THE ROLE OF SMALL-SCALE IRRIGATION IN

CLIMATE CHANGE ADAPTATION: THE CASE OF EAST BELESA DISTRICT,

AMHARA REGION, ETHIOPIA

M .Sc. THESIS

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HAWASSA UNIVERSITY, WONDOGENET, ETHIOPIA

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APPROVAL SHEET-I

This is to certify that the thesis entitled as "***The role of small-scale irrigation in climate change adaptation: The case of East Belesa district, Amhara region, Ethiopia***" submitted in partial fulfillment of the requirement for the Degree of Master of Science in **Climate Smart Agricultural Landscape Assessment**, Wondo-Genet College of Forestry and Natural Resource, and is a record of original research carried out by ***Abebe Tilahun*** under my supervision, and no part of the thesis has been submitted for any other degree or diploma.

The assistance and help receive during the courses of this investigation have been duly acknowledged. Therefore, I recommend that it is to be accepted as fulfilling the thesis requirement.

Demamu Mesfin /PhD/	___________________	_________________
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Name of co-advisor	Signature	Date

APPROVAL SHEET-II

We, the undersigned, members of the Board of examiners of the final open defense by **Abebe Tilahun** have read and evaluated his thesis entitled "***The role of small-scale irrigation in climate change adaptation: The case of East Belesa district, Amhara region, Ethiopia***" and examined the candidate. This is therefore to certify that the thesis has been accepted in partial fulfillment of the requirements for the degree of Master of Science in Climate Smart Agricultural Landscape Assessment**.**

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Name of internal examiner	Signature	Date
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DEDICATION

I dedicate this thesis to my beloved wife Selam Ayalew for her courage and sincere support.

DECLARATION

I, Abebe Tilahun, here by declare that the thesis entitled "**The role of small-scale irrigation in climate change adaptation: The case of East Belesa district, Amhara region, Ethiopia**" submitted for the partial fulfillment of the requirements for the Master of Science in Climate Smart Agricultural Landscape Assessment, is the original work done by me under the supervision of Dr. Demamu Mesfin and Dr. Birhanu Biazen. 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.

Abebe Tilahun Abetew	________________	_______________
Name of student	Signature	Date

ABBREVIATION /ACRONYMS

CRGE	Climate Resilient Green Economy
CSA	Central Statistical Agency
CV	Coefficient of Variation
DAs	Development Agents
EBWARDO	East Belesa Woreda Agriculture and Rural Development Office
ECSNCC	Ethiopian Civil Society Network on Climate Change
EPA	Environmental Protection Authority
FAO	Food and Agricultural Organization
FDRE	Federal Democratic Republic of Ethiopia
FGD	Focused Group Discussion
GDP	Gross Domestic Product
GHG	Green House Gas
Ha	Hectare
HH	Household
INDC	Intended Nationally Determined Contribution

IPCC	Inter-governmental Panel on Climate Change
IWMI	International Water Management Institute
KIs	Key Informants
MoA	Ministry of Agriculture
MoWR	Ministry of Water Resources
NAPA	National Adaptation Program of Action
NGOs	Non-governmental organizations
PCI	Precipitation Concentration Index
Qt	Quintal
SD	Standard Deviation
SRA	Standardized Rainfall Anomaly
SSI	Small-Scale Irrigation
TLU	Total Livestock Unit
UNESCO	United Nations, Educational, Scientific and Cultural Organization
UNFCCC	United Nation Frame work Convention on Climate Change

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ABSTRACT

*Ethiopian economy is highly dependent on agriculture with lack of adequate rainfall, combined with variability in the onset and duration of rainfall. Small-scale irrigation development approach is believed in helping to address such problem at household as well as national level. The objective of the study was to assess the role of small-scale irrigation in climate change adaptation in East Belesa district. The study followed a multi-stage sampling procedure to select 144 households (82 irrigation user and 62 non-users) in four rural kebeles. Individual interview, group discussions, key informants and field observations data collection tools were used. The data analysis was carried out by descriptive, inferential statistics and binary logistic model. The result obtained from meteorological data of three decades and farmers' perception on local climate change indicated an increase in temperature and variability, decreased in rainfall. Irrigation is becoming a practice for households due to climate variability/change, improving/livelihood and others as means of livelihood diversification. The annual income of irrigation users and non-users was 40,166 and 20,379 ETB respectively. It implies that irrigation has a great role in increased households' income and safety net through increased production and diversified livelihood strategy enable to buffer against climate variability. The result from the binary logit analysis shows that education level, cultivated land size, frequency of extension contact, access to credit, livestock holding size and age have positively and significantly affected households' participation in irrigation (*other factors being constant*). In contrast, market distance, farm distance and dependency ratio have negatively and significantly affected. Therefore, the study concluded that small-scale irrigation is one of the viable solutions to climate variability and change adaptation. Finally, it is recommended that GO and NGO should expand access of small scale irrigation by farm households to improve their adaptation to climate variability and change.*

Keywords: *adoption, climate smart agriculture, income, diversified livelihood strategy*

1. INTRODUCTION

1.1. Back ground

Climate change is one of the most pressing issues that poses a threat to the sustainable development and life of the global society now and in future (IPCC, 2014). Climate change alters the world's climate in both natural and anthropogenic causes by increasing the concentration of greenhouse gases in the atmosphere (Venkataramanan, 2011; IPCC, 2014).

Climate change is expected to adversely affect all economic sectors, eco-regions and social groups (Singh and Purohit, 2014). Realizing this threat, the global community is putting effort of their capacity to avert the trend; United Nations established the Intergovernmental Panel on Climate Change (IPCC) and created the Kyoto Protocol as the first international agreement on mitigating GHGs (IPCC, 2014). The goal of this protocol is to reduce the GHGs of committed countries by at least 5% compared to the 1990 level by the period 2008 – 2012 and developing countries move based on their Intended National Determine Contribution (INDC). In order to reduce the green house gases (GHGs) in the atmosphere enhancing the three win strategies such as; productivity, adaptation and mitigation enhancement are the pillars for sustainability (Fisher, 2013).

In developing countries, agriculture is one of the sensitive sectors which is both a source and a solution for climate variability and change that critically determine the growth of all sectors and the whole national economy (Vermeulen, 2012; IPCC, 2014).

Ethiopia is predominantly an agrarian country with above 85% of its population directly or indirectly involved in agriculture and it has an important role in the development of the national economy, contributing about 50% of GDP and almost 90% of export earnings (FAO, 2012).

Adaptation response of farmers to climate variability and change is varied from area to area and among local farmers to maintain food security in the face of agricultural crop production loss exacerbated by climate change (Schipper et al., 2010; Woldeamlak et al., 2015). The choice of irrigation as climate smart agriculture is one of the key adaptation strategies to boost agricultural production in the rural parts of the country (Dereje et al., 2011).

Ethiopia is believed to have the potential of 5.3 million hectares of land that can be developed for irrigation through river and spring diversion, pump, gravity, pressure, underground water, water harvesting and other mechanisms but it doesn’t utilize enough (Seleshi et al., 2010). If it is around water, irrigation has key role to stabilize agricultural production, productivity and mitigate the negative impacts of variable or insufficient rainfall. It also has potential to increase both yields and cropping intensity (Abdissa et al., 2017; Mango et al., 2018). This helps poor farmers to overcome rainfall and water constraint by providing a sustainable supply of water for cultivation and livestock, strengthen the base for sustainable agriculture, provide increased food security to poor communities through irrigated agriculture and contribute to improve the overall performance of agriculture (Hussain and Hanjra, 2004). Therefore, this research was conducted to investigate the role of small-scale irrigation in climate change adaptation in the study area.

1.2. Statement of the problem

In Ethiopia, climate variability and the frequencies of extreme events have increased over recent times (Kidane, 2010). This is greatly menacing the various agricultural sectors and natural resource base upon which the poorest Ethiopian people depend for their livelihoods. Such vulnerability and sustained food supply deficiency cannot be solved with the rain-fed agriculture (Dejene, 2011).

Irrigation has the potential to stabilize agricultural production and mitigate the negative impact of the variable or in sufficient rainfall. It contributes to agricultural production through increasing crop yield and enabling farmers to increase cropping intensity and switch to high value crops (Abdissa et al., 2017). Even if Ethiopia has a huge potential in terms of surface and ground water availability and vast suitable land for irrigation, the adoption of small-scale irrigation is in its infancy stage (Seleshi et al., 2010).

The major constraints that limit the adoption of irrigation are predominately primitive nature of the overall existing production system, shortage of agriculture inputs and low level of user participation due to limited trained power and in adequate extension service (MoA, 2011). Irrigation practice is taken to greatly reduce the problem caused by rainfall variability, enhance production per unit of land and increase the volume of annual production significantly (Kalkidan and Tewodros, 2017).

In the study area, the livelihood of the people is relied on mixed farming especially crop production is the prominent source of livelihood which depend on rain fed agriculture. Due to the erratic nature of rainfall, the area is highly prone to frequent climate variability that lead to low production and productivity.

Consequently, around half of the people are supported by different programs and donors such as productive Safety-net Program and other related emergency support projects every year (EBWARDO, 2018). For this matter, it is one of the hot spot areas in Amhara Regional State which is severely prone to food gap. On the other hand, in study area, there are seven perennial and several seasonal rivers which have large enough irrigation potential that enable to buffer against the negative impact of climate variability. In spite of its surface watering potential, small-scale irrigation is practiced by some farmers and the other can not be practiced in water accessible areas. There has been no considerable investigation so far to deal with the role of SSI in climate change adaptation. Therefore, the study was carried out to fill these gaps.

1.3. Research objective

1.3.1. General objective

- The overall objective of this study was to uncover the role of small-scale irrigation in climate change adaptation and guid policy and development interventions that can enhance the adaptive capacity of rural households to climate change in the study area.

1.3.2. Specific objectives

The specific objectives of this study were:

- To compare farmers' perception of climate change with that of temperature and rain fall data trend over the last three decades.
- To assess the contribution of small-scale irrigation to climate change adaptation.
- To assess factors that influence small-scale irrigation adoption in the study area.

1.4. Research question

In order to address the stated problem and objectives, this study was attempted to answer the following key and specific questions corresponding to each research objective.

- How farmers' perception of climate change is compared with that of temperature and rainfall data trend over the last three decades?
- What are the roles of small-scale irrigation to climate change adaptation?
- What are the factors and constraints to adopt small-scale irrigation in the study area?

1.5. Significance of study

The research will be relevant in providing valid data to institutions and departments that invest in irrigation practice to small holder farmers towards climate change adaptation. The result of the study will be help local authorities and development agents to formulate appropriate intervention mechanism. The outcome of the study could serve as an input to policy makers and stakeholders concerned with developing a strategy on climate change prone areas to promote and improve irrigation farming to climate change adaptation in sustainable manner. Moreover, the research findings could be used as an input for researchers to further knowledge generation in concepts related to irrigation development.

1.6. Scope and Limitation of the Study

Conceptual Scope**:** This study was limited to the role of small-scale irrigation in climate change adaptation among irrigation users and non-irrigation users.

Methodological Scope**:** 144 sample household heads was selected by simple random sampling method from the two strata household lists prepared in selected study area to analyze and to give conclusion and recommendations. It focused on household heads those who have both using irrigation for agricultural production and non-irrigation users.

Geographical Scope**:** The study was conducted in East Belesa district in the selected sample areas of four *kebeles.*

Temporal or Time Scope**:** Time series data was employed by using 2017/2018 production year.

Limitation of the study: This study was limited to assess the role of small scale irrigation in climate change adaptation. There are above ten *kebeles* which practices irrigation agriculture in the district; however, due to limited resources (budget, time, and facilities) the study was limited to only four *kebeles.*

2. LITERATURE REVIEW

2.1. Definition and explanation of relevant concepts

Climate : is the average weather of a particular region (Ahrens, 2009).

Climate variability: According to Folland et al.(2002); IPCC(2007) climate variability is the way climate fluctuates yearly above or below a long term average value or the variety of climate data points above and below the long term mean.

Climate change: According to UNFCCC (2011) climate change refers to 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 observed over comparable time periods.

However, IPCC define as a change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer.

Small holder farmers: Smallholder farmer is a farmer with limited land availability and resource poor farmers. Those farmers are characterized with limited capital (including animals), fragmented holdings, and limited access to inputs. They are risk prone and vulnerable in different conditions. They mostly have small farm size and are unable to satisfy their commitment (FAO, 2015). It maintains that agriculture is predominantly on a smallholder basis in Ethiopia. About 90% of farm holdings are less than 2 hectares in size.

Perception: is the process of attaining awareness or understanding the elements of the surrounding environment based on what is observed or thought physical sensation (Maddison, 2007)**.**

Adaptation: Adaptation refers to activities that make people, ecosystems and infrastructure less vulnerable to the impacts of climate change (Shanahan et al., 2013).

Adaptation strategy: A strategy designed to respond climate change based on the nature of deriver (anticipatory, autonomous and planned), the outcome (process and outcome oriented strategies) and the type of strategy or action taken (Schipper et al., 2010).

Adoption: A decision to make full use of innovation as the best course of action available (Rogers, 2003).

2.2. Overview of climate change in the world

Greenhouse gas emissions are retained in the atmosphere, where they absorb and re-emit solar radiation, leading to planetary warming, changes in precipitation, increases in extreme weather events, ocean acidification, glacier melting, and sea level rise (IPCC, 2014).

The net result of climate change negatively impacts terrestrial, freshwater, and marine plant and animal species, some of which are key food sources (Pereira et al., 2010).

Climate change causes an increase in infectious diseases, decreases water and food availability especially risks are highly disproportionately fall on the global poor and have the potential to result in forced migrations, increased numbers of internally displaced people and refugees, and violent conflict over resources (Singh and Purohit, 2014). In order to limit the global temperature increase to less than 2°C, it needs to decrease greenhouse gas emissions by 25 to 50 percent between 2010 and 2050. However, emissions have been increasing, by 2.2 percent every year from 2000 to 2010 due to human activity (IPCC, 2014).

2.3. Climate variability and change trend in Ethiopia

Many evidences show that between 1960 and 2006 the mean annual temperature of the country has risen by about 1.3°C, an average rate of 0.28°C per decade, and spatial and temporal rainfall variability has been increasing (McSweeney et al., 2010). Long-term climate data for Ethiopia shows increasing rainfall for some regions and decreasing rainfall for others to rising for all regions (ECSNCC, 2011). In Ethiopia climate variability and change in the country is mainly manifested through the variability and decreasing trend in rainfall and increasing trend in temperature (Solomon et al., 2015).

For the IPCC mid-range emission scenario, the mean annual temperature will increase in the range of 0.9 -1.1 °C by 2030, in the range of 1.7 - 2.1 °C by 2050 and in the range of 2.7- 3.4 °C by 2080 over Ethiopia compared to the 1961-1990 normal (EPA, 2012; Emerta, 2013).

In addition, precipitation is projected to decrease from an annual average of 2.04 mm/day(1961-1990) to 1.97 mm/day (2070-2099) for a cumulative decline in rainfall 25.5 mm/year (Aklilu et al., 2009).

Climate projections also suggests that an increase in rainfall variability with a rising frequency of both severe flooding and drought due to global warming (World bank, 2010).

2.3.1. Impact of climate variability and change in Ethiopia

Ethiopia is one of the most vulnerable countries in the world to the impact of climate variability, change and with least capacity to respond (IPCC, 2007; Haileab, 2018). Climate change causes wide-ranging effects on the environment, socio-economic and related sectors, including water resources, agriculture and food security, human health, terrestrial ecosystems and biodiversity (Aklilu et al.,2009; EPA, 2012; Negussie and Ashebir, 2015; Getaneh and Belay, 2016; Teshome, 2017; Haileab, 2018).

According to Mekonnen (2018) finding revealed that the impacts of climate change in rural areas include reduced in crop yield (49%); increase in pests and disease (34%) and soil erosion (98%). At national level, World Bank (2010) suggests that climate change may reduce Ethiopia's GDP compared to a baseline scenario by 2-6% by 2015, and by up to 10% by 2045.

2.3.2. Farmers' perception on climate variability and change in Ethiopia

Understanding of local people's perception on environmental conditions is crucial to design and implement appropriate adaptation strategies to climate change and variability (Woldeamlak, 2012). Various studies in different part of Ethiopia shows that small holder farmers' perceived the occurrence of climate variability and change in terms of increase in temperature, decrease in rainfall and change in time of rain, change in the onset of rains, erratic rainfall patterns (Woldeamlak, 2012).

The indicators for what they perceived from studies are weather related to problems such as soil erosion, loss of soil fertility, reduction in agricultural production, high rate of disease occurrence and frequent occurrence of drought (Dejene, 2011; Alem et al., 2016; Kebede and Gizachew, 2016; Desalegn and Filho, 2017; Seyoum, 2018).

Studies also compare the farmers' perception on climate change against climatological data shows that there is an evidence of study in the reduction of rainfall and increased temperature (Solomon et al., 2015). According to Aklilu et al.(2016) indicates that household across the three eco-environments (pastoral, agro pastoral and mixed crop-livestock high land) perceived increasing number of extreme warm days, warm nights and decreasing number of extreme cool days and cool nights. This household's perception agreed with the record extreme temperature.

2.3.3. Adaptation strategy to climate variability and change in Ethiopia

Climate change as a global community agenda based on intergovernmental panel on climate change is created by Kyoto protocol (IPCC, 2007). In Ethiopia, through National Adaptation Program of Action (NAPA) process, priority activities are identified that address immediate climate change adaptation needs of the country. These activities broadly focus in the areas of human and institutional capacity building, improving natural resource management, enhancing irrigation agriculture and water harvesting, strengthening early warning systems and awareness raising quite relevant areas in improving Dry lands livelihood systems (Aklilu et al., 2009).

Ethiopia has prepared its Intended Nationally Determined Contribution (INDC) document to implement both mitigation and adaptation initiatives. To reduce the vulnerability of the population, environment and economy to the adverse effect of climate change, The Ethiopian government has already put in place a number of policies, strategies and programs aimed at enhancing the adaptive capacity and reducing climate variability and change.

Thus, the country's CRGE focuses on four pillars (namely agriculture, forestry, renewable energy, and advanced technologies) that will support Ethiopia's developing green economy. Due to this, Ethiopia has planned to achieve middle income status in 2025 by climate resilient green economy through a green growth path that fosters development and sustainability (FDRE, 2011).

2.3.4. Over view farmers' adaptation effort in Ethiopia

Climate change adversely affects Ethiopian economy due to heavy dependence of the agricultural sector on rainfall (Temesgen et al., 2014). A decrease of rainfall and rise in temperature has been increasing the exposure of the country to frequent drought. According to Temesgen et al.(2011); Dejene (2011); Alem et al.(2016); Paulos and Belay (2018) and Mekonnen (2018) different adaptation measures are practiced by small holder farmers such as soil and water conservation, crop rotation, change crop variety, changing planting date, diversification of crop type and variety which differs from area to area even farmer to farmer. Those adaptation measures are highly affected by level of household education, agro-ecology, livestock owned, farm income and credit services, lack of information, lack of capital, shortage of labor, lack of access to water and poor potential for irrigation.

2.4. Irrigation

Irrigation is the process of applying water to soil, primarily to meet the water needs of growing plants (Reddy, 2010).

Irrigation development could also be a case of agricultural development technology intervention to provide control for the soil moisture regimes in the crop root zone in order to achieve a high standard of continuous cropping (Makin, 2016).

Irrigation schemes in Ethiopia are classified on the basis of the size of command area, technology used and management system. Firstly, in the command area classification, they are classified as small (less than 200 ha), medium (200 to 3000 ha) and large scale, over 3000 ha (Seleshi et al., 2005). Secondly, the level of technology used determines the type of irrigation schemes. The type of technology affects the choice of irrigation method followed to control and divert water.

It is also highly associated with the availability of water, water loss and establishment as well as for operation and maintenance costs. Based on the technology employed irrigation scheme is classified into; drip irrigation, flood irrigation, sprinkler or spray irrigation and furrow irrigation (MoWR, 2002). The third classification is based on management system. Management system is developed to help public, private irrigators and decision-maker for the proper management, utilization and application of irrigation water. It includes tank irrigation, shallow or deep tube well irrigation and small dam irrigation (MoWR, 2002). The management systems of small-scale irrigation schemes usually involving local leadership and water users' association with the government providing extension support, while the medium and large-scale schemes are usually managed by the government (MoWR, 2002).

2.5. Irrigation development in Ethiopia

Irrigation practice is an old art and was practiced for many years in the Nile Valley. Egypt claims to have the world's oldest dam built about 5000 years ago to supply drinking water and for irrigation purposes (Seleshi et al., 2007).

In Ethiopia, irrigation agriculture was started in the 1960 with the purpose of producing industrial crops which is Cotton and Sugar cane (Gebremedhin and Peden, 2002). However, local communities had already practicing irrigation by diverting water from rivers in the dry season for the production of subsistence food crops by traditional irrigation practice (Seleshi et al., 2006). During 1970, modern SSI practice and management is started by the ministry of agriculture in the response to overcome droughts which caused wide spread crop failures and consequently hunger and starvation (MoA, 2011).

Irrigation practices reduce the risk of crop failure by resulting from drought. Currently, government gives high attention to develop the sector to fully its potential by assessing and supporting local farmers to improve irrigation practices as well as the promotion of modern irrigation practices (Kalkidan and Tewodros, 2017).

Agriculture in Ethiopia is dependent on rain fed systems, and it is highly vulnerable to climate change (Getaneh and Belay, 2016). On the other hand, Ethiopia has great irrigation potential, which is estimated as 5.3 million hectares of land of which 3.7 million hectares can be developed using surface water sources and 1.6 million hectares using ground water and rain water management (Seleshi et al., 2010). Moreover, ample rainfall is available to be tapped through rainwater management for household level small-scale irrigation. However, the developed irrigation from all these sources is so far, not more than 0.7 Million ha (Seleshi et al., 2010).

2.6. Agricultural crop production through irrigation farming in Ethiopia

Crop production is a function of water, nutrient, climate and soil environment (Gebremedhin and Peden, 2002). Provided that all other requirement are satisfactorily for proper growth and production, rainfall rarely meets the time with required amount of water application for plant growth. As result average yield of agricultural crops under rain fed agriculture is low compared to irrigated land.

The average crop yields per hectare from irrigated land increases 2.5 times higher than the yield produced by rain fed agriculture (Kalkidan and Tewodros, 2017). Higher productivity helps to increase returns to farmers' endowment of land labor resources and produced more than twice per year (Dereje et al., 2011). This implies that switching from subsistence production to market oriented production.

Despite its economic and social benefits, production and productivity of different agricultural crops in Ethiopia are mostly on a small-scale and average crop yield is very low, as compared to other developing countries (Seleshi et al., 2010). To increase productivity and diversify the livelihood scenarios as an option, development of small-scale irrigation schemes has been introduced through water harvest technology (Hussain and Hanjra, 2004).

Small-scale irrigation is an important strategy in reducing risks associated with both rainfall variability, production of different crops twice or three times within a year and increasing income of rural farm-households (Fitsum et al., 2009). In attempting to do so, Ethiopia has yet developed not more than 5% of the irrigation potential.

2.6.1. Role of small-scale irrigation on household income

Adoption of small-scale irrigation is a viable strategy to increase production to meet the growing food demand, market oriented production, to achieve food security, make food available and improve the livelihood of small holder farmers that increases the adaptive capacity to climate variability and change (Woldegebrial et al., 2015). Studies shows that irrigation generates an average income of US $323/hectare compared to an average income of US $147/hectare rain fed system in 2005/2006 and 2009/2010 cropping season. It also contributes to the national economy 5.7% and 2.5% to agricultural GDP and overall GDP respectively during 2005/2006 cropping season. By the year 2009/2010 the irrigation contribution also shows to agricultural GDP and overall GDP is estimated to be approximately nine and 3% respectively. However, the contribution is differed in type of irrigation even in small-scale irrigation which is in both modern and traditional scheme (Fitsum et al., 2009).

According to Leta (2018) participation of a household in irrigation has increased annual farm income by 19,474.8 ETB than non-participant households. Other study Woldegebrial et al. (2015) also show that income of household's from irrigation has accounted for 38% of total income.

2.7. Small-scale irrigation Adoption as adaptation strategy in Ethiopia

Expansion of small-scale irrigation can be an important strategy to increase farm production, income, building up asset and to use an improved agricultural technology (Fitsum et al., 2009). According to Woldegebrial et al.(2015) study participant of rural households in irrigation prevails the degree of poor and food insecurity difference between irrigation users and non-users that irrigation users are less share of poor (20%) than non-users (30%).

These evidences show that irrigation users have more adaptive capacity to climate variability and change than non-users.

Participation in small-scale irrigation depends on a variety of institutional factors and on the presence of rural service. The local institution and the rural infrastructure services can improve the awareness of people regarding irrigation (Woldegebrial et al., 2015). It indicates that House hold size, access to information, and education level of house hold head and members of rural associations are the main factors that significantly explain the farmer's small-scale irrigation adoption. Other study Mango et al.(2018) implies that off-farm employment is positively influence small-scale irrigation adoption whereas farmers' age, distance to market and formal employment are negatively influence the adoption. Leta (2018) also indicated that education level and contact frequency with agricultural development agent were positively affecting probability of participation in irrigation.

According to Dillon (2011); Chazovachii (2012) and Fanadzo (2012) there were a statistical significance difference between irrigation user and non-users in farm land size, livestock and education but insignificant difference in household size, age and gender. Other study Woldegebrial et al. (2015) indicates that a statistical significance difference in education status and household size between the irrigation user and non-users and there is a significant difference in the application of agricultural inputs and improved seed varieties. But statistically insignificant difference in age of household head, livestock ownership, land holding, adult equivalent household size rural services.

2.8. Conceptual frame work: inter relation between small-scale irrigation development and climate change adaptation

Naturally, rainfall is the main source of water supply for crops, but when it becomes scarce or not evenly distributed over the entire agricultural areas it creates the gap with the actual demand for water. Irrigation water is an important agricultural technology for agricultural activities. Agricultural technology is generally based on the expected benefit derived from technology practice, where farmers are assumed to maximize their benefit from the practice of irrigation. In this regard, farmers practice irrigation when they perceive that this will provide them with greater benefit and improve livelihood. Without water people cannot water crops, provide food and productive environment for the fast growing population, animals, plants, and microbes worldwide (Pimentel et al., 2004).

Irrigation can benefit the small holder farmers through raising yields and production by lowering the risk of crop failure. This framework describes the way by which irrigation practice increases the adaptive capacity of households through enhancing farm income (Figure 1). Investing in irrigation is a mean to hedge against weather variability. Irrigation water allows for all year round food production. This allows food production in two or more cycles in a year (Laia, 2015). In order to enhance small-scale irrigation for increasing the adaptive capacity to climate variability and change of small household farmers' socioeconomic and institutional factors must be considered for farmers' decision to irrigation adoption.

Access to good irrigation allows poor people to not only increase their production and incomes, but also enhances their opportunities to diversify their income base and to reduce their vulnerability to the seasonality of agricultural production and external shocks.

It should be noted that the poor also use water for other farm and non-farm production activities, particularly small-scale rural enterprises such as livestock rearing, fish production, brick making and so on. Irrigation enables the poor and smallholders to achieve higher yields. The productivity of crops grown under irrigated conditions is often substantially higher than that of the same crops under rain fed conditions. Higher productivity helps to increase returns to farmers' endowments of land and labor resources.

Apart from yield improvements, higher productivity partly stems from higher land use intensity and cropping intensity (Abdissa et al., 2017). Access to good irrigation enables crop-switching: substituting low-yielding and low-profitable crops with new high-yielding and more profitable crops. This implies switching from subsistence production to market-oriented production. Further, crops can be grown year-round. Thus, irrigation culminates in what is commonly known as crop diversification and enables the poor and smallholders to spread risk more evenly over the course of a year (Kalkidan and Tewodros, 2017). In fact, crop diversification is both an income maximization and risk minimization strategy.

Increased employment for the poor may originate from the labor-intensive nature of irrigation developments/construction and subsequent maintenance, and from intensive cultivation both on their own farm, as well as on the farms of other large farmers who may find it difficult to provide extra labor from family resources during peak times. Additional employment opportunities may come from non-farm activities generated through increased demand for inputs and increased supply of outputs. Generally, irrigation has positive impact on farm household income through enhancing agricultural performance, using inputs and high value crops that give rise to increase in production which in turn gives rise to household income and finally enhance adaptation to climate change.

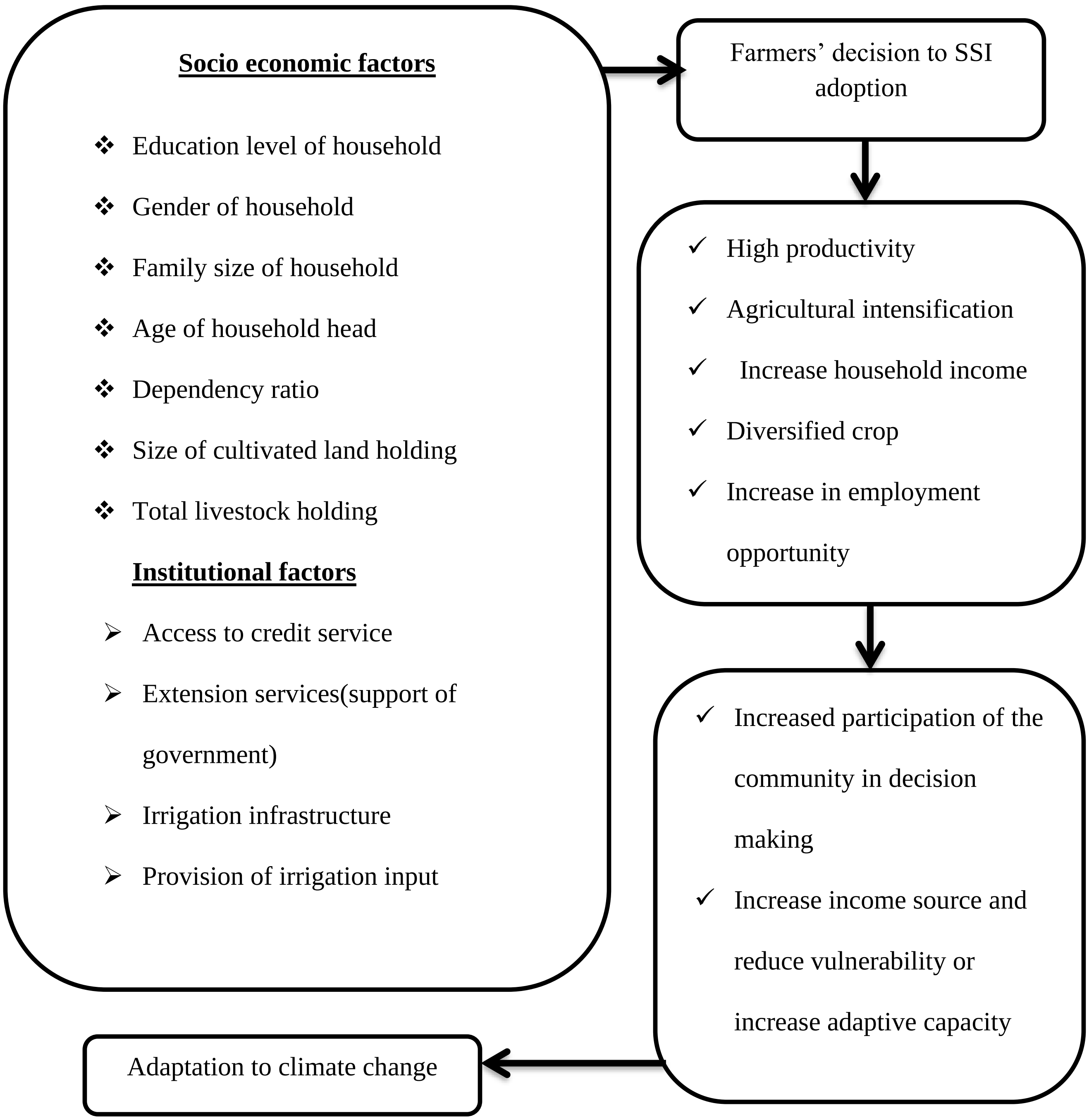

Figure 1: Conceptual frame work**.** Source **:** Adopted from Dereje and Desale (2016).

3. MATERIAL AND METHODS

3.1. Study area description

3.1.1. Geographical location of study area

The study was conducted in East Belesa district which is one of the 24 districts of North Gondar. East Belesa district is found in Amhara Regional state, North Gondar zone, at about 120 kilometer far from the zonal capital city, Gondar and 180 far from the regional city, Bahirdar. It is located at $37^0 54' 0''$ to $38^0 27' 0''$E and $12^0 15' 0''$ to $12^0 50' 0''$N. It is bounded by Janamora district in the North, South Gondar zone in the South, West Belesa district in the West and Wagemera zone in the East. The total land area of the district is 181, 755 ha which comprises a total of 30 rural *kebeles* administrative (EBWARDO, 2018).

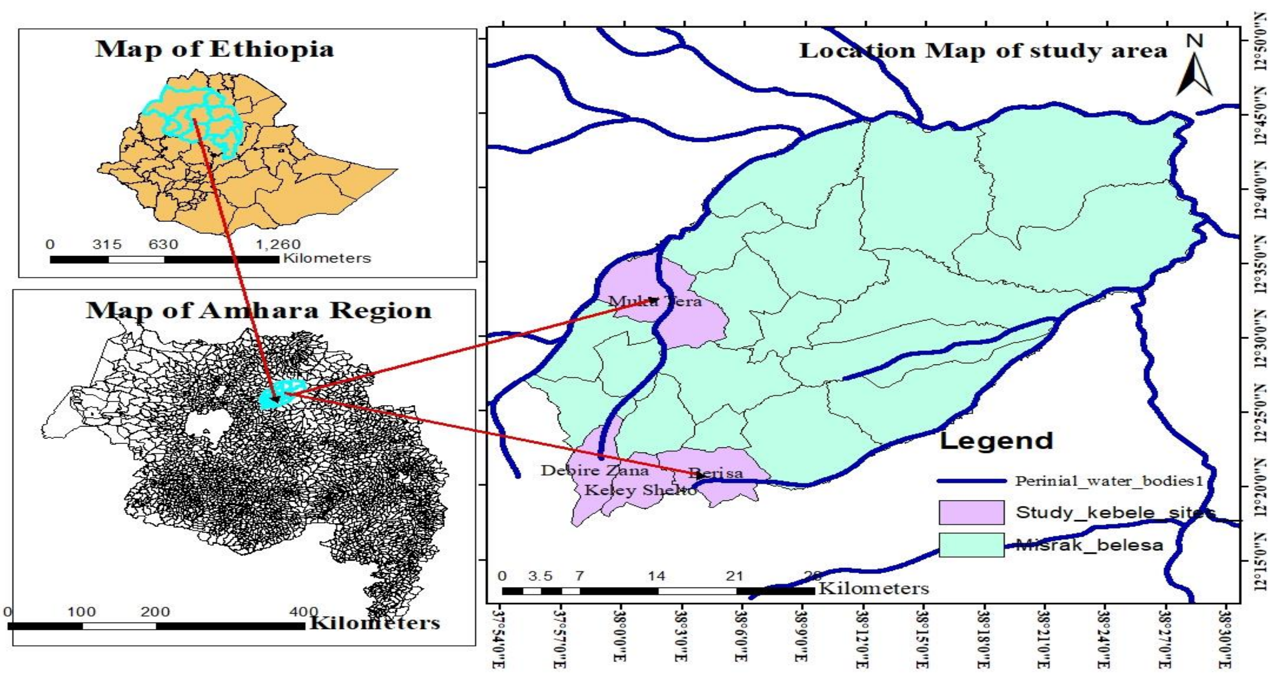

Figure 2: Location map of the study area.

3.1.2. Altitude and soil

Based on 2018 East Belesa district agricultural and rural development office annual report, the district's topography is generally characterized by different land forms such as flat, steep, gentle sloping plain and undulating to rolling plains with substantial proportion of low to moderate relief hills. On average the study area coverage in slope interval from 0-15% about 65,234 ha (36 %), 15-30 % covered 55,416 ha (30 %) and above 30 % is covered 61,104 ha (36%). The altitude ranges from 1200 to 2300 meter above sea level. The dominant soil types are Luvi soil to Nito soils on undulating land to steeping lands including the rolling plateau. The soil of this area is highly susceptible to erosion with gradually declining productivity. Thus, management of the soils of the area is likely dependent on soil types, fertility, slope, workability, water holding capacity, and susceptibility to erosion. Addition of nutrients through the crop residues and maturing is very rare and tends to rapidly increase in moisture depletion.

3.1.3. Agro-ecology and Climate

There are two agro ecological zones in the district namely 90% Kola and 10% Woyna dega. The Maximum and minimum temperature of the district is 28.6 °C and 13 °C respectively. The rain season is unimodal which is highly varied from year to year. In normal year, the rain season starts from the end of June to August. The annual rain fall ranges between 500 – 800 mm, with a medium period of rain season.

3.1.4. Demographic and socio economic activities

Based on the district administrative office annual report (2018), the district has a total population of 142,174 of which 72,606 males and 69,568 are females. 13.4% of (19,051) and 86.6 % (123,123) of population are urban and rural inhabitants respectively. As common in many parts of Ethiopia, agriculture is the main income source of population in the study area. It involves subsistence rainfall cultivation of crops and livestock production. The dominant crops in the area coverage, production and consumers number in the study area are cereal, pulse and oil crops such as Sorghum(*Sorghum bicolor L.*), Teff (*Eragrostis tef*), Bean (*Vicia faba L.*), Pea (*Pisum sativum L.*), Maize (*Zea mays*), Chick pea (*Cicer arietinlum*) and Sesame (*sesamum indicum*) are common and cultivated for household consumption and income source. With regard to livestock, cattle, goat, sheep, donkey and poultry are common.

3.1.5. Vegetation cover

Acacia species, *Combretum molle* and *Dodonaea* tree species are the major species that found in the district. The vegetation cover ranges from bare to shrub land and closed areas. However, as a result of human interference due to population pressure, conversion of the forest land to farm lands, clearing and cutting natural forest for fuel wood, charcoal and settlement purpose, the vegetation area is extremely decreased.

3.1.6. Water resource

As East Belesa district agriculture office (2018) indicates that the water potential consists of seven perennial rivers, 164 seasonal rivers, 228 hands dug well, 163 developed springs, 10 small dams that the people utilize for different purpose. Since the area is highly prone to drought, most of the above-mentioned water sources are utilized for domestic purpose.

Around 14 canal diversions, 125 traditional river diversions are currently utilized for irrigation purpose by the small holder farmers.

3.2. Research Design and Methodology

A research design is the set of methods and procedures used in collecting and analyzing measures of the variables specified in the research problem (Clancy, 2002). The study was employed cross-sectional data collection tools because it is better and more effective for obtaining information about the current status or the immediate past of the case under study (Rani, 2003). The study was investigated on two sample groups (irrigation user and non-user groups). It is also appropriate and suitable to use data collection tools such as questionnaires, interviews, focus group discussions (FGD) and field observations.

3.2.1. Site selection

The study was carried out in East Belesa district (comprises 30 rural *kebeles)* due to the occurrence of repeated climate variability related problems such as drought and a hot spot area of food insecurity, on the other way, there is enough surface water potential and irrigation is practiced. For this case, the area was selected for investigation. To select the representative samples, first consultation was made with the district council members and development agents. Then four *kebeles* namely, Debere zana, Buresa, Kalay sholit and Mukateria were selected purposively mainly because of availability of irrigation potential and irrigated agriculture practices.

3.2.2. Sampling technique and sample size determination

The study followed a multi-stage sampling technique to select sample households. In the first stage, the study area, East Belesa district, was purposively selected based on the availability of small-scale irrigation practice and its high vulnerability to climate variability and change. In the second stage, among the total 30 rural *kebeles,* four *kebeles* namely Debere zana, Buresa, Kalay Sholit and Mukateria were purposively selected on the basis of their irrigation practices and potential for irrigation. In the third stage, the four sample *kebeles* selected, the households who have land around rivers were stratified into irrigation users and non-users, and then simple random sampling was used to select households. For every selected sample size of irrigation user and non-irrigators, proportional sample size was selected. The total irrigator and non-irrigator households sample size was determined using the developed formula by Yemane (1967).

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

Where: n = the number of required sample size; N = total households (population size);

e = error limit to maintain 95% confidence level, 8% level of precision and ΣN= total house hold of the selected four *kebeles.* The required sample household of each stratum which is irrigation user and non-user was determined by the following formula.

$$n_1 = \frac{N_{1(n)}}{\Sigma N} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

Finally, a total of 144 sample households, 82 irrigation user households and 62 non-irrigation users were selected simple random sampling using probability proportional to size sampling technique.

Table 1: Number of sample households for two strata from each *kebeles.*

Kebeles	Total HH	Irrigation user		Non-user		Total Sample
		Total	Sample	Total	Sample	
Buresa	500	300	(300*144)/1725 = 25	200	(200*144)/1725 = 17	42
Kalay- sholit	350	250	(250*144)/1725 = 21	100	(100*144)/1725 = 8	29
Deber zana	400	230	(230*144)/1725= 19	170	(170*144)/1725 = 14	33
Mukateria	475	200	(200*144)/1725 = 17	275	(275*144)/1725 = 23	40
Total	1725	980	(300*144)/1725 = 82	745	(745*144)/1725 = 62	144

Source: own computation (2018).

3.3. Data collection

For the purpose of this study, both quantitative and qualitative data were collected from the primary as well as secondary sources. Primary data were collected from key informants (KIs), focused group discussions (FGDs) and household (HH) survey. Secondary data were obtained from relevant published and unpublished data sources. Qualitative data were used to capture information pertaining to local households' perception and opinions on climate change and irrigation issue using KI and FGD. FGDs and Key informants interview was mainly aim at collection of qualitative information on: the trends of rain fall and temperature for the last three decades, the role of small-scale irrigation in climate change adaptation, and the constraints that influence the adoption of small-scale irrigation.

3.3.1. Primary data sources

Key informant interview: Key informants (KIs) are those people who are knowledgeable about the area and the major issues of the study (Elder, 2009).

For this study, KIs are peoples who are knowledgeable and understanding about the existing trend of climate change, the socio-economic status of small holder farmers, livelihood activities of the communities, the current status of the small-scale irrigation and its role in climate change adaptation in the area and have certainly lived in the area long enough to clarify the issue of interest. The key informants were selected by snowball method (Bernard, 2011). This is done by asking a randomly selected three farmers from each *kebele* to give the names of five key informants based on the above criteria. Then the mentioned key informants are ranked and the most frequently appeared top three farmers were assigned as the key informants in each *kebele*. In general, 12 (twelve) KIs were selected. The key informants were individually interviewed on the overall information that has risen as criteria. Like most qualitative data collection, key informants were asked repeatedly in order to explore issues in-depth based on open-ended questions.

Focused group discussion: In a focus group discussion, a group of people having similar concerns and experience regarding a subject are encouraged to participate. Focus group discussions (FGD) with development agents, district agricultural and rural development office irrigation experts, irrigating and non-irrigating farmers to gather qualitative data were conducted. The FGD considered 6-12 individuals per *kebele* (Elder, 2009). Therefore, one FGD in each sample *kebeles* that make up a total of 4(four) FGDs which have 32 participant (10 were females). The discussion was facilitated by the researcher together with the enumerators based on the designed check list.

Household survey: A household survey was used to collect quantitative information. Sample household heads were used as the unit of analysis from which quantitative data were collected.

In this regard, carefully designed open for quantitative data and close-ended questionnaires consisting of interrelated issues were administered by trained expert enumerators under the supervision of the researcher and the development agents of the selected *kebele.* To convey the questions effectively to the rural interviewees, the questionnaire was translated into the local language (Amharic). For the sake of checking the quality of the questionnaire, a pre-test was administered for a few 15 randomly selected households. Based on the feedback obtained, some possible adjustments and modifications were made.

Observation: In order to handle the most pertinent information, transect walks with the researcher, Development agents (Das), model irrigator farmers, water use committees and *kebele* leaders across the small-scale irrigation practice area was conducted. During the transect walks, informal discussions with households and elderly people was conducted to gather useful and detailed information which difficult to collect through the questionnaire.

3.3.2. Secondary data source

Secondary data collection was done through published and unpublished documents, From the published documents like literature, previous studies, books, journals. The unpublished document was obtained from both regional and district office reports from the study area, including reports on weather and demographic data.

A 34 years recorded station meteorological data, for the period from 1983 to 2016, of daily minimum and maximum temperature and rainfall were obtained from the study area's meteorological station, i.e. Guhalla station, for climate trend and variability analysis. These data was directly obtained in tabular formats from Ethiopian National Meteorological Agency.

Alternatively, gridded rainfall and temperature data of the study area was obtained from the same agency to replace the missing data of continuous days from records. Data related to community views on the various implication of the observed trend and variability of the two variables, on local people and ecology, was used to qualify and verify the implication depicted by the researcher, that are solely based on trend and variability analysis of the two data.

3.4. Data analysis

The collected data were analyzed using SPSS statistical software (version 22) for household survey data and XLSTAT (2016) for climate data. Descriptive, inferential statistics and econometric model were applied. Monthly and annually mean of daily time series data of climatic parameters, temperature (maximum and minimum), precipitation was computed. **Descriptive statistics** such as frequency distribution, mean, maximum, minimum, standard deviation and percentage was used to analyze the quantitative data.

Inferential statistics such as Chi-square(X^2) was used to identify the association between categorical variables and independent t-test was used to compare the mean difference between adopters and non-adopters across the continuous variables, while taking the research objective take in to consideration. Data that obtained from KIs and FGDs and other qualitative data were analyzed in qualitative way.

3.4.1. Climate data analysis

Since Guhalla station is found in the study district to the study area it was selected to be used for the analysis of climate variable for this study. Prior to analysis, the obtained daily rainfall and surface air temperature data were carefully inspected for their quality and completeness. A number of techniques have been developed for the analysis of rainfall and temperature that generally fall into variability and trend analysis categories (Amogne *et al*., 2018).

Descriptive statistics were used to summarize rainfall and temperature data and to find the central tendency of the data, mainly mean and standard deviations. In this study, the non-parametric Mann-Kendall test and Sen's slope estimator was used to detect the time series trend and magnitude of slope for the trend, respectively. Mann-Kendall test has been used to detect the presence of monotonic (increasing or decreasing) trends in the study area and Sen's slope estimator and p-value to check whether the trend is statistically significant or not (Amogne *et al*., 2018).

According to Liu *et al*. (2006) the Mann-Kendall method has been widely used and tested to be an effective method to evaluate the presence of a statistically significant trend in climatological and hydrological time series. Similarly, for variability and distribution analysis Coefficient of Variation (CV), Precipitation Concentration Index (PCI) and Standardized Precipitation Anomaly/standardized rainfall anomaly (SRAt) has been used as Statistical descriptors.

Coefficient of variation was used to evaluate and classify the degree of variability of time series climate parameters and its implication on vulnerability of the systems. It was computed using Equation (1) below simply by dividing the standard deviation (σ) with the mean (μ) value.

$$CV = \frac{\sigma}{\mu} * 100 \quad (1)$$

The PCI of Oliver (1980) was used to see the uniformity and temporal distribution of precipitation and its implication on flood risks and moisture stress in the study area. Thus, PCI was computed using the distribution of monthly rainfall data across the analysis period (1983-2016) deploying Equation (2).

$$\text{PCI} = \frac{\sum_{i=1}^{12} p_i^2}{(\sum_{i=1}^{12} p_i)^2} \text{ -- (2)}$$

where: Pi is the rainfall amount of the i^{th} month.

Σ = summation over the 12 months.

As indicated by Amogne *et al*. (2018); Agnew and Chappel (1999) SRAt have been computed using Equation (3) to examine the nature of the trends, to enable determination of dry and wet years in the record and to assess frequency and severity of drought. Standardized rainfall anomaly also referred to normalized anomaly is simply the deviation from the long term mean. It is computed by subtracting long term mean rainfall from each annual total rainfall values and then dividing by the standard deviation as indicated below.

$$SRA_t = \frac{p_{t-p_m}}{\sigma} \text{ --- (3)}$$

Where, SRA*t* = standardized rainfall anomaly for year *t*.

Pt = annual rainfall in year t.

Pm = long-term mean annual rainfall, over a given period of observation.

σ = standard deviation of rainfall over the period of observation.

3.4.2. Econometric model specification

Econometric model was adopted to assess factors influencing farmers' adoption of small-scale irrigation. The dependent variable is farmers' adoption of small-scale irrigation which is a dichotomy, and the independent variables are any type. According to Gujarati (2004) there are different approach to develop a probability model for a binary response variable such as linear probability model(LPM), logit and probit model. LPM is not selected since it is plagued by several problems: non-normality, heteroscedasticity of error term and lower values ofR^2.

Most scholars used binary logistic model than probit due to its computation simplicity, easy to interpretation and provides odds ratio. Thus, Binary logistic regression model was applied to analysis parameters of binary logistic regression model for factors influencing the adoption of small-scale irrigation.

The dependent variable is small-scale irrigation participation which is a qualitative variable (nominal) that the values were either yes or no (binary outcome). This dependent variable may affect by different socio economic and farm specific characteristic. So this was analyzed by binary logistic regression model (logit). It is used to identify the determinants of participation to irrigation and assess their relative importance determining the probability of being irrigation adopter. The functional form of logit model is specified as follows:

$$P_i = E(y=\frac{1}{xi}) = \frac{1}{1+e^{-(Bo+BiXi)}} \quad (1)$$

For ease of exposition it can write Equation (1) as $P_i = \frac{1}{1+e^{-zi}}$ (2)

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

$$1- P_i = P_i = \frac{1}{1+e^{zi}} \quad (3)$$

Therefore it can be written as

$$\frac{Pi}{1-Pi} = \frac{1+e^{zi}}{1+e^{-zi}} = e^{zi} \quad (4)$$

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

$$L_i = \ln \left[\frac{P_i}{1-P_i}\right] = z = B_0 + B_1X_1 + B_2X_2 + B_kX_k \quad \text{where } X_1, X2+\ldots + X_k \qquad (5)$$

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

Z_i = is a function of n- explanatory variables(x) which also expressed $Z_i = B_0+B_1X_1 + B_2X_2 + B_kX_k$, B_0 = intercept, B_1 , B_2….. B_k 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 parameters. X_i = is vector of relevant household characteristics. If the disturbance term (u_i) is introduced, the logit model becomes:

$$Z = B_0+B_1X_1 + B_2X_2 + B_kX_k \quad \text{where } X_1, X2+\ldots + X_k + U_i. \qquad (6)$$

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.

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

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 (Gujirati, 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.

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

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).

Definition of variables and working hypothesis

Once the analytical procedures and their requirements are known, it necessary to identify the potential variables and describe the measurements (Kamara et al., 2002). Accordingly, the variables expected to have influence on SSI participation were explained Table (2).

Dependent variables

Household participation of small-scale irrigation (one for adopter and zero for non-adopter) was investigated as dependent variable. Based on the review of the literatures and practical experiences, explanatory variables which have logical and justifiable rational in determining household participation to SSI were identified.

Age of a household head: age is a continuous variable measured in years that determine the small-scale irrigation (SSI) adoption. From different finding of studies age of household head was affected negatively in participating irrigation (Beyan et al., 2014; Sithole et al., 2014). Hence, the expected effect of age on household decision to participation of SSI was negative.

Gender of the household head: This is a dummy variable with one for males and zero otherwise. In Ethiopia, household head is the decision maker for farm activities.

Male household heads are expected to decide for participation of SSI as compared to female household heads. This variable is found that the probability of participating in irrigation will be higher for male headed households as compared to female household heads from different study sources (Tadesse *et al.*, 2014; Evans et al., 2018; Petros and Yishak, 2017)**.** Therefore, this variable was hypothesized as, if the household head is female there would be low probability of participating in small-scale irrigation practice and less area of land to be irrigated when found participating in irrigated farming.

Education level of a household head: It is a continuous variable measured in formal schooling years completed by the household head. Households with better education level are 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. Woldegebrial et al.(2015); Leta (2018); Dillon (2011); Chazovachii (2012); Fanadzo (2012) indicated that the higher educational level of household head, the more participate to SSI household is expected to be. Hence, education has positive contribution to SSI adoption.

Family size: It is a continuous variable measured in the number of peoples living in the household. For farming activity, an able body is a necessary condition in the family in order to fulfill the household consumption. A household who has more number of family members could share the work load to them and contribute a lot to the income of the specific household. Evidences show that the farmers with higher family size were found participating in small-scale irrigation practice more than those with lower family size (Tewodros *et al*., 2013; Woldegebrial et al., 2015 and Evans et al.,2018). Hence, it was expected to influence the adoption of SSI of the household positively.

Contact to development agent (extension): Refer to the frequency of contact those respondents with development agent. It is the continuous variable. Farmer's contacts more with development agent have better knowledge about extension packages including irrigation technology than the others (Woldegebrial et al., 2015; Legesse Leta, 2018). This enables them to enhance SSI adoption of household production. As a result, positive relationship was expected between contacts with development agent and SSI adoption.

Access to credit: is a dummy variable that takes the value one when the household takes a loan and zero otherwise. Credit is very much useful to purchase inputs such as improved seeds, other important inputs including staple food (Sithole et al., 2014; Mango et al., 2018). Hence, farmers who have access to credit would have positive effect on crop production due to use of agricultural inputs which enhance food production and ultimately increase household decision to participate SSI. Both pathways indicate that a direct relationship of credit access and household participation to SSI.

Total Livestock Holdings /TLU/: This refers to total number of livestock measured in tropical livestock unit (TLU). Livestock is important source of income, food and draught power for crop cultivation in Ethiopian agriculture. Households with more number of livestock have a chance to obtain more direct food or income to purchase foods commodities, particularly during food crisis. Therefore, higher livestock size would significantly increase the household participation to SSI that enables to increase status of income (Leta, 2018; Dillon, 2011; Chazovachii, 2012 and Fanadzo, 2012).

Market distance: This is a continuous variable that measured time taken in hours on foot from market center to village of household head. As the farmer is nearer to a market, the higher will be the chance of increasing the household's decision to engage in irrigation due to transaction cost (Kenfe, 2012; Mango et al., 2018). It was, therefore, expected that households nearer to market will incur lower transaction cost and can easily access the market the required food.

Cultivated land size: this refers to total cropping land cultivated by a household in the past one year production period. It has a direct relation with crop production. A larger size of cultivated land implies more production and availability of food grains. According to Dillon (2011); Chazovachii (2012); Fanadzo (2012); Beyan et al.(2014)*;* Sithole et al.(2014)*;* Petros and Yishak (2017*),* food production can be increased extensively through expansion of areas under cultivation. Hence, size of cultivated land was expected to have positive effect on household SSI adoption.

Participation in Non-farm activities: This variable is dummy variable taking on one if the respondent has involved non-farm activity or zero otherwise. It is a measure of any household member participated in non-farming activities. Off-farm employ is expected to contribute negatively on SSI participant to generate household income (Mango et al., 2018).

Dependency ratio: The dependency ratio shows the ratio of economically active persons compared to economically dependent household members. Economically active members of households (14- 64 years old) were assumed to be the principal productive force for the household, 0-14 and above 64 were considered as economically inactive and dependent members of the household (Rowland, 2003).

The dependency ratio reflects the pressure and responsibility on household members in the labor force. As the dependency ratio increase, the participation decreases in irrigation and vice versa. Hence, this variable was hypothesized to have a negative relationship with participation in the small-scale irrigation scheme (Jema, 2013).

Distance of farm 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 (Kinfe *et.al*, 2012; Beyan *et al*., 2014; Sithole *et al.*, 2014). This factor leads to the higher cost for the farmers to bring the irrigation water to their farm land, or even they may be unable to apply the irrigation water to their farm land because of high cost required. Thus, this may force the farmers having the farm 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.

Table 2**:** Description of hypothesized variables in the binary logistic model

Variable	Description	Measurement	Expected sign
Explanatory variables			
Age	Age of household head	Continuous (Years)	-
Gender	Gender of household head	Dummy(1 if male, 0 for male)	-
Family size	Household size	Continuous	+
Education	Education background of household head	Continuous(number of years formal education)	+
Extension	Access to agricultural extension services	Continuous (no of contact with Das)	+
Credit access	Credit access of household head	Dummy (1 if yes, 0 if no)	+
Livestock holding	Number of livestock holding of household head	Continuous (TLU)	+
Cultivated land size	Size of land available for cultivation	Continuous (Hectare)	+
Off farm employment	Members of the household with off-farm employment	Dummy(1 if yes, 0 if no)	_
Market distance	Time taken in hour from market center	Continuous	-
Dependency ratio	Ratio of economical inactive to active labor in a household	Continuous	_
Farm distance	Farm distance from river (walking hours on foot)	Continuous	-

4. RESULTS AND DISCUSSION

The results of the findings from both quantitative and qualitative data are discussed thoroughly followed by the discussion of the respective issues of interest. It has four sections: The first subsection summarizes results to describe the characteristics of sampled households. The second sub section focused on perception of sample households to climate change comparatively with the last three decades of local climate trend. The third subsection presents the contribution of small-scale irrigation in climate change adaptation. Finally, the fourth sub section presents the results of the econometric analysis, which helps to identify the factors affecting participation of households to small-scale irrigation.

4.1. Demographic, Institutional and Socio-economic characteristics of households

There were some differences between irrigation user households and non-users regarding their socio-economic, institutional and demographic characteristics.

Sex: 95.1% of the total household heads were male, whereas the proportion of the male headed households for users and non-users were about 97.6% and 92%, respectively (Table3). The chi-square test result on this variable shows that there was no significant difference between users and non-users**.**

Credit access: Credit is an important institutional service to finance poor farmers for input purchase and ultimately to adopt new technology. However, some farmers have access to credit while others do not have due to problems related to high interest rate. As indicated in Table (3), out of the 144 total households sampled only 40.3% of households had access to credit. From the total sampled households, only 55% of the irrigation user households and 21% of the irrigation non-user households had received credit in the last three years.

The Chi-square test indicated that there was a significant difference in access to credit between irrigation user and non-user households at 5% significance level. The significance difference shows that households who practice irrigation have more access to credit.

Contact to development agent (extension): Provision of extension service to farmers play important role in terms of creating knowledge and skills in using improved agricultural inputs. Development agent had contacted with farmers only once (59.7%), twice (27.8%) and more than twice (12.5%) of sample households per month. Similar contact with irrigation users was once (34.1%), twice (43.9%) and more than twice (22%), while with non-irrigation users was once (93.5%), twice (6.5%) but no contact more than twice per month (Table 3). The chi-square test indicated that there was a significant mean difference of contact with agricultural development agents at 1% between irrigation user and non-user households ($p < 0.01$). This implies that households who practice irrigation had more access to extension service.

Access to non/off farm activity: As Table (3) shows the proportion of households that have access to non-farm activity was about 68.1% of the total sampled households. The proportion of households that have access to non-farm activity for non-users was 62.9% where as that of users was 72%. The top six non/off farm activities that the sample households were engage in are: - woodlot (33%), food aid (21.4%), cash for work (13.3%), house rent (10.2%), food for work (6.1%) and grinding mill (4.1%). Moreover some sample households participate in other activities such as petty trade (1%), working on others farm (2%), sale of stone and fire wood (4.1%) and self-employment in manufacturing (1%). The chi-square test indicated that there was no significant difference in non/off farm activities engagement between two groups ($p > 0.05$).

However, there was a significance difference in the type of non/off farm activities at 1% that might imply income difference. This shows that Irrigation users had participated in better non/off income generating activities.

Table 3**:** Categorical /discrete variables

Variables	Categorical	Irrigation users (N=82)		Non irrigation users (N=62)		Total (N=144)		χ2 value	P value
		Freq.	%	Freq.	%	Freq.	%		
Sex	1=male	80	97.6	57	92	137	95	2.416	0.12
	0= female	2	2.4	5	8	7	5		
Credit access	1= yes	45	55	13	21	58	40.3	3.977**	0.046
	0 = otherwise	37	45	49	79	86	59.7		
Access to extension per month	One times	28	34.1	58	93.5	86	59.7		
	Two times	36	43.9	4	6.5	40	27.8	52.296***	0.000
	More than two times	18	22	0		18	12.5		
Access to non/ off farm activity	1= yes	59	72	39	62.9	98	68.1	1.330	0.249
	0= otherwise	23	28	23	37.1	46	21.9		
What type of non/off farm activities your household participates in?									
House rent		9	15.3	1	2.7	10	10.2		
Food for work		1	1.7	5	12.7	6	6.1		
Food aid		4	6.7	17	43.6	21	21.4		
Cash for work		3	5.1	10	25.6	13	13.3		
Petty trade		1	1.7	0	0	1	1	56.69***	0.000
Woodlot		31	52.5	2	5.1	33	33.7		
Working other farm		0	0	2	5.1	2	2		
Sale of stone/wood		3	5.1	1	2.6	4	4.1		
Self-employment in manufacturing		3	5.1	0	0	3	3.1		

Source: survey data (2019), ****, ***** significant at α = 0.01 and α = 0.05 respectively.

Age: The mean age of the respondents was 43.58 years, with the minimum being 26 years and the maximum 70 years. The standard deviation was 9.67. The mean age of irrigation non- user was 46.10 years, with the minimum being 26 years and the maximum 70 years and had a standard deviation of 10.28. The mean age of irrigation user was 41.05 years, with the minimum being 28 years and the maximum 60 years. The standard deviation was 7.94. The mean age difference of household head between the users and non-users was significant at 1% (Table 4). The result indicated that the age of irrigation non- users was higher as compared to irrigation users. It implies that the aged farmers are less engaged in irrigation than the younger one.

Education: The mean years of education of the total sample households in the study area was 2.44 years of schooling, whereas the non-user and users had a mean education level of 1.65 and 3.23 years of schooling, respectively (Table 4). There was a significant difference in the education level between users and non-users household heads at 1% level of significance. The result indicates that, the education level of the non-users was lower as compared to users that have less possibility to use irrigation.

Family size: The mean family size of the total sample households in the study area was about 5.93, with minimum and maximum family size of 2 and 10 respectively (Table 4). The family size of the study area was greater than the average national family size is 4.7, for that of rural Ethiopia is 4.9 and Amhara 4.3 (CSA, 2007). The mean family size of irrigation non-user was 5.63, with the minimum 3, with the maximum 10 and standard deviation of 1.63.

The mean family size of irrigation user was also 6.20, with the minimum 2, with the maximum 10 and standard deviation of 1.795. The descriptive analysis revealed that there was no significant difference in the family size of households between user and non-users in irrigation practice.

Dependency ratio: The dependency ratio for the members of the sampled households was estimated to be 0.79, which means every 100 economically active persons, had 79 extra persons to feed, clothe, educate and medicate. The mean dependency ratio of irrigation user households was 0.69 with standard deviation of 0.41, and that of irrigation non-user households were 0.89 with standard deviation of 0.42 in Table (4). This shows that irrigation user households had less dependency ratio than non-user households. Therefore, irrigation user households were more economically active as compared to non-user households. The t-test shows that there is a significant difference in the mean dependency ratio between irrigation user and non-user households at 1% significant level.

Cultivable land holding of household: The mean cultivable land size of the households was 1.33 ha with minimum and maximum of 0.75 and 4 ha respectively. The standard deviation of cultivable land size households was also 0.47. On the other hand, the mean cultivable land size of irrigation non-user was 1.23 with minimum and maximum of 0.75 and 2 ha, respectively with standard deviation of 0.367, and that of irrigation user was 1.43, with minimum and maximum values of 0.75 and 4 ha, respectively and standard deviation of 0.568 (Table 4). The descriptive t test analysis revealed that there was a significant difference in the cultivable land size of households between users and non-users at 1% significance level.

This implies that irrigation users have larger cultivable land size on average with compared to that of non-users.

Total livestock holding (TLU): The average size of livestock holding in tropical livestock unit (TLU) for the total sampled households was found to be 4.21 with a standard deviation of 1.72 (Table 4). Average holdings for irrigation user and non-user households were 4.73 and 3.68 TLU with standard deviation of 2.019 and 1.412 respectively. The survey result shows that user households possessed relatively higher number of livestock than non-user households and the t-value also shows that there is a significant mean difference between two groups at 1% significance level. The significance difference shows that irrigation users had a better off in livestock holding than those irrigation users.

Distance to market: This variable was analyzed across the farm households and a proxy for transaction cost. From the descriptive analysis, the mean walking distance of the district market for the total sample households in the study area was 1.555 hours, with minimum and maximum market distance of 0.5 hour and 3 hours, respectively. But the mean walking market distance of the non-users was 1.71 hours with the minimum and maximum market distance of 0.5 hour and 3 hours respectively, where as that of the users was 1.40 hours, with minimum and maximum values of 0.5 hour and 3 hours respectively (Table 4). The descriptive analysis revealed that there was a significant difference in the distance of the market from household residence between users and non-users in irrigation practice at 1% significance level. The result indicates that households who practice irrigation were nearest to the market center.

Table 4: Continuous variables

variable	Irrigation users (N=82)			Non- irrigation users (N=62)			Total (N=144)			t-value	P value
	Mean	Min /Max	Std. Devi.	Mean	Min /Max	Std. Devi.	Mean	Min /Max	Std. Dev i.		
Age (year)	41.05	28/60	7.94	46.10	26/70	10.28	43.58	26/70	9.67	3.325***	0.002
Education (in years)	3.23	0/12	3.011	1.65	0/9	2.52	2.44	0/12	2.77	2.048***	0.001
Livestock size (TLU)	4.73	1.34/11.7 4	2.019	3.68	0.32/11.9 5	1.412	4.21	0.32/11.95	1.72	3.513***	0.004
Family size	6.20	2/10	1.795	5.63	3/10	1.485	5.93	2/10	1.64	0.979	0.329
Dependency ratio	0.69	0/1.5	0.41	0.89	0/2	0.42	0.79	0/2	0.42	-2.858***	0.005
Crop land/ha	1.43	0.75/4	0.568	1.23	0.75/2	0.367	1.33	0.75/4	0.47	2.506**	0.019
Distance to market (hour)	1.38	0.5/3	0.911	1.71	0.5/3	1.054	1.555	0.5/3	0.98	-2.07**	0.04

Source: survey data (2019), ****, ***** significant at α = 0.01 and α = 0.05 respectively.

4.2. Local climate trend

4.2.1. Meteorological climate data analysis

4.2.1.1. Rainfall Trends and Variability in East Belesa district

Trends of annual rainfall

The Mann-Kendall (MK) trend test and Sen's slope estimator result showed no significant trend for the long term inter-annual rainfall (Table 5). In general, this result indicated that rainfall remained more or less constant when averaged over the whole period for the study area and this is in agreement with the national rainfall trend (NMA, 2007). However, even if statistically not significant, there is a slight declining trend of inter-annual rainfall amount at a rate of 11 mm per decade, and this partly agree with farmers perception. This nonsignificant declining trend also agrees with the national long term rainfall trend (MEF, 2015).

Table 5: Trends of annual rainfall in East Belesa for the period 1983-2016.

Study area	Mann-Kendall tau	Sen's slope	P value
East Belesa	-0.059	-1.1	0.638^{ns}

Source: NMA (2018). Slope (Sen's slope) is the change (mm)/annual; ns is non-significant trend at 0.05 significant level.

Variability of annual rainfall

The maximum rainfall record for the area was obtained in 2007 with rainfall amount of 992.7 mm and the minimum rainfall record was during the current event of El Nino in 2015 that recorded 485 mm (Table 6). In the study area, during the following year in 2015 most of people have been experienced in food gap as a result of failure of crop yield and livestock production and productivity.

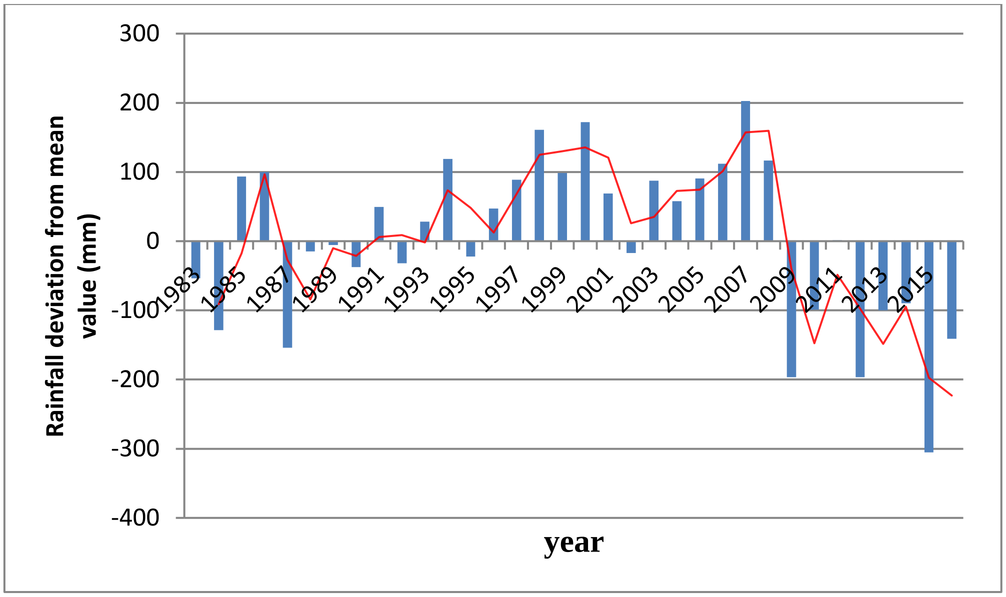

Figure 3 : Deviation of annual rainfall from its long term mean (1983-2016).

Even if the area is known by such range of rainfall deviations, the trend analysis indicates that more or less rainfall of the study area looks constant when averaged over a longer time period. Thus, this demands to look at its variability and distribution. According to Amogne *et al*. (2018) and Abiy *et al*.(2014) variability of rainfall can be expressed by many statistical parameters such as mean, standard deviation, Skewness, Kurtosis, range, Cofficient of variability (CV), standard rainfall anomaly (SRA) and precipitation concentration index (PCI). To this end the inter-annual rainfall variability and distribution pattern of the available rainfall was seen by deploying CV, PCI and SRA to check this variability.

A. Coefficient of variability (CV)

According to 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. Thus, areas with CV > 30% is an indicator of larger variability and are said to be vulnerable to drought, and vice versa.

Hence, the CV of annual rainfall 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% (NMA, 1996b).

Table 6: Descriptive statistics of annual rainfall in East Belesa district (1983-2016)

Number of years	Minimum (mm)	Observed year	Maximum (mm)	Observed year	Mean (mm)	SD	CV
34	485	2015	992.7	2007	790.2	119	15.1

Source : NMA (2018) analysis by the Author.

B. Precipitation Concentration Index (PCI)

According to Oliver (1980), PCI values and ranges indicate the significance of precipitation concentration as indicated in Table 7 below.

Table 7: PCI range and Classification according to Oliver (1980)

PCI value	Significance (Temporal Distribution)
PCI ≤ 10	Uniform precipitation distribution (low precipitation concentration)
10 ≤ PCI ≤ 15	Moderate precipitation distribution
16 ≤ PCI ≤ 20	Irregular precipitation distribution/High concentration
PCI >20	Strong irregularity of precipitation distribution/Very high concentration

The result of the relative distribution of rainfall patterns in the study area indicated that there is no single year with uniform and moderate precipitation distribution for the whole period of years under the analysis (1983-2016).

Result shows that annual PCI value range from the lowest of 20.9 in 2015 to the highest of 38 in 2012. As indicated in Table (8) about 100% of the years were characterized by strong irregularity of precipitation distribution indicating a high irregular rainfall distribution across the months for the study area with mean PCI of 28.8.

According to Dereje *et al*. (2012) Amhara region was characterized by high to very high monthly rainfall concentration with PCI value between 12 and 20 and the current study partly disagree with this study.

Table 8: Pattern of Precipitation Concentration Index at East Belesa (1983–2016).

Index value	Description	Number of years (1983-2016)
PCI ≤ 10	Uniform Precipitation Distribution (low precipitation concentration)	0
10 ≤ PCI ≤ 15	Moderate Precipitation Distribution	0
16 ≤ PCI ≤ 20	Irregular Precipitation Distribution /High concentration	0
PCI >20	Strong Irregularity of Precipitation Distribution/Very high concentration	34
Mean PCI (1983-2016) =28.8 (High Concentration of Rainfall)		

Source: NMA (2018) analysis by the Author.

As figure 4 shown below the degree of PCI increased by 1.2% per decade in the last three decade.

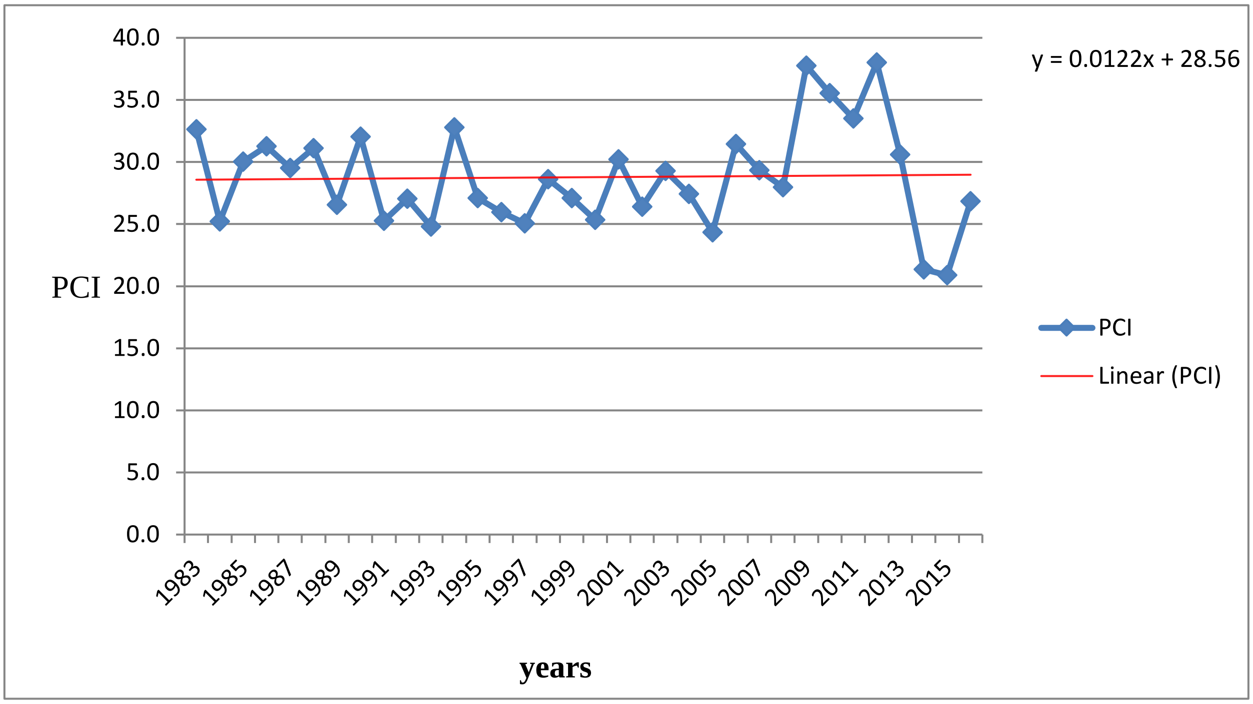

Figure 4: Annual Precipitation Concentration Index at East Belesa (1983-2016).

C. Standardized rainfall anomaly (SRA)

As seasonal rainfall variations exist with set of data used, it is helpful to present the result in terms of standardized anomalies. Agnew and Chappel (1999) suggested to classify degree of drought based on SRA as extreme drought (SRA < -1.65), severe drought (-1.65 < SRA < -1.28), moderate drought (-1.28 < SRA< -0.84) and no drought (SRA > -0.84). Accordingly, the result of SRA analysis indicated that there was three years of extreme drought event, one year severe drought incidence and two years moderate drought in the area over the period from 1983-2016. These six years faces meteorological drought that might contributed to the other three type of drought (agricultural, hydrological and socioeconomic droughts). The result showed the magnitude of SRA ranges from the lowest -2.6 in 2015, indicating the presence of extreme drought, to the highest 1.7 in 2007 (wet year). In about 82.4% of the 34 years, the result showed there was no drought (Table 9).

Table 9: Drought frequency and Severity of drought at East Belesa (1983-2016)

SRA value	Drought type	Frequency (years) [1983-2016]	List of the years with the value
SRA < -1.65	Extreme drought	3	2009 [-1.70], 2012 [-1.70], 2015 [-2.6]
-1.65 < SRA < -1.28	Severe drought	1	1987 [-1.30]
-1.28 < SRA < -0.84	Moderate drought	2	1984 [-1.1], 2016 [-1.20]
SRA > -0.84	No drought	28	All the rest [value between -0.8 and 1.70]

Source: NMA (2018) analysis by the Author.

The result showed a negative anomaly for more than half, 44.1%, of the total years and when the recent two decades considered, mainly since 2002, for 50% or 8 out of 16 years, the anomaly trend was negative almost for continuous years with value below zero indicating moisture deficit is becoming more pronounced in the area (Figure 5). According to McKee *et al*. (1993) drought begins when the SRA first falls below zero and ends with the first positive value. Thus, the recent declining trend of rainfall anomaly has an effect on the Socio-ecological system of the study area. This drought ocuurence was agreed with farmers perception.

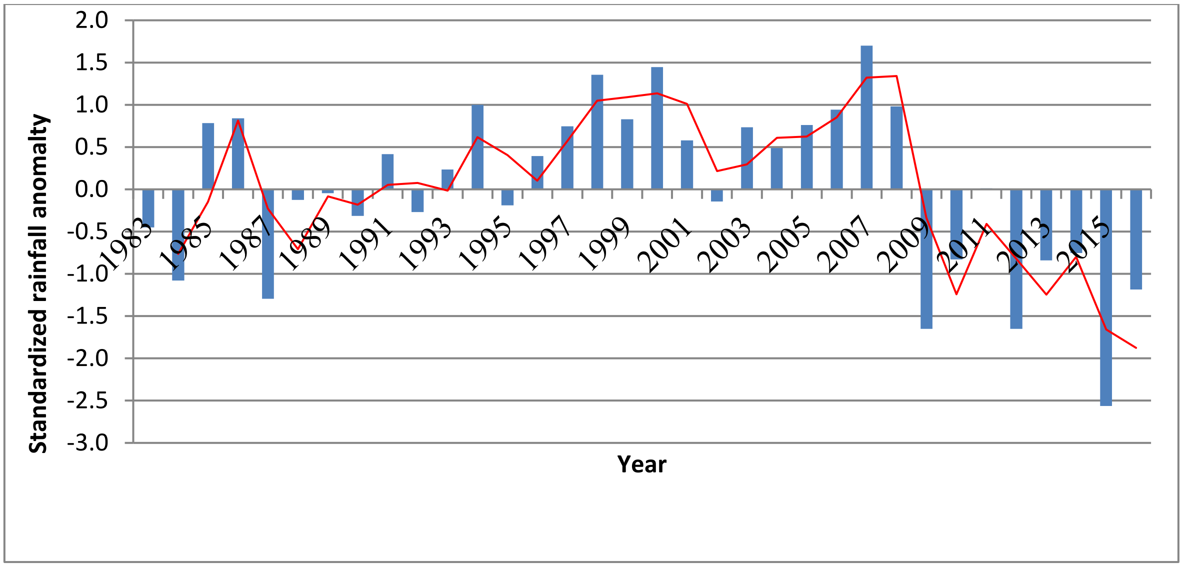

Figure 5: Standardized anomalies of annual rainfall at East Belesa (1983 – 2016).

Seasonal rainfall trend and variability

The results indicated that summer, autumn and winter seasons contributed 82, 9.1 and 8.9% to the total annual rainfall respectively; in East Belesa district (Table 10). The summer season provides important rain showers for agricultural production since the rain season is unimodal. As it is shown by Table (10) coefficients of variations were 18.3%, 42.6% and 52.6% for the summer, autumn and winter respectively, which indicates there was high inter annual variability of rainfall between 1983 and 2016. Degree of variation in amount rainfall was higher for winter (CV > 20) and autumn than summer and annual (CV < 20).

Table 10: Descriptive statistics of seasonal rainfall in East Belesa District (1983-2016)

Rainfall level	Winter	Autumn	Summer
Maximum	133.3	144.6	892.8
Minimum	0	18.9	321.5
Mean	70.6	72.2	648.2
SD	37.1	30.8	118.3
CV (%)	52.6	42.6	18.3
PCI (%)	57.4	70.1	41

Source: NMA (2018) analysis by the Author.

Trends of seasonal rainfall

As Table (11) shows the amount of rainfall was decreased by 2.37 mm, 4.94 mm and 21.15 mm per decade in winter, autumn and summer seasons respectively. How ever, Similar to the inter-annual rainfall trend, the result of Mann-Kendall trend test indicated there is no significant trend for all seasonal rainfall at 5% significant level.

Table 11: Trends of seasonal rainfall for the period 1983-2016

rainfall period	Mann-Kendall tau	Sen's slope	P value
Winter	-0.023	-0.237	0.86^{ns}
Autumn	-0.102	-0.494	0.41^{ns}
Summer	-0.08	-2.115	0.517^{ns}

ns = not significant at 5% significant level.

4.2.1.2. Temperature Trends and Variability in East Belesa district

Temperature is another important climate variable that influences the climate of an area. Availability of moisture in a given area, even if normal rainfall amount exists, is highly influenced by intensity and magnitude of its temperature.

Thus, the descriptive statistics, trend and variability of time series maximum, minimum and mean annual temperature data were analyzed to understand and summarize the long term temperature of the study area.

Trend and variability of annual temperature

The result showed that the study area's mean annual temperature was 20.7 °C and the maximum and minimum temperature were 25 °C and 18.7 °C, respectively (Table 12).

Table 12 : Descriptive statistics of annual temperature (1983- 2016)

Temperature level	Annual temperature(°C)		
	Minimum temperature	Maximum temperature	Mean temperature
Minimum	10.3	19.6	12.7
Maximum	26.9	33.5	28.7
Mean	18.7	25	20.7
SD	1.68	1.71	1.48
CV (%)	13.2	6	7.2

Source: NMA (2018) analysis by the Author.

Annual temperature trends

The result of Mann-Kendall trend test for minimum, maximum and mean temperature 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 13). The annual mean temperature showed a positive trend at a rate of 0.1°C per decade, which is contributed to the national annual mean temperature rate of change that in fact differ according to different sources. 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.

Table 13**:** Trends of annual temperature in East Belesa district (1983-2016)

Annual temperature	Mann-Kendall tau	Sen's slope	P value
Maximum	0.704	0.122	< 0.0001
Minimum	0.538	0.05	<0.0001
Mean	0.697	0.103	<0.0001

Source: NMA (2018) analysis by the Author.

Annual temperature variability

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. The result indicated mean annual temperature ranges from 18.7°C in 1990 to 25°C in 2013 with mean value of 20.5°C and standard deviation of 1.48 (Table 12). The annual maximum temperature ranges from 26.9°C in 1993 to 33.5°C in 2016 with mean value of 28.7°C and standard deviation of 1.71. Similarly, the annual minimum temperature ranges from the lowest 10.3°C in 1990 to the highest 19.6°C in 2013 with mean value of 12.7°C and standard deviation of 1.68. It was observed that the annual minimum temperature was more variable (CV=13.2%) than the maximum (CV= 6%) and mean temperature (CV = 7.2%) over the analysis period (Table 12). This agrees with the result of Muluken (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.

4.2.2. Farmers' perception of local climate change

90.3% of the households were reported that there is a change in local climate during the last three decades through local climate change indicators (Table 14). The result implies that change of climate was well perceived by community of the study area as most of them has been observing. The Pearson chi-square test statistics revealed that there is no significance difference between irrigation user and non-users (X^2 = 1.26, def. = 2, p > 0.05).

Table 14: farmers' perception of local climate change

Characteristics	Response	Irrigation users (N=82)		Non- irrigation users (N=62)		Total (N=144)		χ2	P value
		Frequ	%	Frequ.	%	Frequ.	%		
Perception to climate change	Changed	76	92.7	54	87.1	130	90.3	1.26	0.263
	Do not know	6	7.3	8	12.9	14	9.7		
	Total	82	100	62	100		100		

Source: survey data (2019)

4.2.2.1. Farmers' perception on temperature change

According to the survey result 90.3% of total sample household perceived local climate change in increasing temperature for the last three decades while the remaining(9.7%) do not know about the temperature trend (Table 15). 92.7% of irrigation users and 87.1% of non-users perceived the increased temperature trend. The Pearson chi-square test revealed that there is no significance difference ($\chi2$ = 1.26, def. = 2, p > 0.05) between irrigation user and non-users. The result shows that there is an increasing temperature trend in the study area.

A similar case was reported by Woldeamak (2012); Aklilu (2016) and Solomon (2015) small holder farmers perceived local climate change in terms of increased temperature.

Table 15: Farmers' perception on temperature changes

Characteristics	Response	Irrigation users (N=82)		Non-irrigation users (N=62)		Total (N=144)		$\chi2$	P value
		Frequ.	%	Frequ	%	Frequ	%		
Temperature change	Increasing	76	92.7	54	87.1	130	90.3	1.26	0.263
	Decreasing	0	0	0	0	0	0		
	Similar	0	0	0	0	0	0		
	Do not know	6	7.3	8	14		9.7		

Source: survey data (2019).

4.2.2.2. Farmers' perception on rainfall changes

90.3% of sample households were reported that there is a rainfall change through increased rainfall trend (48.7%), late onset and early offset (48.7%), decreasing rainfall (36.8%) while the remaining do not know (9.7). Irrigation users also perceived that 4.8% increased trend, 48.8% late onset and early offset, 39% decreased trend and 7.3% do not know about the trend (Table 16). On the other hand non-users reported that increasing (4.8%), late onset and early offset (48.4%), decreasing (33.9%) and do not know (12.9%). The Pearson chi-square test revealed that there is no significance difference between irrigation user and non-users (X^2 = 1.30, def. = 3, p > 0.05). The result shows that there is rainfall change trend in the study area.

This is agreed with Woldeamak (2012) small holder farmers perceived local climate change in terms of decrease rain fall, time of raining and erratic of rainfall pattern.

Table 16: Farmers' perception on rainfall changes

Characteristics	Response	Irrigation users (N=82)		Non-irrigation users (N=62)		Total (N=144)		χ2	P value
		Frequ	%	Frequ	%	Frequ	%		
	Increasing	4	4.8	3	4.8	7	4.8		
Rainfall changes	Late onset and Early offset	40	48.8	30	48.4	70	48.7	1.3	0.73
	Decreasing	32	39	21	33.9	53	36.8		
	Do not know	6	7.3	8	12.9	14	9.7		

Source: survey data (2019).

4.2.2.3. Farmers' perception on drought occurrence

According to the survey result 90.3% of total sample household perceived local climate change in increasing occurrence of drought for the last three decades while the remaining (9.7%) do not know about the drought occurrence (Table 17). 92.7% of irrigation users and 87.1% of non-users perceived the increased drought. The Pearson chi-square test revealed that there is no significance difference between irrigation user and non-users (X^2 = 1.26, def. = 2, p > 0.05). The result shows that there is a frequent drought in the study area. This is agreed with Dejene , 2011; Alem et al., 2016; Kebede and Gizachew, 2016; Desalegn and Filho, 2017 and Seyoum, 2018 small holder farmers perceived local climate change by considering weather related to problems such as soil erosion, loss of soil fertility, reduction in agricultural production, high rate of disease occurrence and frequent occurrence of drought.

Table 17: Farmers' perception on drought occurrence

Characteristics	Response	Irrigation users (N=82)		Non-irrigation users (N=62)		Total (N=144)		χ2	P-value
		Frequ	%	Frequ	%	Frequ	%		
Drought frequency	Increasing	76	92.7	54	87.1	130	90.3	1.26	0.26
	Do not know	6	7.3	8	12.9	14	9.7		

Source: survey data (2019)

4.2.2.4. Farmers' perception on cause of local climate change

The survey result shows that perceived local climate change caused by human (40.3%), natural (13.2%), both natural and human induced (22.2%), wrath of God (14.6%) and 9.7% of sample households have not perceived local climate change (Table 18). A Similar trend is true for both irrigation user and non-users. The Pearson chi-square test statistics imply that there is no significance difference between two groups (X^2= 1.63, def. = 4, p > 0.05). This was agreed with IPCC (2014) and Vermeulen et al. (2012) which shows human inducing factor is the major that an increasingly alarm to climate change.

Table 18: cause of local climate change

Cause of local climate change perceived by household	Irrigation users (N=82)		Non-irrigation users (N=62)		Total (N=144)		χ2	P Value
	Frequ.	%	Frequ	%	Frequ	%		
Human induced	32	39	26	41.9	58	40.3		
Natural induced	12	14.6	7	11.3	19	13.2		
Both human and natural	20	24.3	12	19.4	32	22.2	1.63	0.80
Wrath of God	12	14.6	9	14.5	21	14.6		
Do not know	6	7.3	8	12.9	14	9.7		

Source: survey data (2019).

4.2.2.5. Perception on local climate change impact

According to the survey result local climate change have its own effect in the study area. The major consequences perceived by households (90.3%) were decline in crop and livestock production, decline in soil fertility, increased crop pest infestation or attack and frequent occurrence of drought. In addition to this, expansion of unnecessary pant species (59%), prevalence of human and livestock diseases (48.6%) and extinction of indigenous crops and trees (27.1%) have perceived by households (Table 19). This agreed with Dejene (2011); Alem et al.(2016); Kebede and Gizachew (2016); Desalegn and Filho (2017) and Seyoum (2018) where small holder farmers perceived local climate change through soil erosion, loss of soil fertility, reduction in agricultural production, high rate of disease occurrence and frequent occurrence of drought.

Table 19: perception on local climate change impact

Consequences	Irrigation users(82)		Irrigation non-users (N= 62)		Total (N = 144)	
	Frequency	%	Frequency	%	Frequency	%
Decline crop and livestock production	76	92.3	54	87.1	130	90.3
Extinction of indigenous trees and crops	24	29.3	15	24.2	39	27.1
Decline soil fertility	76	92.3	54	87.1	130	90.3
Prevalence of human and livestock diseases	41	50	29	46.8	70	48.6
Increased crop pest	76	92.3	54	87.1	130	90.3
Frequent drought	76	92.3	54	87.1	130	90.3
Expansion of unnecessary new plant species	49	59.8	36	25	85	59

Source: survey data (2019).

Thus, farmers' perception of climate variability and change was partly agreed with the rainfall and agreed with temperature trend analysis.

4.2.3. Farmers' adaptation strategies to climate change

The survey result shows that adaptation practices were implemented in the study area to maintain the local climate change impact through practicing inorganic fertilizer (82.6%), early maturing crops (65.3%), soil and water conservation (65.3%), irrigation (52.8%) and improved seed (12.5). The Pearson chi-square test implies that there is a significance difference between irrigation user and non-users in irrigation ($\chi 2 = 144$, def. =1, $p < 0.01$), soil and water conservation ($\chi 2 = 8.97$, def. =1, $p < 0.01$) and inorganic fertilizer ($\chi 2 = 15.752$, def. =1, $p < 0.01$) at 1% significance level (Table 20**)**. It shows that irrigation users are engaged in more adaptation practices than the non-users. This is agreed with Temesgen et al.(2011); Dejene (2011); Alem et al. (2016); Paulos and Belay (2018) and Mekonnen (2018) different adaptation measures are practiced by small holder farmers such as soil and water conservation, crop rotation, change crop variety, changing planting date, diversification of crop type and variety which differs from area to area even farmer to farmer.

Table 20: Adaptation strategies of household

Adaptation strategies	Irrigating users (N=82)		Non-irrigation users (N=62)		Total (N=144)		χ2	P value
	Frequ.	%	Frequ.	%	Frequ.	%		
Irrigation	82	100	0	0	82	56.9	144***	0.00
Early maturing crops	56	68.3	38	61.3	94	65.3	0.764	0.382
Soil and water conservation	62	75.6	32	51.6	94	65.3	8.97***	0.003
Use of in organic fertilizer	76	92.7	43	69.4	119	82.6	15.76***	0.000
Improved seed	12	14.6	6	9.7	18	12.5	0.793	0.373

Source: survey data (2019), *** indicates significant at 1% significance level.

4.2.4. Barriers to climate change adaptation

To implement the adaptation strategies in the study area, there were barriers reported by sample households (Table 21) such as Lack of access to climate information (90.3%), lack of drought tolerant crop varieties supply (90.3%), poor irrigation infrastructure (69.4%), lack of money (67.4%) and scarcity of land (48.6%). It indicates that lack of access to climate information and drought tolerant crop varieties supply are the most influential barriers to climate change adaptation.

Table 21: Barriers to climate change adaptation

Barriers	Irrigation users(82)		Irrigation non-users (N= 62)		Total (N = 144)	
	Frequency	%	Frequency	%	Frequency	%
Lack of access to climate information	76	92.7	54	87.1	130	90.3
Scarcity of land	30	36.6	40	64.5	70	48.6
Lack of drought tolerant varieties supply	76	92.7	54	87.1	130	90.3
Lack of money	42	51.2	55	88.7	97	67.4
Poor irrigation infrastructure	55	67.1	45	72.5	100	69.4

Source: survey data (2019).

4.3. Small-scale irrigation engagement

56.9% of respondent households were irrigation users while 43.1% were non-irrigation users. Among the irrigation user households, 56.1% uses the traditional river diversion, 30.5% modern small-scale irrigation river diversion (Table 22). A small number of households use motor pump for irrigation (7.3%) and other means of irrigation by using hand dug buckets (6.1%). The perceived reasons for using irrigation were climate variability/change (54.9%), improving/livelihood (43.9%), and diversification of crop varieties for improving livelihood (1.2%) (Table 22). This implies that in addition to improving and diversifying means of livelihood, irrigation have a great role in climate change adaptation to irrigation users. This was agreed with FGDs and KIs reports in four kebeles.

Table 22: Types of small-scale irrigation

Irrigation type	Irrigating users(82)		
	Frequency	Percent	Cumulative
Modern river diversion	25	30.5	30.5
Traditional river diversion	46	56.1	86.6
Motor pump irrigation	6	7.3	93.9
Others	5	6.1	100
Total	82	100	
Reason for being engaged in irrigation			
Climate variability/change adaptation	45	54.9	54.9
Improving income/livelihoods	36	43.9	98.8
Others	1	1.2	100
Total	82	100	

Source: survey data (2019).

4.3.1. Major crops grown by using small-scale irrigation

Irrigation is practiced in the dry cropping season from November to April. In this cropping season, only households who have access to irrigation can cultivate crops. They can cultivate twice a year. The most common crops produced by small-scale irrigation in the study area are onions, chick pea and mung bean although onion was the most dominant one. Onion is grown by 70.7% of the households who are using irrigation and it is followed by chick pea (11%). Crops grown using small-scale irrigation were few in number, but there are different reasons why they are grown by irrigation users. The major factors for production decision were good production (4.9 %), better price (63.4%) and easier to cultivate (12.2%). There are other reasons such as disease resistant, seed availability; water scarcity and others accounted 19.5% of the respondents (Table 23). This finding is in line with Getaneh (2011).

Table 23: Major irrigated crops and reason for those selected crops

Crop type	irrigating households (n=82)		
	Frequency	Percent	Cumulative
Onion	58	70.7	70.4
Chick pea	9	11	81.7
Mung bean	1	1.2	82.9
Two or more	14	17.1	100
Total	82	100	
Reasons for selecting those crops			
Better price	52	63.4	63.4
Good production	4	4.9	68.3
Easy to cultivate	10	12.2	80.5
Two or more reason	16	19.5	100
Total	82	100	

Source: survey data (2019).

4.4. Contribution of small-scale irrigation in climate change adaptation

On average irrigation users produce crops at least two times in a year (89% twice, 11% three times) whereas the non-user of households have only one chance to produce crops in rain fed (Table 24). The result shows that there is a significance difference between the two groups in cropping intensity at 5% level of significance (X^2 = 1.44, def. = 2, p < 0.05). It implies that irrigation users are better off in crop production that enhances household income and enable to buffer against climate variability as compared with non-users. This finding was in line with Dereje et al.(2011) and Woldegebrial et al.(2015).

Table 24: cropping intensity of household

Characteristics		Irrigation users (N=82)		Non- irrigation users (N=62)		Total (N=144)		χ2 value	P Value
		Frequ	%	Frequ	%	Frequ	%		
Production in a year	Once	0	0	62	100	62	43.1		
	Twice	73	89	0	0	73	50.7		
	Three times	9	11	0	0	9	6.2	1.44***	0.000
	Total	82	100	62	100	144	100		

Source: survey data (2019), ******* significant at 1% significant level ($P < 0.01$).

4.4.1. 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 and non-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 mean annual income of a household from cropping income in the sample household was ETB 23,147. 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 crop were teff, sorghum, bean, chick pea, maize, mung bean and onion. As Table (25) shows major cropping income of irrigation users was generated from teff (28.3%), onion (19.4%), sorghum (13.7%), chick pea (14.5%), bean (11.4%), mung bean (7.7) and maize (5.3%). On the other hand, cropping income of non- users was teff (54%), sorghum (17.5%), chick pea (9%), bean (7.5%), mung bean (7%) and maize (5.3%).

The t-test statistics revealed that there is a significance difference between irrigation users and non-users in maize, mung bean, chick pea, onion and bean at 1%. maize, mung bean and chick pea produced again in dry season and supplement irrigation by users when early offset of rainfall is emerged. The onion was the major cash crops produced in irrigation and the difference for bean production might related with farm specific character and management. It is also implied that irrigation enhances the cropping income by increasing productivity and cropping intensity as compared to non-users. This finding was in lined with Fitsum et al.(2009); Dereje et al.(2011); Woldegebrial et al.(2015); Leta (2018).

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 irrigation. Thus, irrigation had enhanced crop production through crop loss reduction, increased production and diversified crop varieties.

Table 25: cropping income of household

Major crop types	Ave. annual price (ETB/quintal)	Irrigation users (82)		Non-irrigation users (62)		t-value	p-value
		value in ETB	Percent	value in ETB	Percent		
Teff	1646	10501	28.3	10237	54	0.312	0.756
Sorghum	800	5084	13.7	4767	17.5	1.882	0.062
Maize	883	1982	5.3	961	5	3.201***	0.002
Mung bean	1700	2871	7.7	1278	7	3.692***	0.000
Chick pea	1967	5289	14.2	1776	9	5.204***	0.000
Bean	1504	4221	11.4	1492	7.5	7.843***	0.000
Onion	1500	7201	19.4	0	0	15.4***	0.000
Tot Gross		37149		20,511	100		
Total agricultural input cost		6411	100	4956		2.436**	0.014
Net cropping income		30738		15555		2.263**	0.02

Source: survey data (2019), ****, ***** significant at α = 0.01 and α = 0.05 respectively.

Irrigated crop income: Ethiopian irrigated farm size per household ranges between 0.25 – 0.5 ha (MoA, 2011). The average irrigated land per irrigation user is 0.389 ha with the minimum 0.25 ha, a maximum of 1.00 ha and standard deviation of 0.204. The major irrigated crops in the area are chick pea, onion, maize and mung bean. The mean annual cropping gross income from the sample irrigating households was ETB 8720 with minimum 750, maximum 32,000 and standard deviation of 5313. 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 9512 ETB and standard deviation of 1562. Thus, irrigated households gain net income with the minimum zero, maximum 25,480, mean of 6282 ETB and standard deviation of 4627. The result shows that irrigation users gain income 31% of the net rain fed income (Table 26). This finding is consistent with Fitsum et al.(2009); Dereje et al. (2011); Woldegebrial et al.(2015); Leta (2018) as irrigation was a means for household income enhancement.

Table 26: irrigated crop income of user households

Characteristics	Mean	Standard deviation	Minimum	Maximum
Irrigated crop gross income	8720	5313	750	32000
Irrigated input cost	2472	1562	450	9512
Irrigated crop net income	6282	4627	0	25480

Source: survey (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. Irrigation users had maintained the shortage of forage for animal during dry season that enable to increase the quality and stock of livestock. The average livestock income for sample households was 3900 ETB. Non-irrigation user households possess a larger average livestock income (4712.58) than irrigation user households (3455.49) although there was no significance difference (Table 27). This indicates that non-irrigation users were gained more income from livestock than users to fill the food gap through selling the existing stock of livestock.

Table 27: livestock income of household

Characteristics	Irrigation user (82)		Irrigation non-user (62)		Total (144)		T test for mean difference	P Value
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation		
Livestock income	3455.49	4344.508	4712.58	6259.007	3900	5485.76	-1.354	0.157NS

Source: survey (2019). NS = not significant

Non/off-farm income: Non/off-farm incomes are important parts of total income in rural households. The average non/off-farm income for sample households was 3554.70 ETB. The mean non/off-farm income of irrigation user households was 5972.80 ETB while for non-irrigation user households were 1536.61 ETB (Table 28). Even though there is no significance difference in participating non/off-farm activities between users and non-users, the result shows that there is a significance mean difference of income from non/off-farm activities between users and non-user groups at 5% significance level. Irrigation user households had enabled to diversified livelihood strategy through engaged in different off/off-farm income generating activities than non-user households. This implies that irrigation users were used non/off-farm income generation activities as livelihood diversification.

Table 28: non/off- farm income of household

Characteristics	Irrigation user (82)		Irrigation non user (62)		Total(144)		T value	P value
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation		
Non/off-farm income	5972.80	9775.41	1536.61	1841.80	3554.70	5808.61	4.02***	0.001

Source: survey (2019), ******* significant at α = 0.01 (P < 0.01).

Total household income: The total mean annual household income in the study area was ETB 30,273 (Table 29). From the total mean annual income of a household, cropping contributes the highest income share (74.1%) followed by livestock (13.5%) and off-farm (12.4%), respectively. Irrigation user households earn higher cropping and non/off-farm income than non-irrigating households, however; there is no significance difference between the two groups in livestock income. Irrigation users earn 28% of sampled household rain fed annual income and 20.8% of sampled household total income from irrigation. The total income significant difference arises from the cropping income and non/off-farm income which is enhanced by irrigation access that contribute to household income. This finding is similar with Fitsum et al. (2009); Leta (2018); Getaneh (2011); Woldegebrial et al.(2015). FGDs in four *kebeles* were reported that irrigation practice increases the user households' purchasing power of agricultural inputs and enable to increase income from rain fed, livestock and other non-farm activities.

Table 29: Total annual household income

Characteristics	Irrigation user (82)	Irrigation non user (62)	Total (144)	T value	P value
Crop income	30,738	15,555	23,147	-2.263**	0.02
Livestock income	3,455.49	4712.58	4084	-1.354	0.157NS
Non/off-farm income	5972.80	1536.61	3755	4.016***	0.001
Total income	40,166.3	20,379.2	30,273	7.017***	0.000

Source: survey (2019), ****, ***** significant at α = 0.01 and α = 0.05 respectively. NS = Not Significant.

4.4.2. Safety net role of small-scale irrigation

The study area is one of the PSNP target areas in Amhara regional state which most of the people experienced a food gap every year due to climate variability. Thus, analysis hanger gap experience between irrigation user and non-users was relevant to show the implication of SSI as climate variability/change adaptation. 60.4% of total sample household was experienced in food gap in the last year with the mean 1.86, minimum zero, maximum eight months and standard deviation of 1.35 (Table 30). 37.8% of irrigation users were experienced in a food gap with the mean 0.71, minimum zero, maximum three months and standard deviation of 1.06 while 90.3% of non-irrigation users were experienced in a food gap with the mean three, minimum zero, maximum eight months and standard deviation of 1.63. The test statistics chi-square and t- test imply that there is a significance difference between irrigation user and non-users in food gap at 5% level of significance. The survey result shows that irrigation users were less experienced in food gap as compared to non-users. It indicates that irrigation has a great role in coping and adaptation strategy to irrigation users.

This finding is in line with Hussain and Hanjra (2004) in that irrigation is relevant to increase productivity and diversify the livelihood scenarios, Woldegebrial et al. (2015) where irrigation enables to less poor share. According to FGDs was conducted in four kebele farmers were reported that irrigation users not only cultivate in dry season but also use irrigation water as supplement in cropping season when early offset of rainfall is occurred. Thus, irrigation users are less vulnerable in food gap and become food sufficient either through own production or purchasing from market even local investment like petty trading and grinding mill have started.

Table 30: safety net role of small-scale irrigation

Characteristics		Irrigation users (N=82)		Non-irrigation users (N=62)		Total (N=144)		statistical test value ($\chi2/T$)	P Value
		Frequ	%	Frequ	%	Frequ	%		
Food gap experience	1= yes	31	37.8	56	90.3	87	60.4	40.72***	0.000
	0 = otherwise	51	62.2	6	9.7	57	39.6		
	Total	82	100	62	100	144	100		
Food shortage (month)	Min/Max	0/3		0/8		0/8		-10.31***	0.000
	Mean(SD)	0.71(1.06)		3(1.63)		1.86(1.35)			

Source: survey (2019)**, ***** significant at α = 0.01 (P < 0.01).

4.5. Factors influencing Small-Scale Irrigation adoption

All hypothesized explanatory variables have extremely lower value of variance infelation factor and contingency coefficient test that have shown (Appendix 7 and 8). Finally, a set of 12 explanatory variables (8 continuous and 4 discrete) were included in the logistic analysis. Out of 12 hypothesized explanatory variables nine (age, education, cultivated land size, extension contact, credit access, livestock holding size, market distance, dependency ratio and farm distance) were a significant impact on participating to irrigation while three explanatory variables (Sex, family size and off-farm activity) were not significantly affected the dependent variables (Table 31).

Age of household head (AGEHH): This variable was significant at 5% and has a negative relationship (B = -0.023) with household decision to adopt small-scale irrigation practice. It indicates that as the age of household increases by one year, the probability of participating in small-scale irrigation decreased by a factor of 0.977, as other factors being constant. It indicates older households have more less in adopting technology and hence decrease in the probability of adopting irrigation. This finding was agreed with Beyan et al. (2014)*;* Sithole et al. (2014) where age of household head was negatively correlated to adopt irrigation.

Education level of household head (EDUHH): This variable was found to affect households' decision to adopt small-scale irrigation significantly and positively at 5% (B = 0.277). It indicates that on average an increase in the years of schooling by one year leads to increase the likelihood of household head participation by 131.8%. This result was consistent with Woldegebrial et al.(2015); Leta (2018); Dillon (2011); Chazovachii (2012) and Fanadzo (2012) where Households with better education level is believed to have a chance to apply scientific knowledge and better manage their farm activities in good manner that enable to adopt irrigation.

Cultivated land size (LANDSZ): This variable was found significantly affected participation of irrigation at 5% and it was positively correlated (B = 1.815). The result shows that on average a unit increase in cultivated land size leads to increase participation of households to irrigation by a factor of 6.141 (other factors being constant). This finding was agreed with Dillon (2011); Chazovachii (2012); Fanadzo (2012); Beyan et al.(2014)*;* Sithole et al.(2014); Petros and Yishak (2017*)* which shows size of cultivated land has a positive influence on household SSI adoption.

Extension contact (EXTENCON): this variable was significantly influence on irrigation adoption at 5% and positive relation with irrigation practice (B = 3.571). Frequent extension contact enables to aware farmers about irrigation. The result shows that a unit increase extension service increases the likelihood of household head participation by factor of 35.452 the finding was in lined with Woldegebrial et al.(2015) and Leta (2018).

Access to credit (CREDIT): significant at 5% and positively influence on irrigation adoption (B = 2.256). It indicates that access to credit leads to increase the farmers decision to adopt small-scale irrigation by of a factor of 9.545 This finding was consistent with Sithole et al. (2014) and Mango et al. (2018).

Market distance (MKTDISTA): significant at 5% and negatively influences the participation of households to irrigation (B = -0.353). The result indicates that as the time taken to market center increases the likelihood of household heads participation is goes down by 70.3%. The finding was consistent with Kenfe (2012) and Mango et al.(2018) which infers that nearest to market reduces transaction costs that enhances adoption of small scale irrigation to households.

Dependency ratio (DR): significant at 5% and negatively correlated with irrigation adoption (B = -1.14) since dependency ratio measures the economically in active family members per active family members. The result shows that a unit increase dependency ratio leads to decrease the decision of participation households by 32%. This finding is in line with Jema (2013).

Total Livestock Holdings (TLHH): significant at 5% and a positive influential factor of irrigation adoption (B = 0.245). The result indicates that a unit increase in Total Livestock Unit (TLU), the likelihood of household head goes up by 24.5%. This finding was in lined with Leta (2018); Dillon(2011); Chazovachii (2012) and Fanadzo (2012).

Distance of farm from water source (FARMDIS.): This variable was significant at 1% level of significance and have a negative relationship with household participation decision in small-scale irrigation practice. It indicates that as distance of farm land from irrigation water source increases by one walking hour on foot, the probability of participating in small-scale irrigated farming decreases by 1.1%, holding other factors constant. an increase in distance of farm land from irrigation water source highly hinders irrigation activity. This phenomena is due to difficulty of bringing water to one's farm land since it involves higher cost as the land becomes more farther from the water source. This finding is in-line with the findings of studies by Kinfe *et al*. (2012), Beyan *et al*. (2014) and Sithole *et al.* (2014).

Table 31: Binary logistic regression model of factors affecting SSI adoption

Independent Variable	Coefficient (B)	S.E	Wald	p- value	Odds ratios
HHSEX	-0.623	1.553	0.161	0.688 NS	0.536
AGEHH	-0.023	0.033	0.485	0.048**	0.977
EDUHH	0.277	0.105	6.94	0.008***	1.318
LANDSZ	1.815	1.04	3.046	0.022**	6.141
EXTENCON	3.571	0.747	22.87	0.000***	35.542
CREDIT	2.256	0.692	10.63	0.001***	9.545
MKTDISTA.	-0.353	0.173	4.142	0.042**	0.703
OFFFARMHH	-1.02	0.628	2.648	0.104 NS	0.36
DR	-1.14	0.417	7.494	0.006***	0.32
Fam SZ	0.529	0.457	1.34	0.247 NS	1.698
TLU	0.245	0.090	7.440	0.006***	1.277
FARMDIS	-4.548	0.768	35.061	0.000***	0.011

Number of observation = 144 -2Log likelihood = 79.446 chi2(11) = 64.87

Prob > chi2 = 0.000 Pseudo R2 = 0.748

Source: survey data (2009), *****, **** significant at α = 0.01 and α = 0.05 respectively, NS = Not Significant.

5. Summary and Conclusion

Most of the local peoples perceive long-term change and variability in local climate. This also confirms the meteorological data findings. The result of meteorological data shows, there was inter-annual variability and strongly irregular distribution of rainfall and a decreased trend. In addition to these both average maximum and minimum temperature shows increasing trend. However, the mann-kenndal trend test indicated that there was no significance defference in rainfall trend but significance in case of temperature trend. Due to increased temperature and rainfall variability with frequent drought create favorable condition for pests and disease which lead to loss of agricultural production.

Irrigation is becoming a practice for many households due to climate variability/change adaptation, improving livelihood and others as means of livelihood diversification. On average irrigation users produce crops at least two times in a year whereas the non-user of households has only one chance to produce crops in rain fed. Thus, irrigation has a great role in climate change adaptation through increased household income, livelihood diversification and safety net role. Finally, the results of binary logit analysis indicates that education level, cultivated land size, frequency of extension contact, access to credit, market distance, dependency ratio, livestock holding size and age have a significant impact on households' participation to irrigation. Market distance and dependency ratio were negatively influence the irrigation adoption and others education level, cultivated land size, frequency of extension contact, access to credit, livestock holding size and age were positively influence households' decision to participate in irrigation. Therefore, policy makers and other relevant stakeholders should give a great attention to strength small-scale irrigation as climate change adaption strategy at rural households.

6. Recommendation

Based on the findings of the study, the following points are recommended for further consideration and improvement.

1. Inspite of its statistical non-significance of rainfall trend, the study area is prone to high variability, decreased rainfall trend. So the concerned body should pay attention for accessing local climate information based on the available data from the district station and developed climate forecasts and early warning for climatic hazards as early as possible. In order to increase households' adaptive capacity, the GO and NGO should design small-scale irrigation development as a means of livelihood diversification strategy to climate change adaptation.
2. Compared to the non-users, irrigation user households are getting a better income to increase the adaptation capacity of climate change; hence in order to increase the income of the farmers, all responsible development partners including government and non-governmental organizations should focus on promoting small and large scale irrigation schemes across the country.
3. In the study area, non-users of the irrigation households' have no adequate access to credit, extension advisory services and participation in many of the agricultural development activities. Hence, all responsible bodies should empower these groups of farmers through the provision of training and facilitating conditions for their full participation in any development agendas.
4. Based on the findings educated farmers are more accessed to irrigation so that the government and other stake holders should invest on effective education system for rural farm household to adopt small-scale irrigation as climate smart technology.

5. Dependency ratio is negatively correlated to irrigation technology adoption. Therefore, the GO and NGO should give more attention to family planning strategy for rural households.
6. Based on the finding, as farmer's plot of land far from the water source (river) it hinders farmers decision to adopt in irrigation. Therefore, irrigation infrastructure should intervene to strength farmers decision to adopt irrigation.

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APPENDICES

Appendix 1: Household Survey Questionnaire

My Name is Abebe Tilahun. I am a student at Hawassa University doing my MSc. Degree in Climate Smart Agriculture Landscape Assessment. I am conducting my master's thesis on role of small scale irrigation in climate change adaptation in East Belesa District, Amhara region, Ethiopia in this area. Dear respondents, the result of this study will help different stakeholders and policy makers to make appropriate measures on irrigation development in the future. Your responses are confidential. Therefore, you are kindly requested to provide genuine responses.

Thank you for your time and cooperation!

Instruction

- ✓ Where choices are available in the below question try to encircle.
- ✓ Where choices are unavailable try to give the answer on the space provided.

No	Indicator	Description
1	Respondents status	1 = Irrigation user, 0 = Non – user
2	Name of HH head	
3	Sex of HH head	1 = male , 0 = female
4	Age of HH head in year	---------------------- years old
5	Educational level of HH head in schooling year	------------------------ year
6	Marital status	1. Married. 2. Single. 3. Widowed. 4. Divorced
7	family labor categorization for irrigated activities	1. Small, 2.Enough, 3. Large. 4. Exclusive
8	Major income source contributing activity	1. irrigated agriculture. 2. Rain fed agriculture. 3. Others specify…….
9	Household size 0-15 years 15-65 Above 65	Male Female Total
	Perception of climate variability and change based on the last 30 years	
10	What is your perception on climate change of your kebele?	1. Changed. 2. Not changed. 3. I do not know
11	What do you think the cause of climate change?	1. Human causes. 2. Natural causes. 3. Both. 4. Wrath of god, curse. 5. Others

12	Have you observed any change on rainfall characteristics like onset, cessation and length of growing period over the past 30 years?	1 = Yes. 0 = No
13	If yes, how did you know?	1. Change of sowing date. 2. Rain fall time is not known. 3. Increased rainfall trend. 4. decline production 5. Decrease rain fall and increase temperature .6. Others,
14	Have you noticed any changes with the recent past 30 years in rainfall trend?	1 = Yes. 0 = No
15	If yes, please specify the trend of the change of rainfall you have noticed?	1. Increasing. 2. Decreasing. 3 = similar 4. Do not know
16	Have you noticed any changes with the recent past 30 years in temperature?	1= Yes. 0 = No
17	If yes, please specify the trend of the change in temperature you have noticed?	1. Increasing. 2. Decreasing. 3 = similar. 4. Do not know
18	Have you ever faced any climate related hazard related to rainfall variability in your locality which altered your production?	1 = Yes. 0 = No.
19	If yes, what type of climate related hazard?	1. Flood. 2. Drought. 3. Crop diseases. 4. Others,
20	When did you observe?	1. Keremet season. 2. Crop harvesting season 3. Bega season
21	If the answer to Q18 is yes, did it affect your crop?	1 = Yes. 0 = No.
22	If yes to what extent?	1. Full crop damage. 2. Partial crop damage. 3. Increased Crop disease and weeds. 4. Others, specify
23	At which growing stage is more hazards happened?	1. Initial stage. 2. Vegetative stage. 3. Flowering stage. 4. harvesting stage
24	Has your agricultural activity changed due to rainfall variability or climate related hazard?	1 = Yes. 2 = No.
25	If yes verify the indication	1. Sowing date changed. 2. Length of growing periods changed. 3. Harvested time changed. 4. Others
26	Has crop diversity increased between climate variability?	1 = Yes. 0 = No
27	What were the agricultural indigenous skills you have taken during climate related hazard had been occurred? Any	1.--------------------------- 2.-------------------------- 3.---------------------------

	traditional prediction system if you have?	4.---------------------------
28	What are the coping mechanism do you have taken?	1. irrigation agriculture 2. artificial fertilizer utilization 3. Soil and water conservation. 4. Drought tolerant verities. 5. Others
30	Do you encounter complete crop failure?	1 = Yes. 0 = No
31	How is the occurrence of drought?	1. Increased. 2. Decreased. 3. Do not know
32	Have you experience a food gap in the last years?	1 = Yes. 0 = No
33	If your answer is yes, for how many months have experienced for hunger gap?	--------- months
34	What are the indicators of climate variability in your locality?	1. Temperature rise, 2. Decrease in crop and livestock production, 3. Extinction of indigenous trees and crops, 4. Decreased in rain fall amount, 5. Increase in human and livestock diseases. 6. soil fertility 7. increase in crop pest
35	Currently, do you own land?	1 = Yes. 0 = No
36	If yes, your total landholding size Timade of land?	Crop land-------timade, area under irrigation------timade. Area under rain fed------timade
37	How do you evaluate the fertility of your land compared to other farmers?	1. Low 2. Medium. 3. High
38	What are your criteria to evaluate the quality of your land? Rank based on your criteria.	1.Productivity of land 2. Degradation status, 3. By soil erosion, 4. Other----------
39	Do you own livestock?	1 = Yes , 0 = no

40. If yes for Q39 , tell me the type and number that you have owned?

	Type of livestock									
	ox	cow	Calf	Heifer	Bull	Goat	Sheep	Poultry	Donkey	Mule
Livestock no.										

Irrigation

No	Indicator	Description
43	Do you have access to irrigation practice in 2009/2010 production year?	1= Yes.0 = No
44	If yes, what the total area is of irrigated you cultivated?	………….. Timade

45	What is your source of irrigation water?	1. Modern river diversion irrigation scheme 2. Traditional river diversion irrigation scheme 3. Underground water. 4. Developed Spring. 5. If other, specify……………….
46	Irrigation utilization	1.Irrigated land covered by vegetables…Timade, 2.Irrigated land covered by other crops …Timade
	Irrigation water utilization	1. Surface flooding, 2. Border 3. Furrow. 3. Spate, 4. Other
47	When did you start using irrigation?	……production year
	Root causes to irrigation engagement	1. Climate variability/change, 2. Improved livelihood, 3. Only one production season and the production is not adequate 4. Others
48	Have you ever faced a problem of crop failure when using irrigation?	1 = Yes. 0 = No
49	If yes, what was the reason?	1. Water shortage. 2. Weed problem. 3. Crop diseases.4. Water logging. 5. Poor administration of water distribution. 6. Poor adaptation of verities used. 7. Others specify…….
50	How do you perceive soil fertility practice your farm land?	1. Fertile. 2. Infertile. 3. Moderate fertile. 4. Less fertile.
51	If you do not use irrigation practice, what are the reasons?	1. No awareness about it. 2. Sufficient rain and moisture. 3. Irrigation infrastructure. 4. Cost of irrigation material, overall cost of technology. 6. other, specify
52	Do you think that irrigation has a positive effect on household income?	1 = Yes. 0 = No
53	If yes, what is the positive effect of irrigation that you have been?	1. Diversification crops grown. 2. increased agricultural production. 3. Increased household income. 4. Proper utilization of family labor.
54	How many times do you produce within a year?	1. Once in a year. 2. Twice a year. 3. Three times in a year
55	The household income source before the implementation of irrigation,	1. Sale of livestock. 2. Rent of own land. 3. Sale of crops. 4. Others specify……
56	Do you face labor shortage in irrigated crop production?	1 = Yes. 0 = No
57	If yes, how do you solve?	1. Family labor. 2. Hiring, 3. Labor exchange arrangement. 4. Other specify

58	Is your family labor force fully utilized due to participation in irrigation activity?	1 = Yes. 0 = No
56	If yes, what do you think the nature of participation?	1. Full time 2. Partial time in terms of age category (0-15, 15-64 and above 64
	Provision of extension, credit and input services for agricultural production	
57	Did you get advisory service from extension service during the production year?	1. = Yes. 0 = No
58	If yes, how frequencies do the extension agents' visit you?	1. Once a week. 2. Every 15 days. 3. Monthly. 4. weekly
59	What are the supports given to you?	1. Advice. 2. Training. 3. Demonstration. 4. Conflict resolution. 5. Controlling water distribution. 6. Others specify……
60	Have you ever used credit for your agricultural activities in production year?	1 = Yes. 0 = No

61. If yes, would you please give me as the following details?

Source of credit	Purpose of credit	Total amount in birr	Interest rate	Amount paid in birr	Amount unpaid in birr
Microfinance institution					
Idir/Iqub					
Private					
Other					

62. If you did not use credits, what is your reason? 1 = lack of asset for collateral,
    1 = no one to give credit, 3 = high interest rate, 4 = no need credit, 5 = others
63. Do you save money? 1 = Yes. 0 = No
64. If yes, in what form do you save? 1. Iqub. 2. in form of livestock.
    3. Save in bank. 4. Others--
65. Did you use chemical fertilizer during the production year? 1 = Yes. 0 = No
66. If No, state your reason in order of importance: 1.Not necessary for cultivated crops. 2. Too expensive. 3. Not available. 4. Shortage of working capital. 5. Lack of credit. 5. Specify if others---
67. Did you use improved seed during the production year? 1 = Yes. 0 = No
68. If No, state your reason in order of importance: 1. not necessary for cultivated crops. 2. Too expensive. 3. Not available. 4. Shortage of working capital.
    5. Lack of credit. 6. Other specify---

Agricultural input cost

69. **Agricultural inputs purchased during 20017/2018 production year**

No	Type of inputs	Unit	Quantity	Unit price	Total price in birr	Source
1	Improved seed					
	Teff					
	Chick pea					
2	Fertilizer					
	In organic fertilizer					
3	Pesticides					
	Herbicides					
	Insecticides					
	Total					

70. Amount of inputs used for irrigation production

Types of crops	Seasons	Seed varieties in (Quintal)		Fertilizer		Area timade
		Local	Improved	Organic	Inorganic	
Cereal						
Chick pea	First round					
	Second round					
Maize	First round					
	Second round					
Mung bean	First round					
	Second round					
Vegetables						
Onion	First round					
	Second round					
Tomato	First round					
	Second round					
Cabbage	First round					
	Second round					

Income generating activities related to irrigation agriculture

71. Income of livestock in the table below:

	Types of livestock									
	Ox	Cow	Heifer	Bull	Calf	Sheep	Goat	Donkey	Mule	Hen
Livestock number										
Livestock sold										
Unit price										
Total sale price										
Purpose										

72. Income from sale of livestock products and by products during in production year (2009/2010 E.C)

Type of products and by products	Quantity	Unit	Amount collected	Amount consumed in a year	Sold in a year(birr)
Milk					
Butter					
Egg					
Honey					
Total income					

Crop income

73. Annual household's income for irrigated income non-vegetable crops production during the 2009/2010 E.C production year

Crop type	Cultivated land in timade	Total annual harvest(Qt)	Consumed (Qt)	Sold(Qt)	Unit price(birr)	Total
Cereal						
Chick pea						
Mung bean						
Others						
Fruit						
Mango						
Avocado						
Orange						
Gesho						
Total income						

74. Annual household's income for irrigated income vegetable crops production during the 2009/200 E.C production year

Crop type	Cultivated land in timade	Total annual harvest(Qt)	Consumed (Qt)	Sold(Qt)	Unit price (birr)	Total
Vegetable						
Onion						
tomato						
Pepper						
Other						
Tot. income						

75. Why do you select the above type of vegetables/crops for your irrigation farming?

1 = better price, 2 = good production, 3 = high diseases tolerance, 4 = easiest to cultivate,

5 = seed available, 6 = others, specify…………………….

76. Were you engage in rain fed agriculture activity in production year 2009/2010?

2 = Yes, 0 = No

77. If yes, provide the pertinent information to crop production for year 2009/2010

Crop type	Area (ha)	Input purchased							Quintal harvest	Unit price	Net income in birr
		Seed (Qt)	Cost birr	Fertili zer (Qt)	Cost birr	Pestic ides (litter	Herbi cides (litter	Cos birr			
Teff											
Wheat											
Maize											
Barely											
Sorghum											
Bean											
Pea											
Sesame											
Chick pea											
Lentil											
Garlic											
Mung bean											
Vegetable											
Fruit											
Woodlot											
Other											
Total											

Other income source

78. Do you have accessed to other income source? 1 = Yes, 2 = No
79. If yes, what is the source of your income?

Source of income	Quantity	Amount in birr	
		Month	Year
Farm implements sale			
House rent			
Grass and hay sale			
Fuel and charcoal sale			
Fuel wood sale support from relatives			
Food for work			
Food aid			
Cash for work			
Petty trade			
Others			

Off/non-farm income opportunity

80. Does your member of household's participate in off/non-farm activities 2009/2010?
    1 = Yes, 2 = No

81. If yes, provide the pertinent information:

No	Types of jobs	Monthly income	Annual income in birr
1	Farm implements sale		
2	House rent		
3	Grass and hay sale		
4	Fuel and charcoal sale		
5	Food for work		
6	Food aid		
7	Cash for work		
8	Petty trade		
9	Woodlot		
10	Working other farm		
11	Self-employment in manufacturing artesian		
12	Sale of stone/sand		
13	Salary		
14	Mill		
	Other		

Appendix 2: Check list for key informants

Name ------------------------------------age ------------------------sex------------------------- educational status ---

1. How do you perceive climate change?
2. What are the climate variability indicators?
3. Do you face climate variability/change in your area?
4. What are the main impacts of climate change?
5. How is the climate change effect severe to your livelihood?
6. What are the major challenges of climate change you come across?
7. What are the coping mechanisms you practice?
8. How do you see irrigation activities as coping mechanism?
9. What are the factors that constraint in irrigation activities?
10. Is there any difference between household income status irrigation user and rain fed?
11. If yes, what are the main differences between these groups?
12. How do you see climate change adaptation difference between adopters and non-adopters of small scale irrigation practice?
13. Do adopters practice SSI due to climate change?
14. Why non-adopters do not adopt SSI?

Appendix 3: Check list for Focus Group Discussions

1. How do you perceive climate change in your kebele?
2. What are the indicators of climate variability in your kebele?
3. How climate changes impose impact on agricultural production?

4. What do you think the possible ways to minimize the impact of climate change?
5. What adaptation measures do people in your area took when confronts with temperature and rain fall shocks?
6. What are the best coping strategies employed in your kebele?
7. Do you participate in SSI?
8. In what type of SSI dominant in your kebele?
9. How do you start irrigated agriculture?
10. Where do you get seed/seedling for irrigated?
11. What motivates to adopt SSI?
12. What benefit do you obtain from irrigation?
13. How do you see irrigated agriculture with other livelihood activities?
14. How do you see the market information and selling price for your irrigated product?
15. Does it help you enhance climate change adaptation during food shortage?
16. For what reason and how do you manage irrigation agriculture?
17. why farmers in the kebele do not adopt SSI
18. Could SSI be one mechanism to climate adaptation?

Appendix 4: Temperature and rain fall data of East Belessa district (1983-2016)

Minimum temperature in °C

	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
1983	9.8	10.4	12.4	13.5	13.3	13	13.5	13.8	12.9	11.3	10.4	9.3
1984	9.6	11.4	13.2	15.1	14.3	13.8	13.3	12.4	12	9.9	10.8	10.6
1985	11	11.9	14.1	13	12.9	13.1	12.7	12.5	11.7	11	10.7	10.4
1986	9.7	11.6	12.7	13.4	14.6	14.2	13.5	12.9	12.1	11	10.1	9.7
1987	10	11.6	12.9	12.9	12.6	12.4	11.7	10.9	10.1	9.6	8.8	9
1988	9.5	10.2	12.4	13.5	13.3	12.5	11.9	11.6	11.4	9.6	8.3	8.4
1989	7.8	9.1	11.3	12	11.9	12.9	12.3	12.1	11.3	9.9	9.6	9.2
1990	9.2	9.5	11.6	12.2	12.9	11.4	10.4	10.1	9.6	8.2	9.3	9.2
1991	10.5	11	12.1	12.2	14.4	14	13.3	13.1	13.2	12.3	10.6	11
1992	11.2	12.2	14.4	13.6	14.1	13.2	11.8	12.7	12.2	11.6	10.1	10.4
1993	9.8	10.4	11.7	12.7	13.4	13.4	12.9	12.5	12.1	13.2	13.7	11
1994	11.4	12.4	12.3	14.4	13.7	13.3	13.5	13.1	12.1	11	11.6	10.6
1994	10.8	12	12.7	14.1	14.8	14.6	14.5	14.6	13.6	12.2	12.3	11.9
1995	11.1	12.1	12.9	13.3	13.1	13.3	13.7	13.5	13.4	12.1	12.2	11.1
1996	10.8	11.4	13.7	13.6	14.1	14.2	14	14	13.2	12.7	12.2	11.1
1997	11.2	12	13.8	14.9	15.3	14.7	13.9	13.5	12.8	11.7	9.8	8.9

1998	10.4	12.4	11.8	14.2	14.1	13.5	12.8	13.1	12.6	12	10.5	10.5
1999	10.3	12	13.2	12.8	13.6	12.4	11.8	12.1	11.6	11	10.3	9.9
2000	9.8	11.9	13	13.6	13.4	13	12.1	12.3	11.5	11.9	11.2	11.3
2001	10	11.8	13.9	15	14.8	14.2	13.1	13	12	11.7	11.8	11
2002	10.6	13.4	14.7	15.8	16.6	13.6	12.7	12.9	11.7	10.4	10.5	9.8
2003	10.3	10.8	13.2	14	14.4	13.9	12.5	12.4	12	10.6	11.3	11.4
2004	9.5	12.3	12.6	14.4	13.2	13.8	12.2	12.3	11.6	9.6	9.1	8.5
2005	9.9	11.6	12.5	13	13.6	13.9	13.3	13.6	12.9	12.6	11.1	10.9
2006	11.3	12.3	14.3	16	17.2	16	15.5	14	13.4	11.5	11.2	10.4
2007	11.8	12.2	14	13.6	14.3	14.8	9.5	12.7	14.2	13.4	12	11.4
2008	11.8	14.2	14.7	15.6	12.1	14.2	10	8.5	9.6	11.2	11.4	12.9
2009	11.3	13.9	13.4	12.3	11.3	11.7	13.4	14.7	14.5	13	12.6	12.2
2010	12.9	12.5	14.8	16.4	16.7	16.6	14.3	14	13.7	11.8	12.6	10.5
2011	11.8	13	15.7	18.1	22.7	19.2	17.7	17.9	17.9	17	17.8	17
2012	18.5	19.8	17.3	20.8	22.1	21.3	19.2	21.1	15.7	20.4	20.1	19.2
2013	11.9	12.5	14.6	14.8	15.3	15.3	14.5	14	13.4	12.9	12.5	10.7
2014	11.3	13.5	15	15.9	15.85	16.7	14.3	13.5	12.9	13.5	13.4	13.2
2015	12.5	14.45	16.4	17	16.4	16.1	14.8	14.8	14.1	13.3	11.6	11.2
2016	9.6	11.4	13.2	15.1	14.3	13.8	13.3	12.4	12	9.9	10.8	10.6

Maximum temperature in °C (1983-2016)

	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
1983	28.8	29.8	30.8	31.6	29.6	27.4	24.7	23.5	24.9	26	26.3	28
1984	28.7	30.3	30.9	32.9	30.2	25.7	23.7	25	24.8	28.4	29	28.3
1985	29.6	29	30.9	28.6	27.2	25.9	24	24.3	25.5	28	27	28
1986	29	29.3	29.7	29.3	30.8	26	24.1	24	24.5	25.7	27.6	28.2
1987	29	29.7	29.6	30.2	26.8	24.8	24.7	24.5	25.8	27.3	28.1	28.2
1988	29.5	28.7	32	32.1	30	26.5	22.2	22.4	24.3	24.6	26.9	28.2
1989	28.7	28.5	28.5	28.4	28.2	25.8	23.8	24.5	24.8	26.4	28.6	26.2
1990	28.3	29.1	29.3	30.1	31.2	25.9	23.4	22.9	23.4	26.9	27.8	27.2
1991	28.2	28.9	30	30.4	29.6	26.1	23.9	23.2	26.2	27.8	28.1	27.9
1992	27.8	30.1	30.7	29.5	29.2	27	24.9	23.7	25.7	26.3	26	27.6
1993	27.6	28.1	29.4	27.6	27.4	25.4	23.3	24.7	25.4	27.3	28.2	27.9
1994	28.4	28.9	30.6	30.1	28.2	25.5	21.9	23.2	25.9	29.1	28.5	27.8
1994	28.3	29.2	29.4	29.9	29	27.3	23.8	24.3	26.2	28.7	28.3	28.2
1995	28.3	29.9	30.5	30	26.7	25	23.6	23.2	25.2	28.3	27.7	27.9
1996	28.3	29.3	30.4	29.2	28.5	25.4	23.8	24.3	27.7	28.1	29	28.4
1997	28.8	29.2	30.5	31.2	29.4	28.3	23.6	23.8	25.7	27.7	28.5	28.3
1998	28.8	31.1	31	31.9	30	27.7	23.3	23.4	24.9	25.6	28.3	28.5
1999	28.7	30	30.9	28.3	30.5	27.3	24.7	26	26.4	27	28.2	28.7

2000	29	30.2	29.9	30.9	29.3	24.9	22.7	23.9	25.2	28	28.3	27.8
2001	28	30.2	30.5	31.6	31.4	27.4	24.9	24.8	25.4	29.8	29.7	29.3
2002	29.6	30.4	30.9	32	32.5	26.7	23.6	24.1	25.6	29.1	29.5	28.9
2003	29.5	30.3	31.4	30	31.6	27.1	24.1	24.3	25.9	28.2	28.6	29.2
2004	28.7	31.8	31.1	31.7	31	27.5	23	24.8	25.8	28.6	29	28.7
2005	29.9	31.3	31.6	31.1	29.3	26.3	23.9	24.4	26	28.7	29.2	28.3
2006	28.9	30.5	31.8	31.5	31.6	26.1	23.3	24.9	27.2	29.6	29.8	29.4
2007	29.5	30.2	31.7	31.3	32.7	30.9	27.6	28	28.5	29.1	29	29.2
2008	30.1	31.4	32.6	33	33.2	31.3	29.4	27.4	28.9	27.9	29.3	29.5
2009	28.8	31.6	32.4	33	32.6	32.8	28.5	27.1	29.8	30.1	28.9	28.9
2010	29.6	31.4	30.7	33.1	31.5	31.5	28.7	26.1	27.6	30.2	30.4	29.5
2011	30.7	32	32.9	33.3	32.6	31.1	29.6	28.2	29.4	31.8	31.1	32
2012	32.6	33.3	31.6	35	34.5	31	27	24.6	26.9	29.9	29.7	29.2
2013	30.5	31.8	32.5	35.1	31.2	33.9	28.5	27.1	33.2	28.8	29.7	27.6
2014	30.2	32	32.8	35.7	33.5	32.1	33.1	34.8	34.9	33.2	33.2	33.1
2015	28.3	29.7	35.2	36.2	35.7	35.7	32.4	32.4	31.9	35.1	34.7	34.2
2016	28.8	29.8	30.8	31.6	29.6	27.4	24.7	23.5	24.9	26	26.3	28

Monthly rain fall in mm

	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
1983	0.0	0.0	0.0	0.7	53.5	56.5	166.8	372.5	64.4	12.3	9.9	0.0
1984	0.0	0.0	5.4	0.0	46.5	75.4	233.9	197.4	93.7	0.0	0.0	9.5
1985	0.0	0.0	4.4	13.7	73.9	81.4	384.5	270.3	32	16.9	6.6	0.0
1986	0.0	0.0	5.3	7.9	0.0	203.5	312	329	25	7.6	0.0	0.0
1987	0.0	0.0	0.0	24.2	67.7	45.5	133.4	303.2	48.1	14.1	0.0	0.0
1988	0.0	0.0	0.0	0.9	12.7	78.6	248.4	339.2	55.1	28.7	11.9	0.0
1989	0.0	0.0	14.7	22.6	49.7	52.3	248.2	305.6	35.8	23.8	7.5	24.5
1990	3.2	0.0	0.0	0.0	4.2	80.0	344.6	224.6	73.2	23.0	0.0	0.0
1991	0.0	0.0	0.0	38.2	50.0	133.0	295.6	255.7	61.5	5.9	0.0	0.0
1992	0.0	0.0	1.4	35.3	46.0	61.0	293.1	243.3	30.4	47.7	0.0	0.0
1993	0.0	2.9	22.6	26.5	57.4	63.4	287.7	267.1	40.8	41.3	8.5	0.0
1994	0.0	0.0	0.0	4.6	74.9	52.6	334.3	386.0	42.1	0.0	10.5	4.2
1994	0.0	0.0	14.2	17.6	58.7	48.6	251.6	288.5	82.4	1.8	0.0	4.4
1995	0.0	0.0	36.2	39.7	45.3	168.8	329.5	198.8	0.0	18.9	0.0	0.0
1996	0.0	0.0	21.1	16.6	73.2	132.1	336.1	231.9	57.8	0.0	8.9	1.3
1997	7.1	0.0	22.9	1.3	102.0	73.4	351.3	343.2	35.7	14.4	0.0	0.0
1998	28.1	0.0	0.0	4.5	0.0	128.5	301.5	317.2	46.0	54.6	0.0	8.3
1999	0.0	0.0	0.0	62.5	31.2	63.9	322.8	337.3	69.3	42.8	32.5	0.0
2000	0.0	0.0	8.8	8.9	21.9	93.5	339.1	308.0	57.6	20.1	0.0	1.2
2001	0.0	0.0	18.1	7.6	1.8	133.5	248.5	263.6	91.1	0.0	0.0	8.9
2002	0.0	17.2	8.8	9.9	1.5	106.2	325.2	316.2	89.6	0.0	2.8	0.0
2003	0.0	9.2	9.8	18.9	0.0	83.6	299.3	305.3	78.1	20.1	23.9	0.0
2004	0.0	0.0	41.2	12.8	64.6	121.5	291.8	279.6	69.4	0.0	0.0	0.0
2005	0.0	0.0	0.0	15.0	70.1	57.8	391.5	300.9	59.6	5.7	0.0	1.6
2006	0.0	0.0	0.0	9.1	56.9	191.4	385.9	315.5	26.5	0.0	7.4	0.0
2007	0.0	0.0	0.0	0.0	78.9	149.6	339.8	291.0	32.9	1.0	13.6	0.0
2008	0.0	0.0	14.1	10.4	0.0	47.4	302.8	196.0	20.5	2.5	0.0	0.0
2009	0.0	0.0	7.8	28.6	40.0	0.0	260.5	312.8	41.7	0.0	0.0	0.0

2010	0.0	0.0	13.0	3.5	51.8	40.9	205.5	395.6	81.2	0.0	0.0	0.0
2011	0.0	0.0	0.0	0.0	0.0	51.0	301.7	196.7	40.3	4.0	0.0	0.0
2012	0.0	0.0	0.0	7.5	32.8	112.0	306.7	193.1	20.0	18.0	0.0	0.0
2013	0.0	0.0	10.5	12.0	107.0	38.5	166.5	234.9	44.0	81.5	5.5	0.0
2014	0.0	0.0	0.0	4.0	55.0	51.0	136.5	134.0	79.0	0.0	25.5	0.0
2015	0.0	0.0	0.0	32.0	71.8	65.0	215.6	235.0	29.6	0.0	0.0	0.0
2016	0.0	0.0	0.0	0.7	53.5	56.5	166.8	372.5	64.4	12.3	9.9	0.0

Source: NMA (2018)

Appendix 5: Livestock conversion factor

Livestock	Conversion factor
Ox	1.1
Cow	1.0
Heifer	0.5
Bull	0.6
Calf	0.2
Sheep	0.01
Goat	0.09
Donkey	0.5
Mule	0.7
Hen	0.01

Source: Ibrahium Abdinasir (2000)

Appendix 6: Crop value production

Crop type	Price in quintal(ETB)								
	Nov	Dec	Jan	Feb	Mar	Apri	Ma.	Jun	Average price
Teff	1349	1462	1530	1571	1695	1793	1845.5	1922.5	1646
Sorghum	678	688.5	702.5	744	810	904	924	949	800
Maize	845	824	780	800	850	940	1000	1025	883
Mung bean	1600	1550	1525	1650	1692	1745	1849	1989	1700
Chick pea	1950	1939	1949	1898	1925	1950	2025	2100	1967
Bean	1400	1430	1440	1430	1470	1510	1598	1754	1504
Onion	1500	1580	1555	1400	1400	1400	1540	1625	1500

Source: East Belessa district trade and transport annual report (2018)

Appendix 7: Variance Inflation Factor (VIF) test of continuous explanatory variables

Collinearity Statistics		
Continuous variables	Tolerance	VIF
Dependency ratio	.810	1.234
Age	.717	1.395
Education	.885	1.130
cultivated size	.783	1.278
Family size	.829	1.206
Total livestock holding	.651	1.535
Extension contact	.852	1.174
Market distance	.868	1.152

Appendix 8: Contingency coefficient test of categorical explanatory variables

	sex	credit access	off -farm activity
Sex	1		
credit access	.120	1	
off farm activity	-.016	-0.045	1

BIOGRAPHICAL SKETCH

The author was born to his father Tilahun Abetew and his mother Abeba Bisete in North Gondar zone of Amhara Regional state, Ethiopia, on May 14, 1988. He attended his Elementary education at Guhalla primary school, Secondary and preparatory education at Guhalla Secondary School and Makesegnt Preparatory School respectively. He joined Hawassa University in November 2008 and successfully completed his Bachelor of Science degree study in Agricultural Resource Economics and Management graduated on July 10, 2010. Immediately after graduation, the author was employed in East Belessa district as soil and water conservation expert for 2 years and 8 months, Gender and youth development mainstreaming for 8 months and East Belessa district Agricultural office vice head for 2 years and 8 months. In September 2018, he joined Hawassa University to pursue his post-graduate study in the department of Climate Smart Agricultural Land scape Assessment.