr)	Income gained (Birr)	
1	Cow						
2	Bull						
3	Heifer						
4	Calf						
5	Ox						
6	Mules						
7	Horse						
8	Donkey						
10	Goat						
11	Sheep						
12	Poultry						
13	Bee colony						

7. What is Livestock output income gain?

8. Type of asset building acquired from farmers? 1 Chemical sprayer 2 Carts 3 Cars 4 Bajaj 5 Houses from town 6 saving 7 Mills 8 Shops 9 Restaurant 10 Beauty salon 11 Butic

9. What was the reasons not using Small scale irrigation?

1 No farmland access on surface water and distance from water sources, 2 Lack of initial capital and irrigation tools 3 Lack of inputs and its costs 4 shortage of labour 5 Lack of effective marketing system 6 presences of disease and pests of vegetables 7 Water seepage and free grazing 8 others specify

10. What is the distance between the sources of water to your irrigated land ____________km?

11. The major problems encountered in small-scale irrigation practices you use per Crop season?

12. Which small-scale irrigation type do you use?

1 Micro pond 2 Traditional river diversion 3 Motor pump 4 Treadle pump 5 others specify

13. How do you evaluate the fertility of your land compared to other farmers?

1 Low 2 Medium 3) High

14. What are your criteria to evaluate the quality of your land?

No	Criteria	Rank
1	Productivity of land	
2	Degradation status	
3	By soil erosion	
4	Other specify	

15. Is credit timely and adequately available for agricultural commodities development?

0 No 1 Yes

16. Do you gain any sort of extension services from agents differently on the specific commodities?

0 No 1 Yes Available in your locality? 0 No 1 Yes

17. Which types of Access to extension services for irrigated & Rain fed farmers to DAs or irrigation experts?

1 training 2 field visits 3 Technical advice 4 inputs delivery 5 weed, pest and disease control

6 Method demonstrations on vegetables 7 Advice on irrigation management practice8 others

18. How far do you travel to get local market ________km?

19. Do you get market information about climate variability, prices and demand condition agricultural inputs and out Puts? 0 No 1 Yes,

20. What significant changes in weather have you observed in your lifetime?

1 Unpredictable rains 2prolonged drought 3Very hot seasons 4 Very wet seasons 5 don't know 6 others (specify)

21. What is the main impact of climate variability on the local community? or in your lifetime?

1 Crop failure 2 Flooding 3 Human disease outbreaks 4 Livestock disease outbreak 5 Famines

6. Don't know 7 food insecurity 8 others (specify

22. Do you perceive climate variability and change in your lifetime? 0 No 1 Yes

23. If yes, what has happened to the number of hot days in your lifetime?

1 Increased 2 Declined 3 More extreme 4 less extreme

24. If yes, what has happened to the number of rainfall days in your lifetime?

1 Increased 2 Declined 3 Change in the timing of rains 4 Decrease in rains and change in timing 5. Change in frequency of droughts/floods

25. Have you made any adjustment in your farming practices to climate variability and change?

0 No 1 Yes

26. What adjustments have you made in your farming practices to these long-term shifts in temperature and rainfall? Rank

1 Use drought resistance and needed less water quantity crop variety 2 Build water harvesting technology 3 Implement soil Conservation practices 4 Diversification of crop & livestock types and varieties 5 crop rotation 6 Changing planting dates 7 Changing size of land under cultivation 8 Reduce numbers of livestock 9 Diversify from farming to Non-farming activity 10 small scale irrigation farming 11 Integration of tree within crops

27. What are the main constraints to adaptation measures?

1 Lack of capital 2 Lack of information 3 Shortage of labour 4 Lack of access to water 5 Poor health 6 others

28. Crops production in rain fed or irrigation 2010/2011 E.C

No	Type of Crops	Plot Size Timad (Hack.)	Total production (Kg)	Consumed at home (Kg)	Sold			Income gained (Birr)
					Amount (kg)	Value (birr)	Total cost(Birr)	
1	Teff							
2	Maize							

3	Wheat							
4	Barely							
5	Sorghum							
6	Finger millet							
8	Beans							
19	Other crops							

29. Vegetables, Fruits, and others production in rain fed or irrigation 2010/2011 E.C

No	Types of crop grown	Plot Size Timad (Hack.)	Total productio n n (Kg)	Consum ed at home (Kg)	Sold			Incom e gained (Birr)
					Amount(k g)	Valu e (birr)	Total cost(Bir r)	
	Vegetabl es							
1	Tomato							
2	Potato							
3	Pepper							
4	Onion							
5	Cabbage							
6	Kosta							
7	chat							
	Others							

30. What help do you need from the government or any organization on your irrigation farming?

31. Do any member of your family has involved last year on non/off farm activities? 0, No 1 Yes If the answer is yes, list each.

Appendix 6 : Interview guideline for Key Informants

1. What are the major livelihood activities in your area?

3. What was the role of stakeholders (Government, NGO, Union, etc.,) in small scale irrigation Practice?

4. Is the amount of rainfall enough to support your crop production?

5. What are the major constraints on SSI activities in the woreda?

6. What are the main opportunities to implement SSI practices in the woreda?

7. What is your observation on the climate variability in your area about for 10 years?

8. Explain years of extreme climate variability your locality (drought and flood).

9. Explain the adverse impact of climate variability on the livelihoods of the community?

10. What things are being considered for the cause of climate variability in the woreda?

11. What are the major adaptation strategies people use to minimize the adverse impact climate variability in the Woreda?

12. What do you recommend to be done that will enhance the fight towards climate variability?

13. What are the strategies that can promote smallholder farmers in improving production through SSI practices?

14. What is the socioeconomic contribution from SSI practices for small holder Farmers in Woliso district?

15. What are the Focus group selection criteria.

Appendix 7 : Checklists for Focus Group Discussions

1. What types of irrigation methods are taking place in this PA?

2. Do you have adequate water for irrigation?

3. Is the irrigation having access to farm land?

4. Is the amount of rainfall enough to support your crop production?

5. What are the major types of crops produced under SSI in this area?

8. What challenges and constraints faced during SSI applied?

9. What are the main opportunities during irrigation practice?

10. Do you take easy loans to support their agricultural production inputs?

11. How do you know about climate variability?

12. What is your observation on the climate variability in your area about 10 years?

13. Explain years of extreme climate variability your locality (drought and flood).

14. Explain the adverse impact of climate variability on the livelihoods of the community?

15. What are the adaptation strategies people use to minimize the adverse impact climate variability?

16. What do you recommend to be done that will enhance the fight towards climate variability?

17. Is there irrigation water user association around your area?

18. If your answer is yes, what are the benefits obtained from the association?