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COLLEGE OF DEVELOPMENT STUDIES
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SMALLHOLDER FARMERS' ADOPTION OF CLIMATE SMART CATTLE PRODUCTION PRACTICES: STATUS AND DETERMINANTS IN *WALISO WOREDA*, SOUTHWEST SHOA ZONE, OROMIA NATIONAL REGIONAL STATE, ETHIOPIA

MSc THESIS SUBMITTED TO CENTER FOR FOOD SECURITYSTUDIES
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DEMISSIE GELASHE FEYISA

ID.NO: GSR/2691/09

JUNE, 2018
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IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN FOOD SECURITY AND DEVELOPMENT STUDIES

DEMISSIE GELASHE FEYISA

ID.NO: GSR/2691/09

ADVISOR
DESALEGN YAYEH (PhD)

JUNE, 2018
ADDIS ABABA, ETHIOPIA

Declaration

I, Demissie Gelashe Feyisa, declare and affirm with my signature below that this thesis is my own original work. I have followed all ethical and technical principles of scholarship in the preparation, data collection, data analysis and compilation of this thesis.

Sources of information other than my own have been acknowledged and a reference list has been attached.

This thesis is submitted in partial fulfillment of the requirements for the degree of Master of Science in food security and development studies.

I solemnly declare that this thesis has not been submitted to any other institution anywhere for the award of any academic degree, diploma or certificate.

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Name: Demissie Gelashe Feyisa Signature: _________________

Date: June, 2018

Department: College of Development Studies

Center: Food Security and Development Studies

Acknowledgement

First of all I would like to thank my organization (Southwest Shoa Zone Rural Land Administration) for permitting and supporting me to attend this MSc program. Next I am very much indebted to express my heartfelt gratitude and my honest thanks to my advisor Dr,Desalegn Yayeh for valuable guidance and constructive comments from the very beginning to the end. I am also very much grateful to the CASCAPE project for giving me grant fund support to conduct this thesis research. Again, I want to thank Dr. Mesay Mulugeta for his guidance to conduct research on this topic, the follow up during the process and for the inspiration He gave me the whole way starting from the research methodology course delivery through conducting this research.

I would like to acknowledge specially my wife Sirgut Abesha for her consistent encouragement and support throughout in the process of conducting this study.

Again, I am greatly indebted to Southwest Shoa Zonal and Woreda animal husbandry and fishery resources offices and development agents for their support during data collection process at the study area without which this research thesis would have not been realized.

In addition, I would like to thank all of the Key Informants, Group Discussion participants and household respondents who provided me with the necessary information in the study *kebeles*. Last but not least I would also like to thank all my friends who gave me encouragement.

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Abbreviations

AG:	Agriculture
AGP:	Agricultural Growth Program
BAU:	Business as Usual
CASCAPE	Capacity Building for Scaling Up of Evidence Based Best Practices in Agricultural Production in Ethiopia
CRGE:	Climate Resilient Green Economy
CSA:	Climate Smart Agriculture
CSA:	Central Statistical Authority
FAO:	Food and Agricultural Organization of the United Nations
FARA:	Forum for Agricultural Research in Africa
FDRE:	Federal Democratic Republic of Ethiopia
FGD:	Focus Group Discussion
GTP:	Growth and Transformation Plan
GDP:	Gross Domestic Product
GHG:	Greenhouse Gas
IPCC:	Intergovernmental Panel on Climate Change
KII:	Key Informant Interview
MICCA:	Mitigation of Climate Change in Agriculture
NGO:	Non-Governmental Organization
NMA:	National Metrological Agency
NONF:	Non-Farm
OFF:	Off-Farm
SDG:	Sustainable Development Goal
SLM:	Sustainable Land Management
SWSRLAO:	South West Shoa Rural Land Administration Office
TLU:	Tropical Livestock Units
THI:	Temperature Humidity Index
UNICEF:	United Nation International Children Fund
WWAHFRO:	*Waliso Woreda* Animal Husbandry and Fishery Resource office
WWANRO:	*Waliso Woreda* Agricultural & Natural Resource Office

Abstract

Cattle production plays an important role in Ethiopian economy and Waliso Woreda is a potential area for dairy and beef cattle farming. But due to human population pressure and menace of climate variability the sector faced many challenges. The adoption of climate smart cattle production practices is considered to be an innovative solution to the challenges. This study is aimed to identify the status of adoption and analyze the determining factors and challenges in adopting Climate Smart cattle production practices in the last ten years in Waliso Woreda, Southwest Shoa of Oromia National Regional State, Ethiopia. Three-staged mixed sampling techniques were used to select the targeted area and sample household respondents. A total of 83 (17 are Female headed) households were selected using systematic simple random sampling method and household survey was conduct with pre-tested structured questionnaire. Key Informant Interviews and Focus Group Discussions were also undertaken to complement the survey data. Various descriptive and inferential statistic techniques were applied to analyze the collected survey data. Multinomial logistic (MNL) regression model was used to analyze the determining factors of adoption practices. All respondents adopted at least two Climate Smart cattle production practices. The widely adopted practices are feed conservation (90.4%) and manure management (89.2%) while the least adopted one is bio-gas generation (12%). Most of the respondents (44) are categorized under medium adoption level. Out of thirteen targeted determining factors in the study area three of them (family size, household head age and farmer to farmer extension contact) are statistically significant at 0.05 level, two of them (land access and access to credit services) are significant at 0.1 level and one of them (education) is significant at 0.01 level in relation to adoption of the practices at different categories with different coefficients. It could be concluded that cattle farmers having higher educational level and productive family size, access to credit service, access to landholding, good farmer to farmer extension contact and middle adulthood age are more likely to adopt Climate Smart cattle production practices. Finally, it can be recommended that this socio-economic factors influencing adoption of Climate Smart cattle production practices is better to be taken into consideration while accelerating the face of technology adoption under similar farming system spectrum by all concerned stakeholders in synergy.

Keywords: Adoption, Cattle, Challenges, Climate Smart, Production, Smallholders

1. Introduction

1.1. Background of the study

Agriculture is the backbone of Ethiopia's economy. At national level the sector accommodates 85% of employment and contributes 90% of foreign exchange earnings. Most importantly 90% of the agricultural output is contributed by small scale farming (Abebaw *et al.,* 2010). According to Federal Democratic Republic of Ethiopia (FDRE) Growth and Transformation Plan II (2016) the agriculture sector contributed 39% of GDP at the end of 2015.

Despite the mentioned role of agriculture in national economy the production system is traditional in nature and heavily based on rain fed system which makes it extremely vulnerable to changes in weather conditions (Andersson *et al.,* 2009).The FDRE GTP-II (2016) indicated 23.4% of the Ethiopian population lives below the poverty line during 2015. Another study by UNICEF (2014) points out that about 10% of Ethiopia's citizens are chronically food insecure and this figure rises to more than 15% during frequent drought years. The recent 2015 El Niño drought is one of the strongest droughts that have been recorded in Ethiopian history were more than 27 million people became food insecure and total population of 18.1 million people require food assistance in 2016 (Abduselam,2017**)**.

Climate change multiplies the challenges of achieving the needed agricultural growth to alleviate poverty and food insecurity and its effects are already being felt and will continue to challenge the effort of the nation to become food secured, free of hunger and poverty and attain national development goals (Nyengere, 2015**)**.The adverse impact of climate change and variability is manifested in Ethiopia through drought, flood, increase in temperature and change in rainfall patterns which has direct and indirect effects on livestock production. In reverse, the business as usual (BAU) livestock production system contributes both directly and indirectly to the climate change and variability through release of greenhouse gases(GHG) emissions in the form of carbon dioxide (CO_2), methane(CH_4) and nitrous oxide (N_2O)(Rust, 2013).

With the aim to manage these adverse impacts of climate variability and also reduce the contribution of conventional agriculture activities to greenhouse gas emissions, Ethiopia adopted the climate change adaptation and mitigation policy framework called Climate Resilient Green

Economy (CRGE) to mainstream the environment issues to all development effort in which the Climate Smart Agriculture development is the main component (CRGE, 2010).

Climate-Smart Agriculture (CSA) is an approach to dealing with the interlinked challenges of climate change, environmental sustainability and food security in a holistic and effective manner. The concept was first launched by FAO in 2010 in a background paper prepared for the Hague Conference on Agriculture, Food Security and Climate Change, in the context of national food security and development goals, to tackle three main objectives (FAO, 2013): sustainably increasing food security by increasing agricultural productivity and incomes; building resilience and adapting to climate change and developing opportunities for reducing greenhouse gas emissions compared to expected trends.

In the context of CSA approach livestock production is an agricultural sub-sector that is preferred to adapt to climate change, especially in arid and marginal land, because of the mobility of live animals, opportunity to relative gestation period and less water requirement (IFAD, 2010).

Climate Smart Agriculture is not completely a new idea but local farmers were used to practice indigenous coping mechanisms to adapt with the adverse impact of climate change and variability. But the magnitude, frequency and pace of climate change and variability gradually become beyond the capacity of poor country’s smallholder farmers to cope up with medium to long-term impacts of climate change. So, innovation and dissemination of Climate Smart modern technologies is essential to help smallholders adapt and mitigate the impact of climate change (Clements *et al*., 2011).

Climate Smart Agriculture (CSA) has a proven potential to improve adaptive capacity and resilience thenby enhances sustainable agricultural production and rural livelihoods. However, the commitment as well as ownership of government and other development partners, systematic response to climate change through adoption of CSA practices and technologies is still very limited in Africa in general, and Ethiopia in particular for a host of socio-economic, demographic, cultural and institutional reasons (James *et al.*,2015).Generally in Africa, CSA is used on less than one million hectares, accounting for less than 1% of the total global area under CSA management (Milder *et al.*, 2011).

A study conducted by Jirata *et al.* (2016) at country level in Ethiopia has identified that the adoption rate of CSA practices is low. To support the facilitation for adoption, different key opportunities and challenges are identified and strategic measures were recommended to capitalize on the opportunities and remove the challenges. The study also indicated that there is a gap in research at local level regarding CSA scoping study (adoption status, opportunities and challenges) considering the bio-physical, socio-economic and developmental context. These situations solicit the need to conduct research at local context in order to strengthen the evidence based decisions for adoption and dissemination of improved technologies across similar farming system.

In the effort to support local smallholder cattle producing farmers in the *Waliso Woreda* local government and partner organizations have implemented different development programs out of which Growth and Transformation Plan (GTP I and II[1]),Agricultural Growth Program(AGP) and Sustainable Land Management(SLM)are some that have integrated a Climate Smart cattle production since the year 2010/11.In AGP-II Climate Smart cattle production practices like zero-grazing, cut and carry system, area closure, bull fattening, breed improvement for dairy cattle production, Artificial Insemination (AI),animal health services and composting are included in the document and implemented since 2015 (GTP-II,2016).

There were insufficient empirical studies and scientific evaluation of context based Climate Smart cattle production program in the study area and elsewhere in Ethiopia so far to identify the adoption status, determining factors and challenges in using the practices. In order to contribute to fill the mentioned research gap this study is aimed to identify the status of adoption, analyze determining factors and challenges in adopting Climate Smart cattle production practices and forward problem oriented context specific strategic action to enhance adoption and scaling up/out the practice by smallholder farmers in *Waliso Woreda*, Southwest Shoa Zone, Oromia National Regional State, Ethiopia.

[1]GTP I and II are Growth and Transformation Plan documents prepared by Federal Democratic Republic of Ethiopia to guide development in the country which lasts from 2010/11 to 2014/15 for GTP I and from 2015/16 to 2019/20 for GTP II.

1.2. Statement of the Problem

Climate change and variability has direct and indirect effects on the livestock production through adverse impact on natural resource bases and ecosystem services which the livestock sector is very much depend up on for their existence and development (Smith *et al.*, 1996). The direct effect is through increased temperature, changes in rain fall amount and patterns of distribution. Indirect impacts are through modification in ecosystem, changes in quantity, quality and type of feed crops, forage and pasture; spread in pests and diseases, competition for resources. Climate change affects the determinants of livestock production such as water, feed, biodiversity (genetics and breeding), human and cattle health. In reverse, business as usual (BAU) livestock production contributes significantly to the emissions driving climate change and variability. It has been estimated that global livestock production contributes 14.5% greenhouse gas emissions in the form of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O).

Cattle production is responsible for 65 % of total global emission from livestock (Kristensen and Mogensen, 2015). In developing nations like Ethiopia the problem of emissions will be further increasing in the future due to the demand and production of milk, meat and other related products that arise from population and income increment as well as urbanization and shift in patterns of consumption (FAO, 2013).

Climate Smart agricultural production as an approach helps to transform and re-orient the farming system at household and landscape level to support food security under the new realities of climate change (FAO, 2013). In spite of the development of several Climate Smart Agriculture technologies and practices and the gains arising from it wide-scale adoption of CSA practices however, remains a challenge especially amongst smallholder farmers in Africa in general and in Ethiopia in particular(Barnard, 2015). Consensus and recognition is reached by different governmental and non-governmental stakeholders on importance of the CSA approach but there is a gap in implementation and scaling up/out to the local context (Barnard, 2015).

There is a lack of context specific and adequate research findings on CSA practices in Ethiopia for the various agro-ecology, soil type, rainfall pattern, farming system, temperature and moisture ranges (Jirata *et al.*, 2016). A study conducted at national level in Ethiopia has identified that the adoption rate of CSA practices is low and there is a gap in research at local level regarding CSA scoping study. Key challenges such as weak capacity (especially the lack of skilled human resources), weak coordination, frequent land ploughing and removal and burning of crop residues, open grazing, land degradation and the loss of forests are identified at national level and recommendation was made to conduct the study at local context.

Another study by Williams *et al*. (2015) confirmed that there is no as such Climate Smart Agriculture per se for all contexts (there is no one-size-fits-all fix) but the natural, bio-physical, socio-economic, institutional and development situation of the local area determines the context with in which the Climate Smartness is evaluated and recommended. There is a gap of study at the local context due to the newness of the approach, capacity limitation and diversity of the local situations. Lack of research-based evidence on adoption impedes the ability of decision makers to target CSA implementation to areas most at risk.

The concept of the new approaches of Climate Smart Agriculture (CSA) is not well introduced among the local community and different stakeholders in the study area but few programs are being attempted to be implemented by government and non-government organizations. Extension program in the Growth and Transformation Plan (GTP I and II), [2]Agricultural Growth Program (AGP_II) and Sustainable Land Management (SLM) are some of the Climate Smart Agriculture integrated program implemented since the year 2010/11 in the *Waliso Woreda*. According to the *Waliso Woreda* GTP-II (2016) the AGP-II program has a Climate Smart cattle production component with intervention in the area of feeding, manure management, animal health service, breed improvement and herd management.

During the preliminary research idea assessment discussions were made with government and partner organization's focal persons and no evidence was gained regarding any research done on the topic at the area under study.

A good experience can be drawn from a study conducted on adoption of Climate-Smart Agricultural practices which focused on understanding of barriers, incentives, benefits and lessons learnt from the MICCA pilot site in Kenya and that provided useful learning lessons for scaling-out of promising CSA practices in similar agro-ecosystems (Mutoko, 2014).

[2] The Agricultural Growth Project (AGP) of Ethiopia is aimed at increasing agricultural productivity and market access for key crop and livestock products in targeted woredas, with increased participation of women and youth.

With the purpose to extend the experience and fill the research gap this study is aimed to identify the adoption status, determining factors and challenges in adopting Climate Smart cattle production practices delivered by government and partner organizations since the year 2010/11 and then formulate appropriate evidence based and context-specific strategic actions to enhance the adoption and scaling up/out of Climate Smart cattle production practices.

1.3. Objectives of the study

The overall objective of this study is to explore the status and challenges of adoption and identifies the determining factors in adopting Climate Smart cattle production practices since the year 2010/11 in *Waliso Woreda*, Southwest Shoa Zone, Oromia National Regional State, Ethiopia.

Specific Objectives are to:

(i) Examine the smallholder farmers' adoption status of Climate Smart cattle production practice in the context of the study area since the year 2010/11

(ii) Analyze the factors determining the adoption of Climate Smart cattle production practices in the study area

(iii) Examine the key challenges to smallholder farmers in adopting Climate Smart cattle production practices in the study area

1.4. Research questions

1. What is the status of adoption of Climate Smart cattle production practices at farm level?
2. To what extent smallholder farmers are practicing Climate Smart cattle production practices?
3. What are the determining factors in adopting Climate Smart cattle production practice
4. How the determining factors and the adoption of the Climate Smart cattle production practices are related?
5. What are the key challenges in adopting Climate Smart cattle production practice at the farm level?

1.5. Significance of the study

Knowledge generated from this study is useful in location-specific capacity building program in Climate-Smart interventions for similar context. Researchers who want to conduct similar and related studies can refer for the findings and can conduct their research on the identified gaps as well.

This study helps to identify and analyze the problem oriented and context specific situation with regard to the study topic. The end result is to enhance the effective, evidence based decision making process by all concerned stakeholders (primarily the smallholder farmers) and thenby promote adoption rate of Climate Smart cattle production practice. Best practice will be scaled up/out in similar context. Additionally, it enhances the political will required to motivate deep transformations within the policy sector.

The output of this research is also essential for animal husbandry professionals, socio-economic development planners, policy makers, environmentalists and development agents in order to have appropriate measures in the effort of planning, implementing and controlling the context specific thematic interventions.

1.6. Scope of the study

The scope of the study can be described in terms of methods, area of study, thematic and time dimensions. Due to time constraints, *methodologically* the study is limited to identify only the adoption status of the practices at least in one production season without looking at the sustainability and intensity of adoption over time using multinomial logistic regression (MNL).

Methodologically an integrated and comprehensive data collection and analysis methods like pragmatic or mixed approach (both quantitative and qualitative) are applied to triangulate analysis and reduce errors and biasness throughout data collection, analysis and interpretations. Quantitative and qualitative data collection and analysis like the structured questionnaire, Key Informant Interviews, Focus Group Discussions and Observation were used. Secondary sources like reports, plan and policy documents, data bases and others were referred for information. The *spatial scope* is limited to the *Waliso Woreda* due to the existing cattle production potential, adverse impact of climate change and variability, population pressure, the research interest to make comprehensive investigation, existence of relative Climate Smart interventions and resource limitation.

Thematically the study is limited to identify the adoption status, analyze determining factors and challenges of adopting Climate Smart cattle production practices due to the interest of researcher to conduct research on this under researched and up surging climate change threats to all humanity.

The *temporal scope* of the study topic would be the production year since 2010/11during when the Climate Smart intervention delivered by integration of government and non-government organizations in the thematic area.

1.7. Limitations of the study

There were some limiting factors during the process of under taking this study. These are the limited information on climate variability at temporal scales and their impacts on agriculture at local level, limited access to relevant research literatures in the area and incomplete recorded data on the project progress. As the concept of CSA is relatively new, there is little relevant research conducted so far, hence this study is limited on the number of published and unpublished literature for reference.

Using descriptive statistics and multinomial logistic regression model data analysis were limited to investigating the status of adoption in terms of the number of practices adopted at least once for the study duration but not its number of technical components adopted from the recommended package, frequency and continuity of practice over time because of the time and other resource constraints.

2. Literature Review

2.1. Climate Change and Livestock Production

The world's population will increase by one-third and expected to reach more than 9 billion by 2050 with the addition of more than 2 billion on the current 7 billion, according to the projection of existing base line data at the year 2013(FAO, 2013). Most of the population increment will happen in the developing countries, especially in the sub-Saharan Africa countries, where Ethiopia is a part. Half of the 2.4 billion increase in global population that will occur between 2013 and 2050 will occur in sub-Saharan Africa (SSA), and 56% of Africa's population is projected to live in urban areas by 2025(UNDESA, 2013 and 2014).Urbanization is expanding and more population growth occurs in the urban area and land encroachment will further occur to the peripheral rural agricultural land and change the land use to urban settlement. If the current trend of food demand due to population growth, urbanization, increment in per-capita income and shift of consumption patterns continue to grow, FAO estimates that agricultural production will have to increase by 60 percent up to 2050 to satisfy the expected demands for food and feed (Lipper *et al.*, 2014).According to Williams *et al*. (2015) the agricultural production even has to grow up to 100% in Sub-Saharan Africa countries including Ethiopia.

Let alone the future food demand increment there is existing current gap between domestic food supply and demand in Ethiopia and as a result food insecurity, poverty and famine incidence is common phenomena cited by many researches (Abduselam,2017; UNICEF 2014 and 2015). According to FAO (2014) Sub-Saharan Africa is the worst of all regions in prevalence of undernourishment and food insecurity; Ethiopia (ranking no.1) is the worst of all African countries as nearly 33 million people are suffering from chronic undernourishment and food insecurity.

Agriculture sector couldn't feed the population of the country but continues to be the backbone of Ethiopia economy where it contributes 85% employment and 90% of foreign exchange. Most importantly 90% of the agricultural output is contributed by small scale farming (Abebaw *et al.*, 2010, as cited in Hiwot, 2014).

Livestock in Ethiopia is an integral part of agriculture and the contribution of live animals and their products to the agricultural economy accounts for 40%, excluding the values of draught power, manure and transport of people and products, contributing 20% of the GDP and accounts for 12-15% of the total export earnings and 31% of total agricultural employment. Livestock perform multiple functions in the Ethiopian economy by providing food, input for crop production and soil fertility management, raw material for industry, cash income as well as in promoting saving, fuel, social functions and employment (Birara and Zemen, 2016).

Even though the livestock sector has economic, social, cultural and risk management functions for the society in general, production and productivity is low in Ethiopia due to different factors like shortage of feed, incidence of disease and parasites, poor genetic profile, insufficient water availability, poor knowledge about improved farming systems management, weak institutional support, inefficient marketing systems, other socio-economic factors and climate change(Birara and Zemen, 2016).

The livestock sector will be under more pressure in the future to increase production due to the increment in demand for livestock products associated with driving factors like population increment, urbanization, per capita income increment and change in consumption patterns. Between 1960and 2005 global annual per capita consumption of meat increased more than triple; consumption of milk almost increased double (FAO,2009a).The demand for this high value dairy and beef cattle product will be expected to grow in sub-Sahara Africa including Ethiopia as a result of the mentioned determining factors. Driven by demand, global production of meat is projected to more than double, from 229 million tons in 1999/2001 to 465 million tonnes in 2050. Milk production is expected to increase from 580 to 1 043 million tons (FAO, 2006).

Livestock production and productivity growth rate is very low and lag behind the human population growth. The result is a decline in per capita consumption of livestock products. A report by Azage*et al.* (2006) show that the per capita consumption of milk and meat is estimated at 19 liters and 8kg respectively, putting Ethiopia as the least even compared to its neighboring countries. The annual per capita consumption of meat in Ethiopia is 43% below the African average of 14kg.

Despite the existing country potential in the livestock sector and the gap in the current production and consumption level mentioned above, much is expected out of the sector to increase production supply in order to fulfill the growing national and international demand requirement for the product.

But climate change undermines the effort of increasing livestock production and expected to be severe in the future. The climate change is already having a significant effect on livestock sector and is expected to make the role of livestock and specifically cattle production in achieving food security even more challenging, especially in the most vulnerable parts of the developing world like Ethiopia. The small holders, the rural poor, the women and the marginalized part of the community are more vulnerable to the adverse impact of climate change. Climate change affects all four dimensions of food security: food availability, food accessibility, food utilization and food systems stability and in reverse the climate is also being affected by livestock and value chain system (Lipper *et al.,* 2014). Its impacts will be both short term, resulting from more frequent and more intense extreme weather events, and long term, caused by changing temperatures and precipitation patterns. Livestock not only be affected by climate change, but also contribute to it through emitting greenhouse gases such as carbon dioxide(CO_2), methane (CH_4) and nitrous oxide (N_2O).

Increased temperatures, shifts in rainfall pattern and distribution and increased frequency and intensity of extreme weather events (e.g. Drought and flood) are expected to adversely affect livestock production and productivity around the world in general and Ethiopia in particular. The adverse impact on developing countries like Ethiopia is greater due to limited capacity to adapt and mitigate the effect, the sensitivity of the sector and vulnerability of the community.

Climate change will affect animal production in four ways both directly and indirectly: the impact of changes on livestock feed-grain availability and price; the impact on livestock pastures and forage crop production and quality; changes in livestock diseases and pests; and the direct effects of weather and extreme events on animal health, growth and reproduction (Smith *et al.*, 1996).Direct effects from air temperature, humidity, wind speed and other climate factors influence animal performance through creating the heat stress as a result of radiation which refers to the exchange of heat between the animal and the environment(ibid).

All these mentioned direct and indirect adverse effects of climate change on livestock production sector are common in the study area and are confirmed by the preliminary assessments made with government concerned experts. All these four aspects of climate change impact will be addressed in this study.

Livestock and cattle production in particular is not only being affected by climate change but also contributes to climate change through releasing greenhouse gasses(GHGs). According to the information from the source IPCC (2007b), it has been estimated that livestock production contributes14.5% of overall (global)anthropogenic greenhouse emissions. Significant amounts of particular gases such as 5% of anthropogenic CO_2 emissions; 44% of anthropogenic methane emissions; and 53% of anthropogenic nitrous oxide emissions are the share of parts. Direct sources such as enteric fermentation by ruminants (39% of emissions) and manure (26%) and indirect sources such as the production, processing and transport of animal feed (which accounts for 45% of sector emissions) can be mentioned. Indirect sources of GHGs from livestock systems are also mainly attributable to changes in land use and deforestation to create pasture land.

The global emission contribution of milk production, including its associated meat production, is approximately 4% of the livestock emission contribution in agriculture (IPCC, 2007b). This figure could probably be higher in Ethiopia as the agricultural emission is 87 %(50% agriculture and 37% deforestation due to agricultural land expansion) of the total country GHGs emissions (CRGE, 2010). Agriculture has much to contribute to a low emissions development strategy. In many countries it is agriculture—not industry or transport— that provides a high mitigation potential. For example 75% of Ethiopia’s estimated economic mitigation potential is in agriculture and forestry (Sintayehu, 2011).

2.1.1. The effect of climate change on dairy and beef cattle production

This section summarizes the adverse impact of climate change on dairy and beef cattle production. Climate change and its adverse impact on pasture and water are responsible for the rise of feed costs; decrease in grain production; decreased milk production; reduced animal weight gain; decrease in reproduction rate, lower feed conversion efficiencies; increase in the prevalence of vector-borne diseases and increase in the prevalence of internal parasite infestation(Rust,2013).

Dairy cattle show heat stress when the temperature humidity index (THI) is higher than 72 (Armstrong, 1994). Dairy cows subjected to heat-wave conditions associated with climate change have shown a 10% -14% reductions in milk production. These animals did not recover, even after conditions returned to normal (Valtorta, 2002).

According to the study conducted by Shambel (2017) livestock production in Ethiopia is under threat from the changing climate. This is because the natural pastures which a majority of the livestock owners rely on for feeding their animals are deteriorating in quality and the amount of fodder available decreases. In addition to that, water sources available are not reliable as they sometimes dry up due to high temperatures and shortage of rainfall. Livestock has been lost due to among other factors excessive heat, shortage of water, feed and diseases and parasites.

2.2. Climate Smart Agricultural Production

As it is discussed in the previous sections climate change affects agriculture and in reverses being affected by agricultural activities. In other word climate change is both a cause and consequence of impact on business as usual agricultural system. As agriculture happens to be an anthropogenic factor for climate change through greenhouse gas emission (GHG) and as a result increase global warming, it also can be a potential solution to adapt with climate change and mitigate its adverse impact (IPCC, 2007).

To achieve the ever growing demand of food security, reduce poverty and achieve agricultural development goals through enhancing the productivity and income from agriculture, adapting and building resilience to climate change and reduction of emission intensity per unit of product compared to past trend is an urgent call for the sector (FAO, 2013). To meet these required three pillars with focus on preserving the natural resource base and vital ecosystem services requires the transition to agricultural production systems that are more productive, efficient, stable and resilient to climate variability. This requires the efficient and effective management of natural resources such as water, land, soil nutrients and genetic resources which requires strong policy, institutional and financial support (ibid).

Climate-Smart Agriculture (CSA) is an approach to dealing with these interlinked challenges in a holistic and effective manner. CSA aims to improve food security, help communities adapt to climate change and contribute to climate change mitigation by adopting appropriate practices, developing enabling policies and institutions and mobilizing needed finances (Lipper *et al.*, 2014).

Climate Smart Agriculture (CSA) accommodates Ecosystem Based Adaptation (EBA) approaches so as to better understand the inter-linkages between water use, agricultural production and ecosystems services within and external to agro ecosystems (Williams*et al.*, 2015).

CSA is not a new production system – it is a means of identifying which production systems and enabling institutions are best suited to respond to the challenges of climate change for specific locations, to maintain and enhance the capacity of agriculture to support food security in a sustainable way. One should, however, not make the mistake of thinking climate change adaptation is something new or novel. Humans have been adapting to their natural environment since time began (CCAFS and UNFAO, 2014).

Lipper *et al.* (2014) asserted that “CSA promotes coordinated actions by farmers, researchers, private sector, civil society and policymakers towards climate-resilient pathways through four main action areas: i) building evidence; ii) increasing local institutional effectiveness; iii) fostering coherence between climate and agricultural policies; and iv) linking climate and agricultural financing’’. As to enforce sustainability under current challenges, CSA identifies synergies and trade-offs among food security, adaptation and mitigation as a basis for informing and reorienting policy in response to climate change (ibid).

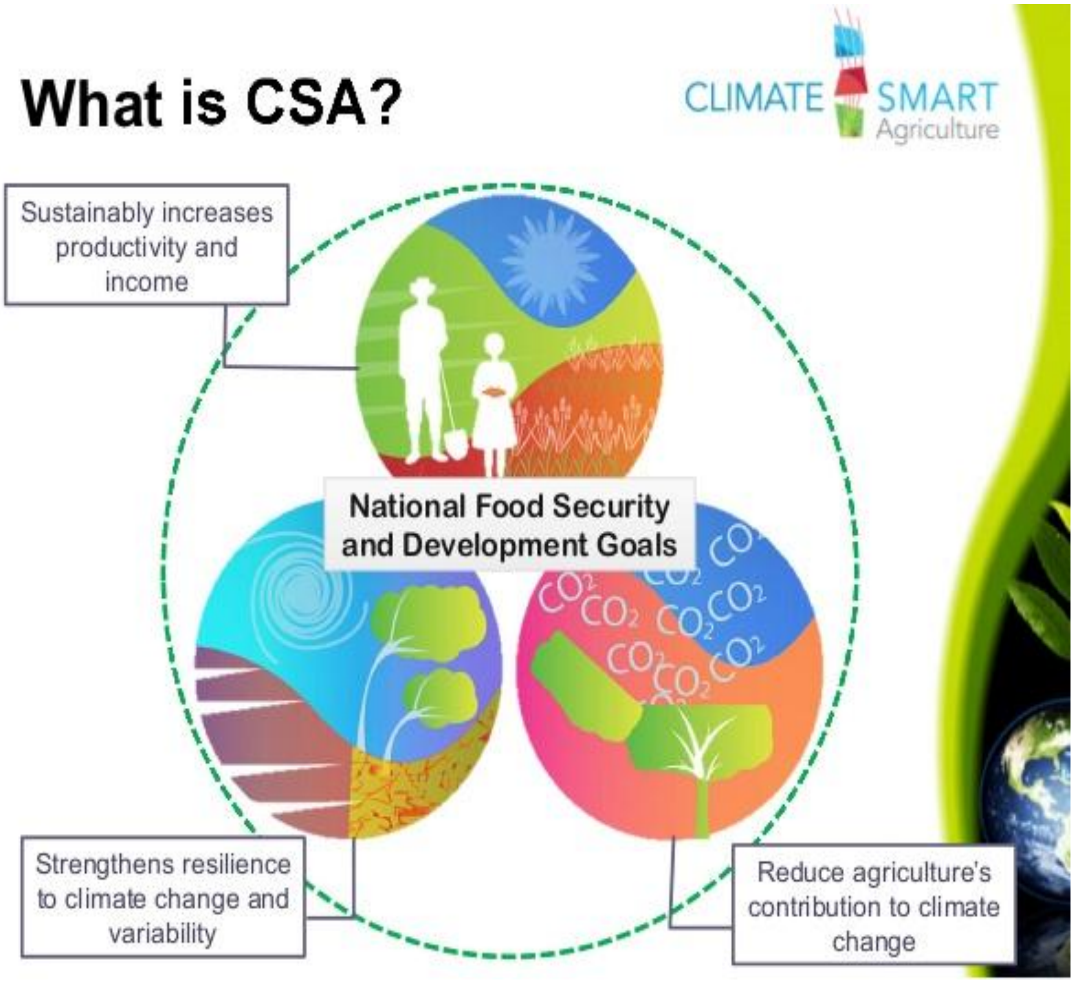

Figure 1. Theoretical Framework of Climate Smart Agriculture

Source: Papuso and Faraby, 2013.

The sustainable development goals(SDGs) strategic document that planned to last between 2016-2030 committed the world to end hunger, achieve food security and improved nutrition and promote sustainable agriculture and at the same time take urgent action to combat climate change and its impacts. Agriculture in the coming decades must feed the Africa continent, serve as the engine of growth and adapt to climate change. Climate-smart agriculture (CSA) puts these conditions at the heart of transformational change in agriculture by concurrently pursuing increased productivity and resilience for food security while fostering mitigation where possible (Williams*et al.*, 2015).

As climate change and variability increases, livestock will become more valuable because it provides a range of options like mobility, use of alternative feed resources and mobilization of body reserves to buffer the effects of this climate variability on food production. In general, livestock is more resistant to climate change than crops because of its mobility and access to feed(IFAD, 2010).

Given the current and projected scarcity of resources and the anticipated increase in demand for livestock products, there is considerable agreement that increasing efficiency in resource use is a key component to improving the sector's environmental sustainability (FAO, 2013). This increased efficiency should be pursued in all possible ways, from livestock selection and nutrition to manure management.

Traditionally, livestock producers have been able to adapt to various environmental and climatic changes. However, expanding populations, urbanization, economic growth, increased consumption of animal-based foods and greater commercialization have made traditional coping mechanisms less effective (Sidahmed, 2008). In addition, changes brought about by global warming are likely to happen at such a speed that they will exceed the capacity of spontaneous adaptation of both human communities and animal species. As a result, the identification of coping and risk management strategies has become very important. This reality lauds the importance of climate smart livestock production to increase the productivity and income, livelihoods, adaptive capacity and resilience of small holder herders and also enhance the environmental co-benefits of mitigating the greenhouse gas emissions (ibid).

According to Naqvi and Sejian (2011) due to the fact that the livestock production system is sensitive to climate change and at the same time itself a contributor to the phenomenon, climate change has the potential to be an increasingly formidable challenge to the development of the livestock sector, and that responding to the challenge of climate change requires formulation of appropriate adaptation and mitigation options for the sector. Several experts (FAO, 2008; Thornton, *et al.*,2008; Sidahmed, 2008) identified the methods of adaptation for the livestock sector such as production adjustments, breeding strategies, market responses, institutional and policy change, science and technology development, capacity building for livestock keepers and livestock management systems.

According to FAO(2008b) Livestock(specifically cattle production) can play an important role in both mitigation and adaptation measures which includes production adjustment, market response, institution and policy change, science and technology development, capacity building for livestock herders, efficient and effective livestock management, selection of faster growing breeds, improved feeding management, better manure management, grazing management, stocking rate management, rotational, planned or adaptive grazing, enclosure of grassland from livestock grazing.

Out of these practices breed improvement, concentrate feeding, rotational feeding, agro forestry and fodder tree planting and better manure management are some of the climate smart cattle production practices introduced by government regular program and with support of partnering NGOs (like AGP, SLM and VOCA) in the study. Dairy cattle production through cross breeding of improved bull variety with local breed by the help of artificial insemination (AI) mechanism and bull fattening are among the cattle production interventions planned and implemented by agriculture growth program(AGP)(GTP-II,2016) .

Table1. Definitions and justification of practices in participation with local experts as per the study context in *Waliso woreda*, central Ethiopia.

Practice	Definitions	Justification for inclusion
Agro forestry	**Agro forestry**: Planting trees together with crops on the farm. These are trees that produce or are primarily used for fruit, fodder, or fuel wood production or that provide other benefits, such as reducing runoff or erosion, enhancing soil fertility, providing shade, and providing medicines.	**Adaptation**: soil fertility maintenance; creation of favorable microclimates; reduced moisture stress **Mitigation**: soil carbon sequestration; erosion prevention **Food security**: tree products and environmental services; improved productivity
Composting	Collection and heaping of organic waste materials such as food scraps, crop residues or livestock manure in a pit, pile or other structure to allow for decomposition and later application to cropland soil.	**Adaptation**: compensation for declining soil fertility **Mitigation**: emissions reduction from avoidance of raw animal manure application; improved soil carbon sequestration **Food security**: increased productivity; lower input requirements
Improved forages	Deliberate sowing of easily digested or high-protein forages, including select undomesticated grass and legume species and genetically improved varieties	**Adaptation**: restoration of degraded lands **Mitigation**: nitrogen fixation with leguminous fodders; reduction of emissions from enteric fermentation of livestock through easier digestion **Food security**: healthier livestock; improved income from market price; meat & milk for household consumption
Improved livestock	Genetic improvement of a herd or flock through targeted cross-	**Adaptation**: resistance to climate related stresses, pests, and diseases

breeding	breeding for specific traits, including pest/disease resistance, heat tolerance and overall productivity.	**Mitigation**: herd reduction through improved quality of fewer number of stock **Food security**: increased milk/meat productivity for own consumption; better market price
Manure management	Supplementation of soil fertility using manure from cattle, goats, pigs, sheep, poultry or other livestock that has been collected, stored and often composted together with household refuse, to later be applied to the fields.	**Adaptation**: compensation for declining soil fertility **Mitigation**: emissions reduction from composted rather than raw manure which release methane; soil structure and soil carbon sequestration **Food security**: improved productivity; fewer input requirements
Feed conservation	Improving the supply of balanced, quality, nutritive feed to bridge the gap between wet and dry season & enhance the yield per animal head	**Adaptation:** Availing feed during shortage and stress **Mitigation:** Improve efficiency and feed conversion rate to reduce carbon emission per animal head **Food security:** Enhance milk and meat yield and income

Source: Author construction based on expert discussion, field data and literature (Adapted from Peterson, 2014)

The implementation of climate smart agricultural (CSA) interventions for dominant livestock system can be based on three different strategies. They are land-based systems, mixed systems and landless systems (FAO, 2013). Mixed livestock system, if well managed, is the most promising means of adapting to climate change and mitigates the contribution of crops and livestock production to GHG(ibid). The options to deal with integrated mixed systems focusing on livestock related interventions for CSA are integrated soil-crop-water management, water use efficiency and management, sustainable soil management, feed management and diversification to climate-resilient agricultural production systems (ibid).

Mainly in the Ethiopian highlands in general and the study area in particular, smallholder farmers operate mixed crop-livestock farming systems, with a strong interaction between the two sub-sectors. Draft power in crop production, transportation of inputs and products and manure for soil fertility are obtained from livestock, while crop residue is used to feed livestock. Livestock are a natural capital as well as insurance during crop failure. Similarly, households may finance crop purchase (if there is a deficit in level of production for home consumption) through income from livestock sale, given that the household is in a better position in livestock assets (Moti*et al*., 2010).

Table 2. Summary of CSA practices and technologies for mixed livestock systems

	Management objective	**Practices/technologies**	**Impact on food security**	**Effectiveness as an adaptation strategy**	**Effectiveness as an mitigation strategy**	**Main constraints to adoption**
Livestock management	Improved feed management	Improving feed quality: diet supplementation; improved grass species; low cost fodder conservation technologies (e.g. baling, silage)	+++	+++	+++	High costs
	Altering integration within the system	Alteration of animal species and breeds; ratio of crop-livestock, crop-pasture	++	+++	++	Lack of information on seasonal climatic forecast trends, scenarios
	Livestock management	Improved breeds and species (e.g. heat-tolerant breeds)	++	++	++	Productivity trade-off: more heattolerant livestock breeds generally have lower levels of

						productivity
		Infrastructure adaptation measures (e.g. housing, shade)	++	+++	+	
	Manure management	Anaerobic digesters for biogas and fertilizer	+++	+++	+++	High investment costs
		Composting, improved manure handling and storage, (e.g. covering manure heaps) application techniques (e.g. rapid incorporation)	++	+	++	

Mitigation/adaptation potential: + = low; ++ = medium; and +++= high
Source: Adapted from FAO, 2013

2.3. Empirical Framework of Adoption of Climate Smart Agricultural Practices

In spite of the potential of CSA to improve resilience and to enhance agricultural production and rural livelihoods, systematic response to climate change through adoption of CSA practices and technologies is still very limited in Africa in general and Ethiopia in particular for a host of reasons. In Africa, CSA is used on less than one million hectares, accounting for less than 1% of the total global area under CSA management (Milder*et al.*, 2011).

For CSA to have the desired impact on the adaptation of global agricultural systems it must be applied across a multitude of geographical, social, economic and political contexts. However, for farming communities within each of these contexts the obstacles that impede or complicate CSA adoption are different. Therefore, local-level assessments are necessary to first verify the suitability of target practices and subsequently to determine how their widespread adoption might best be facilitated (IPCC, 2007).

Empirical studies around the world have identified common variables that affect the probability that smallholder farmers will adopt climate smart agricultural practices. The farmers age, gender, family size, wealth, membership in agricultural organizations, land tenure status and education level have an influence on the adoption of the sustainable practices (Smithers and Smith 1989; Deressa*et al.*, 2009). Adoption rate also determined by subjective variables such as farmer's awareness of new practices, personal willingness and over all concern for the problem the practices aims to address (Below *et al.*, 2010).

Even when conditions allow the adoption of practices the household level barriers such as limitations in-acquiring material inputs can cause additional hindrance. According to Deressa *et al.* (2008) the commonly reported barriers to the adoption of climate-smart practices are financial constraints, shortages of labor, land and water. Farmers may be generally willing to adopt new practices, but perceive a specific practice to be inadequate, unnecessary, or difficult to incorporate into existing management systems (Smithers and Smith, 1989).

Two broad categories of barriers or factors that prevent adoption of climate smart agriculture were identified. These are physical or hard ware and non-physical or software barriers. The physical barriers are inputs such as land, human resources, equipment, infrastructure and finances. And the non-physical or software barriers, relates to the institutional, cultural, policy and regulatory environments; information, knowledge and skills; technologies and innovations; and governance among others (James*et al.*,2015). Thus, technological, social, economic, and institutional factors all play a role in whether target CSA practices can or will be adopted, both within farming communities and on the national and regional scales. Therefore these factors must be considered when analyzing appropriateness of CSA practices as well as barriers to their adoption.

According toGarcía de Jalón,Silvestri&Barnes (2016) all types of capitals (physical, financial, human and social), except natural capital, have a positive and significant effect on the uptake of the livestock production practices. The coefficients of the logistic regressions show that physical and financial capitals seem to have stronger influence on adoption than the other capitals.

The adoption rate of climate smart agriculture is low and different opportunities and challenges are identified according to the scoping study conducted in Ethiopia at national level by Jirat, Grey, & Kilawe,(2016).According to(ibid) there is a lack of adequate research findings on climate-smart agriculture in Ethiopia for the various agro-ecological zones, soil types, rainfall patterns, farming systems, as well as temperature and moisture ranges. Hence there is a need to support and conduct more research projects on climate-smart agriculture, particularly action research and field-based research at the local level.

To contribute in filling this gap and meet the local research need the study aims to identify the status, determining factors and challenges in adopting the climate smart cattle production practices and recommends the strategies and actions to remove or reduce the challenges of small holder farmers and then enhance the adoption status.

2.4. Analytical Framework of the Study

2.4.1. Conceptualization of adoption

Feder *et al.* (1985) define adoption as the degree to which a new technology is used in long-run equilibrium when farmers have complete information about the technology and its potential. Therefore, adoption at the farm level indicates farmers' decisions to use a new technology in the production process. On the other hand, aggregate adoption is defined as the process of diffusion of a new technology within the region.

Factors influencing adoption of new agricultural innovations sometimes are divided into three major categories: farm and farmers' associated attributes; technology attributes (Adesina and Zinnah, 1992; Misra *et al.*, 1993); and the farming objective.

Many empirical studies indicate there are three paradigms that are used to explain the determinants adoption option of farmers when adopting a new climate smart agricultural technology. These are innovation-diffusion model, adoption perception model and the economic constraints model. Innovation-diffusion model contents that access to information about an innovation influences (climate smart agricultural technology) adoption. It assuming that technology is technically and culturally appropriate but the problem is one of asymmetric information and very high search or transaction costs. Thus communicating information to potential end users is the problem (Uaiene*et al.*, 2009).

The economic constraint model asserts that adoption is determined by the economic constraints that are reflected in the asymmetric distribution of resources (Evengelista, 2011). Such as access to natural resources, access to capital, learning/investment costs and risk attitude.

The adoption-perception model stresses perceived attributes of a given innovation as the determinant of adoption. It is defined by personal factors in addition to information in utility maximization. Its decisive factor in adoption behavior includes personal factors, human values, experience, education, perceived severity or urgency of the problem that requires adoption as a solution. The combination of all the three models determines the factors that influence decision on adoption of climate smart agricultural technologies.

Different climate smart agricultural practices are adopted by various farmers, which enhance the farmer's response to climate change. However, adoption of climate smart agricultural practice influenced by socio-economic, demographic and institutional characteristics of the farmers. Demographic characteristics such as age, total members of household, sex and literacy of household, and socioeconomic characteristics such as land and livestock ownerships of the household and income of household affects farmer decision to adopt climate smart agricultural practices. Institutional factors that affect farmer's decision to adopt climate smart agricultural practice includes availability of credit and infrastructure, access of agricultural extension agents, access of information on climate change, and participation of farmers in social and labour organization of the community (Malefiya, 2017).

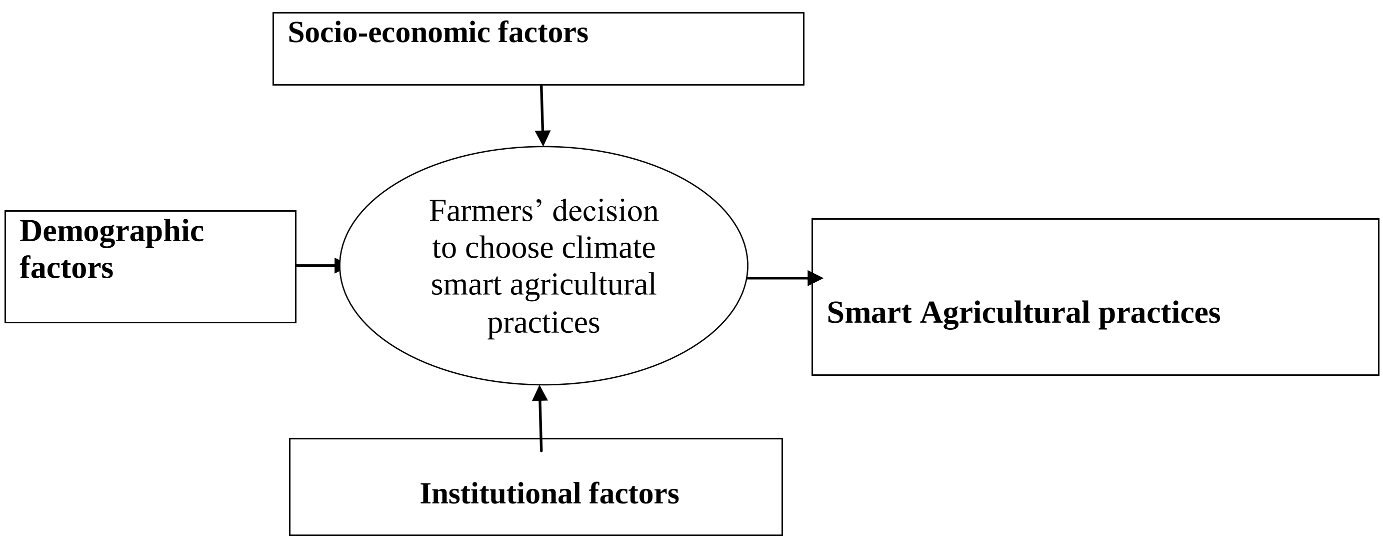

Figure 2. Analytical framework of the study

Source: Adapted from Malefiya, 2017

The factors that determine the status of adoption of climate smart agriculture (CSA) practices including the livestock production sub-sector in Africa in general and Ethiopia in particular has been discussed earlier. If these barriers are not solved the Ethiopian smallholder and poor farmers will not benefit from the potential solution of the climate smart agriculture approach.

According to James*et al.,* (2015) strategies and practical actions for removing the identified barriers while simultaneously promoting adoption of CSA are creating awareness, facilitating access to finance and credit, facilitating information and knowledge use, enhancing the capacity of farmers, improving physical and social infrastructure, strengthening institutions, policies and governance structures, ensuring secure tenure of land, protecting grazing and tree rights, and providing easily accessible weather forecasting systems for Agriculture

2.5. Relevant Policies and Strategies in Ethiopia

According to the Melaku (2016) policies, laws and strategies relevant to climate change and variability in Ethiopia include the Climate Resilient Green Economy Strategy (2011), National Adaptation Program of Action (NAPA), Ethiopian Programme of Adaptation to Climate Change (EPACC) of 2011, Nationally Appropriate Mitigation Actions (NAMA) of 2010; Rural Development Policy and Strategies (2003), Growth and Transformation Plan (GTP), CAADP Compact and the National Environmental Policy of Ethiopia (1997).In addition to this national policies Ethiopia has signed and/or ratified many of the international conventions and protocols related to climate change and land degradation(Melaku,2016).

All these national and international institutions are supporting policy frameworks that guide and support to conduct research, facilitate to expand the evidence base, enhancing financing options in the process of promoting CSA approach and benefit climate variability vulnerable smallholder farmers. Specifically these institutions help to guide and support all effort to scale up/out technologies among smallholder farmers in the effort to adapt with and mitigate the adverse impact of climate variability and enhance the food security and livelihood.

3. Research Methodology

3.1. Description of the Study Area

The study was conducted in *Waliso Woreda*, Southwest Shoa Zone,Oromia National Regional State of Ethiopia. The *Woreda* has a total of 37 *kebeles,* out of which 35 are rural and 2 are urban kebeles.

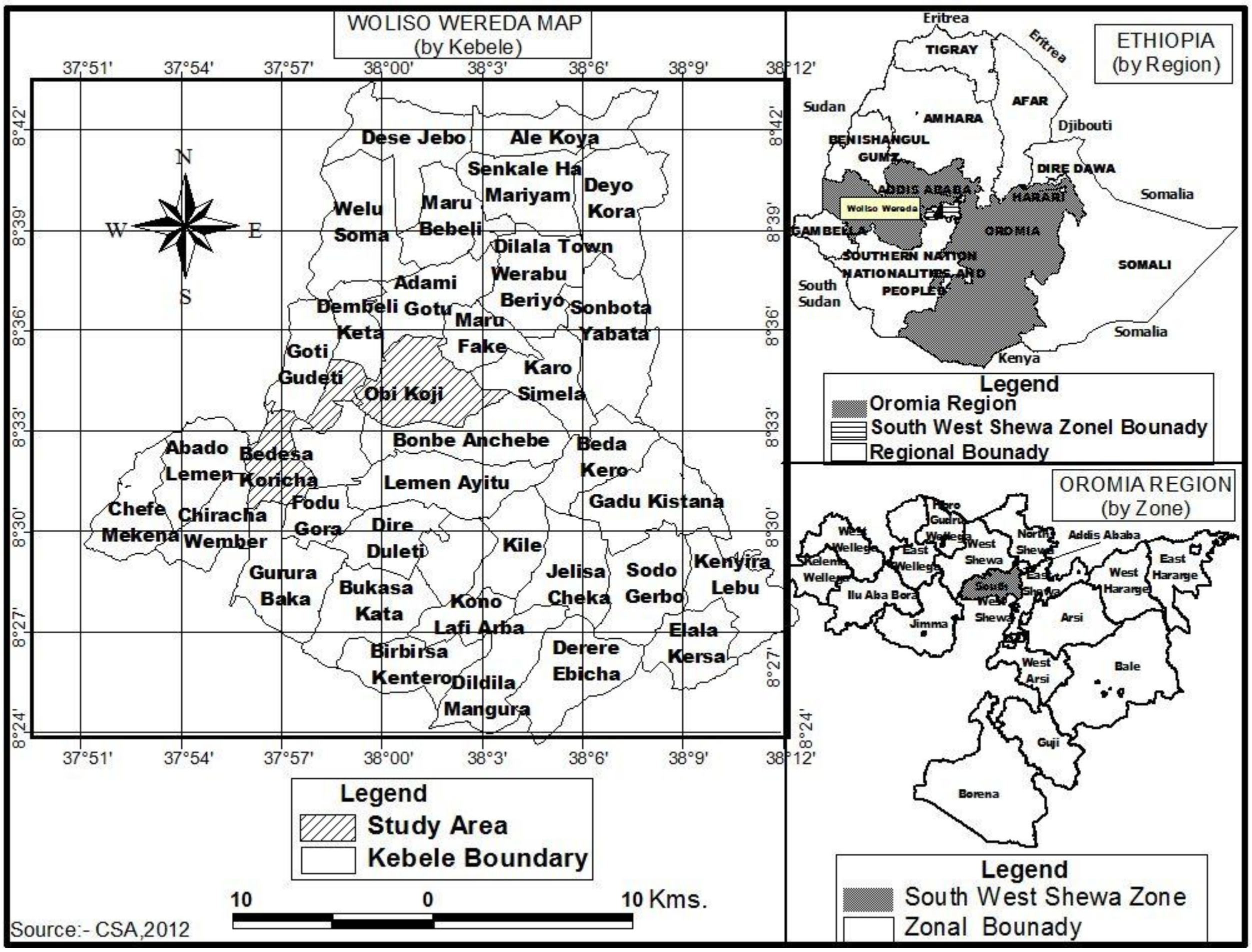

Figure 3. Location Map of the Study Area.

Location and land use

Waliso Woreda is located at 114km distance from Addis Ababa, the capital city of Ethiopia on the highway to Jima city, southwest direction of the country. The highest point is 2800 m.a.s.l and the lowest is 1850 m.a.s.l in the *Woreda*. Geographically, the Woreda is located between 8^0 24'14" and 8^0 43' 11"N latitude and 37^0 51' 11"and 38^0 12'5"E longitude. *Waliso* is found in Southwest Shoa Zone of Oromia National Regional State according to the current administrative region of Ethiopia. It is bordered by Wonich Woreda in the west, Dandii and Dawoo Woreda in the north, Saden Sodo and Bacho Woreda in the east and southeast, and Goro woreda in south direction. The total area coverage of the Woreda is 70,238 hectares and the Woredas land use and land cover consists of cultivable land 38,524 hectares, forest land 5,513 hectares, for building 3,565 hectares, for investment 471 hectares, for planting trees 79 hectares, for grazing 15,820 hectares and not usable land 466 hectares (SWSRLAO,2018).

Climate

The agro-ecological zone of *Woliso* Woreda is 30% high land and 70% mid land. The mean annul temperature and rainfall are 18.5^oc and 1350 mm respectively. The Woreda has unimodal rainfall nature (main rainy season occurs in summer that is between April and August).The area has good rainfall amount and distribution. But over the last more than two decades the rainfall pattern is varying due to climate change (NMA, 2018).

Soil, Vegetation and Water Resources

The soil type in texture is clay, sandy and loam according to the order of percentage in land area coverage. The district soil types in color are 70% red, 25% black and 5% mixed color. The vegetation cover of the study *Woreda* involves mainly natural forest, shrubs, bush and wood land. The district is well known by its underground and surface water like rivers and streams. *Ijersa*, *Keldha* and *Walga* are the three big rivers known in the *Woreda* (WWANRO, 2018).

Population

The *Waliso Woreda* has a total population of 174,453 (Male 87,067 and Female 87,386) at the end of 2014 according to Central Statistics Authority projection. Out of the total population, 14% are less than five years,20% between 6-15 years, 55% from 16-64 and 11% above 64 years old. The number of urban population is 3,539 (*Waliso* city is not included) and that of rural population is 170, 915. The *Woreda* households/HHs/ are 24,901(Female number is 1,113) (Data projected by *Waliso Woreda* Finance and Economic Development Office based up on 2007 CSA population Census study).

Economic activities

The Woreda dwellers earn 80% annual income from agriculture, 18% from trade, and 2% from service sector. The share of agricultural income from crop is 60% and livestock is 40%. The Woreda livestock population number at the beginning of 2016 is indicated in the Table 3 below.

No	Livestock type	Livestock number in 2016
1	Cattle	223,534
2	Sheep	39,543
3	Goat	51,042
4	Donkey	16,320
5	Horse	7,625
6	Mule	2,101
7	Chicken	127,679

Source: WWAHFRO, 2018

3.2. Research Design

The design for this research is non-experimental field based research where the determining variables can be measured in the real context without control, as in the case of experimental one.

Descriptive and explanatory research design types were appropriately applied in this research. Descriptive research set out to describe and to interpret the "what is" questions and looks at the study units with the aim to describe, compare, contrast, classify, analyze and interpret the entities, and the events that constitute the study. Different socio-economic, institutional and demographic situations were described at first. Household survey and field observations as methods enabled the researcher to describe the phenomena. A cross-sectional analysis across the adoption categories was conducted on the representative sample respondents with the intention to describe the nature of existing socio-economic, demographic and institutional situations.

The regression model as an explanatory research tool was used to determine the kind and magnitude of relationship among the dependent and independent variables under study.

In this study, both qualitative and quantitative (mixed) data collection and analysis approach was followed to triangulate the interpretation of data and results to enhance the reliability and validity of findings. In qualitative approach in-depth Key Informants Interview (KIIs), Focus Group Discussions, Observations were techniques for data collection. Education of the household, sex, marital status, awareness of climate change, willingness to adopt practices and belief are some examples of qualitative indicators in this research.

In the quantitative research method household survey on the basis of structured questionnaire interview was conducted by researcher and enumerators during the month of March, 2018. The quantitative data generated include age, income, family size, farm size, livestock holding and distance of infrastructure facilities.

These mixed approach research design was thought to be appropriate to answer the research questions and then met the objectives, because it helps to identify and analyze the existing physical and non-physical (behavioral) dimensions of determining factors in adopting climate smart cattle production practices. This means integrating different methods of research helps to address the socio-economic and institutional context with in which the climate smart cattle production practices are implemented.

3.2.1. Sampling frame

Sampling frame is the actual set of units or elements of study from which a sample has been drawn. Accordingly, the up to dated list of smallholder farmers in cattle production targeted by government and non-governmental organization for climate smart cattle production programs in *Badesa Koricha* and *Obi Koji kebeles* were taken from the *Woreda* animal and fishery resource offices by the researcher. The total list of these cattle producers is 500 (250 in *Badesa Koricha* and 250 in *Obi Koji* kebele).

3.2.2. Sample size

Yamane (1967) provides a simplified formula to calculate sample sizes. This formula was used to calculate the sample size in Tables 4 and is shown below. A 90% confidence level and P = .1 are assumed for the equation.

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

Where n is the sample size, N is the population size, and e is the level of precision. When this formula is applied to the target population in Table 4 below, we get the following equation. This formula is utilized since the target population households are small.

$n=500/1+500(0.1)^2=83$

Table 4.Sample household distribution of the selected *kebeles*

Name of kebele	Total No-Female HHs	Total No-Male HHs	Sum	Sample HHs		Total Sample HHs	Percentage Each KA
				Male	**Female**	**Total**	
Obi Koji	30	220	250	33	7	40	48
Badesa Koricha	34	216	250	33	10	43	52
Total	64	436	500	66	17	83	100

Source: WWAHFRO, 2018

3.2.3. Sampling Techniques

This study follows multi-staged (three stages) sampling technique, where a combination of sampling techniques were used to select the *Kebeles* and households. Purposive sampling method was employed to select the study *Woreda* and the two targeted study *kebeles* intentionally since it is the cattle potential area for cattle production, but threatened by climate change and population pressure and also relatively better targeted by government and NGO for climate smart cattle production programs. Other *kebeles* of the *Woreda* are also targeted for climate smart cattle production practices even though the relative magnitude of intervention by government and non-governmental organizations is low due to the issues of infrastructural and other service inaccessibility. Due to this case, the area was purposively selected to research the adoption status and associated determining factors, as well as challenges with the intention of scaling up/out the practices. Finally, from the total population list of extension program, targeted smallholder cattle producing farmers were selected by systematic simple random sampling technique for household survey. The Key Informants and Focus Group members who are assumed to be resourceful persons were also selected purposively to gather appropriate and useful information to complement the survey data and also develop meaning derived from the analysis of survey data.

3.3. Data sources and method of data collection

Both primary and secondary data types were collected and utilized from primary and secondary sources with different techniques. Sampled smallholder dairy and beef cattle producing farmers in the two *kebeles* were interviewed by researcher and enumerators using the structured questionnaire.

3.3.1. Primary Data Collection

Primary data focused on household characteristics (demographic, socio-economic, and institutional); livestock production, adoption of specific climate smart cattle production practices. In addition, information was collected on adoption challenges and source of climate change information with the help of household survey questionnaire. The primary data has also been generated from Key Informant Interviews, Focus Group Discussions, household survey questionnaire and field observations.

Household Survey Questionnaire

This tool helps to generate qualitative and quantitative information at household level. Household survey was undertaken using structured questionnaire which administers through face-to-face contact and interviewing household head. The questionnaire was tested with 5 non-sampled farmers prior to engagement on the actual interview process in order to check for the design of the questionnaire whether it is understood as per the intended purpose in mind. The questionnaire was rectified based up on the input gained from the pre-test and become ready for actual data collection. Research assistants or enumerators fluent in Afan Oromo were recruited and trained before conducting the survey and supervised during the data collection to reduce error. These selected enumerators are supervisor and development agent from animal husbandry and fishery resource office working in the two study *kebeles*.

Data that was collected on household survey includes household composition and characteristics (demographic, socioeconomic, institutional); off- farm and non-farm activities, ownership of assets, social participation, adoption of specific climate smart cattle production practices, adoption constraints, climate change information and others. Data needed to answer all the formulated research questions and determine the research objectives was collected with the help of this tool. In addition, Key Informant Interviews, Focus Group Discussions and Observations were held after the household interviews to obtain supplementary qualitative information on adoption of climate smart cattle production practice.

Key Informant Interviews (KII)

Key Informants were selected purposively to enrich the data reliability and interview guide or checklists are tools for orienting the discussions.

Five Key Informants from each sample *kebeles* were selected purposively to complement the data collected through household survey and checklist (Appendices E) was followed to orient the discussions. The Key Informants are *kebele* Administrators, Development Agents, animal husbandry & health experts and *Woreda* NGO focal person who better know the general situation about the study context and the program. Developments agents were consulted to identify the appropriate time to get the sample respondents at home for data collection. Key Informant interviews could help determine not only what people do but why they do it. The major points of discussion during Key Informant Interviews were climate variability events which frequently occurred in the study area, the climate change impacts, the types of climate smart cattle production practices the farmers commonly adopt to respond to climate change problem, the adoption challenges and farmer's source of information about climate change. Data gathered through this method helps to augment those obtained through the others methods. The information was collected based on questions generated as indicated on the checklist question in appendices E.

Focus Group Discussions (FGD)

Focus Group Discussions were also used to verify the information given by an individual farmer during the survey and to catch an important issue that wasn't raised by respondent farmers. Four (two in each *kebeles*) Focus Group Discussions were organized. Government and NGO staff, women group and innovative farmers (in each *kebeles*) were organized with 5-7 members in a group for Focus Group Discussions (FGDs).Women groups discussions were held independently because it helps to explore the gender related practices. Additionally, women also develop confidence and become open to express their feeling on the topics of the study when meeting arranged independently. Experts' views were assessed to grasp the technical aspects with regard to the topic of study. The group members were selected purposively based on their better position to adopt new farming technologies, their role in program and gender. The aim of this discussion was to understand climate variability events frequently happened in the study area and its impact on livelihood of the rural household. The questions of "what are the types of climate smart cattle production practices farmers adopt to respond to climate variability problem and why farmers did not adopt any climate smart cattle production practices" are also incorporated in the checklist. Finally, adoption challenges and strategic solutions with the supporting roles of institutions required are asked. This tool synonymously used with other tools to triangulate and scrutinize the information needed to answer all research questions. Checklists for the FGDs are presented in appendices F.

Field Observation

Field observation on characteristics of grazing management, watering points, herd management, bio-gas generation and other climate smart cattle production practice was made to see the real situation as it is. This tool was employed when the data reliability requirement is high and cross checking is required.

3.3.2. Secondary Sources

Secondary data sources were important source of information for this study. Secondary sources; like credible reports, Central Statistics Authority of Ethiopian reports, files, books, journals, published and unpublished thesis and articles, government policy and land use planning documents and other sources. The information includes detailed data with regard to agriculture and climate change, source about climate change problems and climate smart cattle production practices in country level and local level (study area),description of the study area, rainfall and temperature data, human and livestock population data, related research findings, etc. This data source was mainly referred during this research proposal preparation to review literature and identify gaps.

3.4. Description of Variables

Dependent Variable

In the study, the following 8 climate smart cattle production practices which are all explained by explanatory variables were identified: rotational grazing, improved fodder, agro forestry, feed conservation, composting, manure management, genetic breed improvement, and bio-gas generation.

Adoption quotient, developed by Sengupta (1967) is the dependent variable used in this study. Adoption quotient for an individual farmer was calculated based on the adoption scores gained by the farmer for the adoption of climate smart cattle production practices. A total of 8 climate smart cattle production practices were used for calculation of the adoption quotient.

Adoption Quotient = (Total adoption scores gained by farmer/Maximum adoption score) x 100

On the basis of the adoption quotient, farmers were classified into three categories for Chi-square analysis) such as low adoption = < (Mean – 1SD), medium adoption = (Mean ± 1SD) and high adoption = > (Mean + 1SD); and also the same three categories applied for multinomial logistic (MNL) regression analysis (Farid *et al.*, 2015).

Independent Variables: The independent variables that are hypothesized to affect the smallholder farmers' adoption of climate smart cattle production practices are combined effects of various factors, such as: household demographic characteristics, socio-economic characteristics, and institutional characteristics in which farmers operate. Based on the review of related literatures, and past research findings, 13 potential explanatory variables were considered in this study and examined for their effect on adoption of climate smart cattle production practices by smallholder farmer practices.

Sex of household head: it is dummy variable taking the value 1 if the sex of household head is male and 0, otherwise. This study expected that sex of the household head may have positive or negative relation to adopt climate smart agricultural practices. Being a female head of household may have negative effects on the adoption of climate smart agricultural practices, because in most countries in Africa, men control access to land through customary tenure, and, as a result, are often considered the main decision-makers in terms of herd management, pursuing of farm inputs, and other major decision to implement climate smart livestock practices. Deressa *et al.* (2008) showed that male headed households could be more likely to have access to technologies and climate change information than female-headed households. As a result, they were in a better position to practice diverse adaptation strategies than the female-headed ones.

Literacy of the household head: this is a categorical variable which takes a value of 1 if household head is illiterate, 2 if non-formal education and 3 if formal education. Literacy of household head is expected to be related positively since education is important to engage income earning potential of household. Literate household heads are able to acquire and process information easily which may lead to more adoption of climate smart cattle production practices and easily understand and analyze the situation better than illiterate farmers. Education level has a significant effect on adoption of technology, that is, rate of adoption is supposed to be higher with the increases of level of education (Farid *et al.,* 2015). The level of education can enable the smallholder farmer to be open to receive, understand and implement the information relevant for the adoption of a new technology (Namara *et al.,* 2003).

Age of household head: it is a continuous variable measured in years. The age of the household head represents experience in farming. The older the farmer, the more experienced he/she is in farming and the more he or she is exposed to past and present climatic conditions over longer horizons of his/her life spans. According to Umunakwee*t al.* (2014) younger farmers are more likely to adopt climate smart agricultural practices since they are economical active ages.

Additionally Teklewold *et al.* (2013) concluded that an increase in age of the household head reduce the probability of adopting CSA practices, because as farmers advances in age they tend to minimize activities that demand much of their labour and management activities and also relay on their experience of indigenous knowledge that help them relatively resilient to shocks than younger farmers so that they find it convenient to relay on their indigenous knowledge than adopt modern practices.

In the contrary, Maysoon (2015) found that the older farmers are more likely to adopt climate smart agricultural practices. Therefore, this study hypothesis that age of the household head may have a positive or negative effect on adoption of climate smart agricultural practices.

Family size: this is a continuous variable and refers to the total number of family members in the household. It is measured in adult equivalent and represents the labour input to the farm (appendice C: table 2).

In this study, if the majority of the family members are including active labor force age, the household will have enough labor force and the probability to use CSA practices is increase. In such cases family size is expected to have positive effect on adoption option (Abrham *et al.*, 2017). Otherwise, if the majority is dependent, the effect becomes negative on adoption option .Therefore this study expected that the size of the family can affect adoption option of CSA to climate change either positively or negatively.

Source of income: It is categorical and takes the value 1-if the source is only agriculture (AG), 2- if the source AG and off-farm (OFF), 3-if the source is from AG and nonfarm (NONF), take the value 4-if the source is from AG+OFF+NONF. Income diversification has a great contribution to improve the livelihood of rural household by reducing pressure from agriculture and increasing the household coping natural shocks (Tatek, 2012). This study hypothesizes that the more diversified source of income positively influences the decision of the household to adopt climate smart agricultural practice.

Access to credit service: it is a dummy variable taking the value 1 if the farmers use credit services and 0, otherwise. Credit can help ease cash constraints and allows farmers to buy purchased inputs such as improved breeds, improved agro forestry and fodder seed/seedlings,concentrates, bio gas generation, AI services and farm equipments (Malefiya, 2017). Thus, this study hypothesized that there is a positive relationship between use of credit and adoption of climate smart agricultural practices.

Farmer to farmer extension contact: it is a dummy variable taking the value 1 if the farmer has access to farmer to farmer extension (information sharing and input sharing), 0 otherwise. Informal institutions and private social networks important in the agricultural technology in terms of transfer of information about new technology. So those farmers that participate in different social activities are better information compare with non-participant. In the present study, this variable is expected to affect farmer's adoption option positively. Institutional investment in agricultural communities (infrastructure, extension services, health care) will affect farmers' ability to absorb risk and, in turn, adopt new practices (Below *et al.,* 2010).

Exposure to information on climate change: This is dummy variable indicating 1 if the household head exposed to information on climate change, 0 otherwise. Access to information on climate change through extension agents, meteorological service, media , and social networks creates awareness and favorable condition for adoption of farming practices that are suitable under climate change also it is an important precondition for farmers to adopt climate smart agricultural practices(Abrham *et al.,* 2017)) . If the farmers get better climate information about seasonal forecasts and climate change, they are expected to adopt different CSA technologies than others. Because the availability of better climate information helps farmers make comparative decisions among alternative climate agricultural practices and hence choose the ones that enable them to cope better with changes in climate (ibid).

Total livestock ownership: it is continuous variable refers to the total number of animals possessed by the household measured in tropical livestock unit (TLU) appendix table 1. Livestock is considered as another asset which is a security against crop failure. As the total number of animals in the household increases, the farmers more likely to adopt climate smart agricultural practices. This can be attributed to increase wealth and income based on the farm households which makes more money available in the households (Malefiya, 2017).

Landholding: this is a continuous variable measured in hectares. Large land sizes allow farmers to diversify their crop and livestock options and help spread the risks of loss associated with changes in climate (Farid *et al.,* 2015). Therefore, this study hypothesized that land holding has positive relation with implementation of climate smart agricultural practices.

Frequency contacts with extension agent: this is a continuous variable which takes a visiting time by extension agent per year. Extension services are an important source of information on husbandry practices and technical support to cattle husbandry in the context of climate smart cattle production practices as well as on climate. This implies that farmers with more access to information and technical assistance on agricultural activities have more awareness about the consequence of climate change. More frequent DA visits, using different extension teaching methods like attending demonstrations and field day can help the farmers to adopt climate smart agricultural practices,. However, all farmers may not have equal access to extension services. Some farmers visit extension agents more frequently while others visit rarely. If the farmers get better extension services, they are expected to adopt climate smart cattle production practices than others (Quddus, 2012). Therefore, this variable is expected to have a positive effect on farmer's choice of climate smart cattle production practices.

Distance to a farm: this variable is a continuous variable represented by walking time (in minute) from farmers' residence/home to their farming place. We expect that the farmer whose farm is far from his residence is less likely to continuously follow up his farm as compared to those whose farm nearer to their home. Thus, it is expected that farmers who live near to their farm are likely to have regular follow up of their farm, hence motivated to respond to climate change on their agricultural activities (Malefiya,2017). Therefore, this study hypothesized that distance from home to the farm has negative relation with adoption of climate smart cattle production practices.

Distance to the market: this is continuous variable measured in kilometers or minutes from the residence of farm household to the market area. Distance to the nearest market, as expected, negatively affects the adoption decision for all inputs; the distance constitutes indeed a constraint on the time that farmers can devote to accessing information and inputs, which in turns determines the cost of production. The residences of farmers' are nearest to the market they get a lot of opportunities as compare to the far ones (Malefiya, 2017). Therefore, this is variable will have a negative sign for the farmers' who are adopt climate smart cattle production practices to climate change.

The choice of independent variables was dictated by empirical literature, behavioral hypotheses suggested by it, and data availability. Hypotheses have been developed around explanatory variables concerning their expected influence on farm level adoption. Table 5 shows the description of and hypotheses around, or expected signs of explanatory variables used in this study.

Table .5 .Definitions, measurement of explanatory variables and expected effects

Variables acronyms	**Description of explanatory variable**	**Types**	**Value**	**Expected sign**
Sex	Sex of household head	Dummy	Male=1.female=0	+ve/-ve
Age	Age of household head	Continuous	Number of year	+ve/-ve
Education	Literacy of household headed	Categorical	1-illiterate 2-Non-formal 3-Formal	+ve
AE	Adult Equivalent	Continues	Family size in adult equivalent	+ve
TLU	Livestock size in TLU	Continuous	Numbers in TLU	+ve
Income	Income source of the respondent HHs	Categorical	1 AG 2 AG+OFF 3AG+NONF 4 AG+OFF+NONF	+ve
Land	Landholding size	Continuous	Hectare	+ve
Credit	Use of credit	Dummy	Yes=1,No =0	+ve
Extcont	Farmer's agricultural extension contact	Dummy	0=No,1=Yes	+ve
FtoFtact	Farmer to farmer extension contact	Dummy	Yes =1,No =0	+ve
DistFarm	Distance to the farm	Continuous	Km/min	-ve
Mktdist	Distance to the market	Continuous	Km/min	-ve
WhetInfo	Exposure to whether related information	Dummy	1=Yes,0=No	+ve

Source: Adapted from Bernier *et al.*,2015

3.5. Methods of data analysis

Based up on the data collected from the sample household respondents, both descriptive and inferential statistics were employed to analyze the quantitative data using SPSS software version 20. Multinomial logistic regression model was used to analyze the factors determining choice of climate smart cattle production practices in the study area.

3.5.1. Descriptive data analysis

Descriptive statistics which includes frequency distribution, percentages, mean, standard deviation and cross-tabulations were used to summarize and presents demographic, socio-economic and institutional factors that was collected from sample household using structured survey questionnaire. The two formulated specific objectives that address the status of adoption of climate smart cattle production practice, and the challenges in adoption were analyzed using the descriptive statistics.

Qualitative data collected through Key Informant Interviews, Focus Group Discussions and field observations was organized, summarized, analyzed and interpreted in relation to the survey results with the purpose to triangulate and complement the results from household survey.

3.5.2. Econometric Data Analysis

The hypothesized explanatory variables were checked for the existence of multi-co linearity problem before starting econometric data analysis. When there is multi-collinearity problem and one of the explanatory variables with strong collinearity is dropped.

Econometric data analysis model has been used to identify factors affecting smallholder farmers' decision to choose climate smart cattle production practices to response to climate change and variability. Multinomial logistic regression (MNL) model as a type of econometric model was used to identify and interpret main socio-economic factors affecting adoption of climate smart cattle production practice. This model suits such type of analysis as it permits the analysis of decisions across more than two categories, allowing the determination of choice probabilities for different categories. The Multinomial logistic regression model was used to answer the research questions related to the specific objective of determining the factors of adoption and how they are related with adoption level.

The assumption to use this model is that farmer's decision of adoption of climate smart cattle production practice is influenced by different socio-economic, demographic and institutional factors. Inferential statistic like the one way ANOVA-F test and kruskal-Wallis Chi-square were used in order to compare the difference among adoption categories for different continuous and categorical variables and also whether the difference is significant or not.

Application of multinomial logit model to identify the factors influencing degree of climate smart cattle production practices adoption

To identify the level of adoption and factors that influence the respondents' level or degree of adoption of climate smart cattle production practices, a multinomial logit model (as used by Pundo & Fraser 2006) was fitted. The multinomial logit model focused on the degree of adoption of climate smart cattle production practices. In the fitted model, the dependent variable assumed three discrete values – 1 (when the respondent adoption level is low), 2 (when the respondent adoption level is medium), 3 (when the respondent adoption level is high). These adoption levels were calculated based up on the adoption quotient of each respondent. Given the alternatives before a respondent, the probability that an individual i choose alternative j, therefore, can be expressed by the following equation:

$$Pr[Y_i = j] = \frac{\exp(\beta'_j X_i)}{\sum \exp(\beta'_j X_j)},$$

Where:

$Pr[Y_i = j]$ = Probability that an individual i belongs to either 'low adoption', 'medium adoption' ,'and 'high adoption' category.

$j = 1, 2, 3$

$i = 1, 2, 3 \ldots 83$

X_i = Vector of the predictor variables and

β_j = Vector of the estimated parameters

The multinomial logit model determines the effect of independent variable on the probability that a farmer will belong to one of the three categories. This model was estimated by keeping the dependent variable 2 (i.e. medium adopter) as the reference category. The odds ratio (OR), which is the ratio of probability of happening of an event to probability of not happening of that event associated with change in the independent variables is calculated. The variables having higher multi-co linearity were dropped in the final model to improve the values of the variables.

4. Result and Discussion

4.1. Descriptive Analysis Results

4.1.1. Demographic and Socio-Economic Characteristics

The results in the Table 6 show that the household's adoption status of climate smart cattle production practices in relation to demographic and socio-economic characteristics at the study area. According to the data in the Table the majority of the respondents are 66(79.5%) male headed households and the remaining 17(20.5%) are female headed households. When further disaggregated in gender about 4 (16.7%), 9 (20.5%) and 4 (26.7%) of the respondents in the category of low, medium and high level of adoption are female headed while 20 (83.3%), 35 (79.5%) and 11 (73.3%) of the respondents in the category of low, medium and high are male headed households respectively.

Table 6. Climate smart cattle production practices households' adoption status in relation to categorical socio-economic and institutional factors

		Adoption								X^2	Sig
		Low		Medium		High		Total			
		Cout	%	Cout	%	Cout	%	Cout	%		
Sex of the respondent	Female	4	16.7o	9	20.50	4	26.70	17	20.48		
	male	20	83.3	35	79.50	11	73.30	66	79.52	0.567	.753
Education level of the respondent	Illiterate	5	20.80	3	6.80	1	6.70	9	10.84		
	Non formal education	3	12.50	3	6.80	2	13.30	8	9.64		
	Formal education	16	66.70	38	86.40	12	80.00	66	79.52	4.645	.326
Land access	No	2	8.30	0	0.00	0	0.00	2	2.41		
	Yes	22	91.70	44	100.00	15	100.00	81	97.59	5.038	.081
Income source of the respondent household	Only agriculture	12	50.00	18	40.90	6	40.00	36	43.37		
	Agriculture and off farm	6	25.00	18	40.90	7	46.70	31	37.35		
	Agriculture and non-farm	5	20.80	5	11.40	2	13.30	12	14.46		
	Agriculture,off farm and non-farm	1	4.20	3	6.80	0	0.00	4	4.82	3.91	.689
Access to credit service	No	18	75.00	20	45.50	7	46.70	45	54.23		
	Yes	6	25.00	24	54.50%	8	53.30	38	45.78	5.882	0.053
Farmer's agriculture extension contact	No	3	12.50	5	11.40	1	6.70	9	10.84		
	Yes	21	87.50	39	88.60	14	93.30	74	89.16	0.351	.839
Farmer to farmer extension contact(experience sharing)	No	13	54.2	14	31.8	0	0	27	32.53		
	Yes	11	45.8	30	68.2	15	100	56	67.47	5.339	0.069
Access to whether related information	No	0	0.00	1	2.30	0	0.00	1	1.20		
	Yes	24	100.00	43	97.70	15	100.00	82	98.80	0.897	.639

Source: Field survey results, 2018

With regard to the education level of the respondents again the majority 66(79.5%) have a formal education in general, and 9(10.8%) of the total respondents are illiterate which can't read and write. The remaining 8(9.6%) do have non-formal education. When we cross-tabulate these figures as indicated in Table 6 the majority of the respondent are in the category of medium level adopters 44(53%) from which 38(86.4%) have formal education. The minority of the respondent fall in the categorization of high adoption level 15(18.1%) out of which 12(80%) have formal education. The result of the Chi-square shows insignificant relationship of education with adoption level(X^2=4.645, df=4, p=0.326). The result of the Chi-square test shows statistically insignificant relationship between the education level and adoption status but we can see majority of medium and high adopters have formal education which shows the importance of education level in positively influencing the adoption status. Even though the relationship is insignificant, this result is in confirmation with the expectation set before the finding with regard to the direction of relationship. The result shows that there is more probability of educated smallholder farmers to be in medium and higher adoption categories when compared to illiterate ones. The insignificance might be due to the quality and access of formal and non-formal education services to effectively support the smallholder farmers' technology adoption. The level of education can enable the smallholder farmer to be open to receive, understand and implement the information relevant for the adoption of a new technology (Namara *et al.*, 2003).A study conducted by Mamudu *et al.* (2012) also confirmed the more educated a farmer is, the easier he or she adopts modern technology/innovations.

According to the survey report 81(97.5%) of the respondent households have land access through different means and the remaining sample respondents (2) are landless and categorized under low adoption level. When we see land access in terms of household adoption categories 22(91.7%),44(100%) and 15(100%) of the respondents are in the categories of low, medium and high adoption level respectively. According to the survey report these farmers accessed land through different means like government allotment (24.7%), renting from individuals (24.7%) and inheritance or gift (50.6%) from parents. From the total land owners 60.5% has free hold with title mode of land ownership right. There is significance statistical difference between farmers choice of climate smart cattle production practice at less than 0.1 significance with regards to land access (X^2= 5.038, df=2, P =0.081). This shows that secured land access is a basic determining factor for adoption of climate smart cattle production practices. Land access is obviously a fundamental natural resource to run farming and this research analyzed the land access as a dummy explanatory variable and confirmed this fact. But here is recommended to investigate the significance of adoption relationship with regard to household farm size. The result is supported by Henry (2011) who proves that farm size has positively and significantly increased the likelihood of adoption of climate change by diversifying the option for livestock production.

The annual income sources of the respondent households are diversified as it is shown in the Table 6 and in that order of importance 36(43.4%),31(37.3%),12(14.5%) and 4(4.8%) of the respondents earned their 2016/07 production year annual income from only agriculture, agriculture and off-farm, agriculture and non-farm, and agriculture, off-farm and non-farm, respectively. Accordingly, agriculture is the major occupation of the households in the study area as it is the reality in many parts of Ethiopia in general. The majority of medium level adopters earned their income from only agriculture 18(40.9%) and again the same respondent number 18(40.9%) earned income from agriculture and off-farm. Even though the more diverse income sources can be observed in the medium adoption category from the descriptive Table, the diversity of household income source is not statistically significant from the Chi-square test result. According to Tatek (2012) income diversification has a great contribution to improve the livelihood of rural household by reducing pressure from agriculture and increasing the household coping mechanisms against natural shocks. This study was hypothesized that the more diversified source of income positively influences the decision of the household to adopt climate smart agricultural practice.

The result from the household survey showed the majority of the respondents 45(54.2%) does not have access to credit service and the remaining 38(45.8%) reported access to credit service. Out of the total credit service user respondents 6(25%),24(54.5%) and 8(53.3%) of them are under the category of low, medium and high adoption level respectively. There is significant statistical difference between farmers choice of climate smart cattle production practice at less than 0.1 significance level with regards to access in credit service (X^2 = 5.882, df=2, P =0.053).Access to credit service strengthens the financial capacity of the smallholder cattle producers to utilize the innovations which enhances efficiency and productivity of the sector. Access to credit services enhances probability of a smallholder farmer to adopt climate smart cattle production practices that improve smallholder food security and income. This result agrees with the findings of Amao and Ayantoye (2015), who proved that access to credit, can be used to expand farm production through creating the financial capacity to purchase and use of modern improved agricultural inputs.

The survey result in the Table 6 indicates 74 (89.2%) of the respondents have agriculture extension service contacts. Out of this service users 21(87.5%),39(88.6%) and 14(93.3%) are in the low, medium and high adoption categories respectively. This result shows most of the respondent are extension service users where the majority of medium adopters are extension users and the level of adoption has some insignificant relationship with the services. The result of the study is in line the finding of Quddus (2012) who proved that if the farmers get better extension services, they are expected to adopt climate smart cattle production practices than non-users. Here it is recommended for further study with large sample size to further prove the significance of existing relationship, causations and effectiveness of government extension services.

According to the survey report 56(67.47%) of the total sample households have a farmer to farmer extension contact in the form of field day visits for experience sharing and the remaining 27(32.53%) respondents reported they did not make any extension contact with fellow farmers. Some respondent farmers participate in adoption of the improved practices despite their non-contact with surrounding fellow farmers for experience sharing. But as it is evident in the descriptive summary report majority of the respondent households who engaged with other farmers for experience sharing participate in greater number in medium and higher categories of adoption.

The X^2 test revealed the existence of significant statistical difference between the smallholder farmers in choosing climate smart cattle production practice (X^2=5.339, df=2, p=0.069) with respect to farmer to farmer extension contact at 0.1 significance level. Farmer to farmer learning by doing is a strong extension method that helps to disseminate technologies among smallholder farmers. Farmers can highly convinced and motivated to adopt when they see by themselves how the nearby fellow farmers succeeded in doing farming. This is in line to the findings of Tessema *et al.(*2013) which says that social networks can facilitate cooperation to overcome collective action dilemmas and helps those farmers that participate in different social activities to have better information to adopt improved practices when compared with non-participants.

82(98.8%) of the respondent reported access to whether related information through different sources. This access to whether information in relation to level of adoption categories are 24(100%), 43(97.7%) and 15(100%) for low, medium and high adoption level respectively.

The result of the study in Table 7 shows that the mean age of the sample households is 44.69 years with standard deviation of 10.481. This shows that the sample households are dominated by relatively middle adulthood farmers who are still within the economically active group. According to Santrock, (2011) the age is grouped based on psychological age classification as early adult hood (20 to 40's years), middle adulthood (41 to 60's years) and late adulthood (60 years and above).

The age of the household head represents the experience in farming and the work force for the adoption of climate smart cattle production practices. As indicated in the Table 7 the mean age of respondent that fall in the adoption categories of low, medium and high are 43, 47 and 43 respectively. In a similar manner the standard deviation for low, medium and high adoption categories are 12, 10 and 9 respectively which are not far from each other as the mean age does. According to the Ch-squre result in the Table, there is statistically insignificant relationship between the household head age and adoption level which shows age is not significantly determining the status of adoption.

Adult equivalent is the weighted family size and the family labor for the adoption of climate smart cattle production practices. As indicated in the Table 7 the mean adult equivalent (AE) for the respondents is 5.75 and the standard deviation is 2.48 in general.

When the cross-tabulation is analyzed the mean adult equivalent(AE) for the respondent family members that fall in the adoption categories of low, medium and high are 4.69, 6.09 and 6.48 respectively. In a similar manner the standard deviation of AE for low, medium and high adoption categories are 2.14, 2.44and 2.72 respectively. The one way ANOVA result in the Table 8 shows that there is significant mean difference between the groups of adoption categories at less than 0.05 significance level(P =0.036, F=3.464) with regards to family size in adult equivalent. This result implies that productive family labour significantly determine the adoption level and is important factor to enhance adoption of climate smart cattle production practices.

The household survey results indicate the mean and standard deviation of households' livestock holding in TLU is 5.80 and 2.2 respectively. The mean livestock holding of the respondent households in Tropical Livestock Unit (TLU) are 5.21, 5.81,and 6.72 for low, medium and high adoption categories with the standard deviation of 1.74, 2.21 and 2.67 respectively. The result of the study shows there is insignificant relationship between climate smart cattle production practices adoption in all categories (F=2.247, P=.112) with regards to livestock holding size.

Even though the result is not significant it indicates that as the livestock holding of the respondent households in mean TLU increases the number of smallholder farmers categorized under the medium and high adoption level increases. This implies that the livestock holding is important for adoption.

The distance between the home and the farm site is assumed to be determining factor for adoption of the climate smart cattle production practices. It was hypothesized that as the distance increases the rate of adoption would be decreased since the efficiency for cattle management could be compromised. In a similar manner as the distance between market place and the home increases the marketing linkages for the farm inputs and output would not be strong and have a negative relationship. The result of the study in Table 7 shows both the mean and standard deviation for the adoption categories with regard to the two explanatory variables and Table 8 shows that there is insignificant relationship for both variables. From this result we can interpret that distance is not a significant determining factor for adoption of the practices.

Table 7. Mean and standard deviation for the continuous variables

	N	Minimum	Maximum	Mean	Std. Deviation
Adult equivalent	83	.90	14.40	5.7542	2.47792
Agriculture experience of respondent	83	2	56	23.43	11.022
Livestock size in TLU	83	1.07	14.49	5.7981	2.20820
Landholding in hectare per household	81	.38	5.00	1.5293	1.02074
Amount of household annual income in birr	83	20000	274,200	37,904.83	47,872.600
Age of respondent	83	23	73	44.69	10.481

Source: Field survey results, 2018

Table 8. Climate smart cattle production practices households' adoption status in relation to continuous explanatory variables

	Adoption	Mean	Standard Deviation	F	P-value
Age of respondent	Low	43	12	1.49	0.231
	Medium	47	10		
	High	43	9		
AE	Low	4.69	2.14	3.464	0.036
	Medium	6.09	2.44		
	High	6.48	2.72		
TLU Livestock size	Low	5.21	1.74	2.247	0.112
	Medium	5.81	2.21		
	High	6.72	2.67		
Distance between home and farm site in kilometers	Low	0.95	1.03	0.146	0.865
	Medium	0.87	0.65		
	High	0.83	0.65		
Market distance from home in kilometers	Low	4.81	1.74	0.18	0.836
	Medium	4.99	1.98		
	High	4.67	2.13		

Source: Field survey results, 2018

4.1.2. Smallholders' perception on climate variability and its adverse impact

Smallholders' perception on climate variability

At the beginning it was thought important for this research to assess the smallholders' perception in relation to climate variability as well as its associated adverse impact on cattle production during the last 20 years before directly engaged on surveying household adoption status of the climate smart cattle production practices. The smallholders' perception or attitude that has been developed over time due to different determining factors has its own stake in influencing the adoption level of the climate smart cattle production practices (Zighe, 2016). Accordingly, the general climate variability and its associated adverse impact on the cattle production sector were surveyed. In order to assess the details of perception on the weather change items or events subsequent questions were administered to the individual sample households and the results was summarized as it is described in Table 9.

All the 83 sample respondents' reported that in the last 20 years there was climate variability in the *Woreda*, in general. Specifically, 97.6% of the interviewed households responded for temperature and drought increase and the remaining 2.4% responded that there was a decrease of temperature and drought over the last two decades in the study area. When it comes to flooding 89.2%, 9.6 % and 1.2% of the responded household said that there was increase, decrease and no change respectively over the past 20 years. In a similar way as it is indicated in the result Table 9 we can generally observe that the majority of household claimed that water availability and rainfall amount decreases, rainfall intensity and variability increases, and rainfall duration or period become shortening over the last two decades.

In a similar way, results from Key Informant Interviews (KIIs) and Focus Group Discussions (FGDs) that were made with different targeted individuals and groups confirmed the same results of household survey on climate variability. According to the primary results from KIIs and FGDs there is generally observable local climate change and variability. Specifically the identified whether events are increased temperature and drought, decreased rainfall amount and duration, increased rain fall intensity and unpredictability, occurrence of wild fire, increased flooding and wind pressure associated with unusual coldness, shift in agro ecology, change in bio-diversity and habitat. These findings are confirmed with IPCC (2007) study result that climate change and variability became both a global and local real phenomena and manifested with different forms of whether events.

Table 9. Respondent households' perception on local climate variability

		Count	Percentage
Climate change perception of respondent	No	0	0.0
	Yes	83	100.0

	Increasing		Decreasing		No change	
	Count	%	Count	%	Count	%
Temperature change perception of respondent	81	97.6	2	2.4	0	0.0
Drought change perception of respondent	81	97.6	2	2.4	0	0.0
Flood change perception of respondent	74	89.2	8	9.6	1	1.2
Water availability change perception of respondent	3	3.6	80	96.4	0	0.0
Rainfall amount change perception of respondent	7	8.4	76	91.6	0	0.0
Intensity of rainfall perception of respondent	53	63.9	30	36.1	0	0.0
Variability of rainfall perception of respondent	68	81.9	15	18.1	0	0.0

Source: Own field survey result, 2018

Smallholders' perception on adverse impact of climate variability

The general question on adverse impact of climate variability was asked each of the respondent and 98.8% of total respondents reported that there was generally adverse impact of climate variability on their cattle farming. The detail results in Table 10 show that 100% of the respondent mentioned increase of both feed and water shortage during the past two decades due to climate variability. In a similar manner 96.4%,80.7%, and 91.6% of the respondent perceived that over the last 20 years there was spread of disease and parasites, increase in animal heat stress and decrease in cattle growth and reproduction respectively.

Key informant interviews (KIIs) and focus group discussions(FGDs) made with different model farmers, women groups, government development agents, *Woreda* experts and zone officials showed the same results of climate variability adverse impacts on the cattle farming. These negative impacts of climate variability in turn adversely affected the food and nutritional security, livelihood and income of smallholder farmers.

According to KIIs with experts feed availability in terms of quantity, quality and diversity of species gradually decreases. As a result of poor feed availability cattle nutritional content deteriorate, disease out breaks(like ticks, foot and mouth disease, black leg and pastorolosis, fungus),animal growth stunted , lactation interval become shortened , mating time become elongated, which all together adversely impacted the milk and meat productivity. Afla toxin chemicals are formed in the milk which is dangerous for human health.

This conclusion goes with the facts of many literatures (IFAD,2009; FAO, 2013;IPCC,2007) that prove the adverse impact of climate change events in adversely influencing the cattle production sector on which the smallholder depend up on for their livelihood and source of income in many ways.

Table 10. Respondents perception on climate change adverse impacts

	Frequency	Percent
No	1	1.2
Yes	82	98.8
Total	83	100.0

	Increasing		Decreasing		No change	
	Count	%	Count	%	Count	%
Respondent perception of feed shortage	83	100.0	0	0.0	0	0.0
Respondent perception of water shortage	83	100.0	0	0.0	0	0.0
Respondent perception on occurrence of disease and parasites	80	96.4	0	0.0	3	3.6
Respondent perception on cattle heat stress	67	80.7	15	18.1	1	1.2
Respondent perception on cattle growth and reproduction (lactation period, age of fertility, milk productivity.)	7	8.4	76	91.6	0	0.0

Source: Own field survey result, 2018

4.1.3. Climate Smart Cattle Production Practices Adoption status

As it was discussed in the previous section all the sample respondents, key informants and focus groups have reported that climate variability occurred during the last 20 years in the study area. This climate variability has brought an adverse impact on the smallholders' cattle production system. In response to these adverse impacts both government and non-governmental organizations working in the area had promoted climate smart cattle production practices.

According to the information gained during the secondary data collection process, these practices helped to adapt with and mitigate the effect of climate variability during the past five to ten years. Government animal husbandry and fishery resources office, agriculture and natural resource office, Agricultural Growth Program (AGP) and NGO supported Sustainable Land Management (SLM) are some of the climate smart cattle production promoting organizations and programs in the study area. It has also been known from KIIs and FGDs results that local smallholder cattle producers were practicing indigenous adaptive strategies like manure management, rotational feeding, agro forestry, feed conservation and others to cope up with the adverse impact of climate change. The eight climate smart cattle production practices that have been promoted by development actors and adopted by smallholder cattle herders at different level are rotational grazing, improved fodder, agro forestry, feed conservation, composting, manure management, genetic breed improvement and bio-gas generation.

The survey results indicated in the Table 11 shows that the entire sample respondents adopted at least two of the practices targeted for the study. Results presented revealed that the widely adopted practices are feed conservation (90.4%) and manure management practices (89.2%) and the less adopted one is bio-gas generation (12%). Adoption of composting (67.4%), rotational grazing (62.7%), improved breed (54.2%), agro forestry (51.9%) and fodder species (46.9%) are intermediary adopted climate smart cattle production practices. As it can be seen from the same Table in all practices male households are the major adopters. This result is line with the hypothesis set before start conducting the research and is in line with the study result of Deressa *et al.* (2008) that showed male headed households could be more likely to have access to technologies and climate change and variability information than female-headed households. As a result, they are in a better position to practice diverse adaptation and mitigation strategies than the female-headed ones.

Table 11.Types of Climate Smart Cattle production Practices Commonly practiced in the study area.

	Female		Male		Total adopters	
	Cou	Total %	Cou	Total %	Cou	%
Adoption of rotational grazing	11	13.30	41	49.40	52	62.70
Adoption of fodder species	10	12.00	29	34.90	39	46.90
Adoption of feed conservation	14	16.90	61	73.50	75	90.40
Adoption of agro forestry	11	13.30	32	38.60	43	51.90
Adoption of improved breed	10	12.00	35	42.20	45	54.20
Adoption of manure management(collection, storage &application).	16	19.30	58	69.90	74	89.20
Adoption of composting	10	12.00	46	55.40	56	67.40
Adoption of Bio-gas generation	2	2.40	8	9.60	10	12.00

Source: Field survey result, 2018

The *kebele* and gender distribution of adopting climate smart cattle production practices is presented in the Table 12 as follows. According to the result more practices are adopted by large number of respondent in *Badesa Koricha kebele* as compared to *Obi Koji kebele*.

Table 12. Adopters of Climate Smart Cattle Production Practices by *kebele* and gender

Climate Smart Cattle Production Practices		*Kebele* of respondent							
		Obi Koji				*Badesa Koricha*			
		Female		Male		Female		Male	
		Count	%	Count	%	Count	%	Count	%
Adoption of rotational grazing	No	4	44.4	12	38.7	2	25.0	13	37.1
	Yes	5	55.6	19	61.3	6	75.0	22	62.9
Adoption of fodder species	No	6	66.7	21	67.7	1	12.5	16	45.7
	Yes	3	33.3	10	32.3	7	87.5	19	54.3
Adoption of feed conservation	No	0	0.0	0	0.0	3	37.5	5	14.3
	Yes	9	100.0	31	100.0	5	62.5	30	85.7
Adoption of agro forestry	No	6	66.7	16	51.6	0	0.0	18	51.4
	Yes	3	33.3	15	48.4	8	100.0	17	48.6
Adoption of improved breed	No	4	44.4	9	29.0	3	37.5	22	62.9
	Yes	5	55.6	22	71.0	5	62.5	13	37.1
Adoption of manure management	No	1	11.1	7	22.6	0	0.0	1	2.9
	Yes	8	88.9	24	77.4	8	100.0	34	97.1
Adoption of composting	No	6	66.7	19	61.3	1	12.5	1	2.9
	Yes	3	33.3	12	38.7	7	87.5	34	97.1
Adoption of Bio-gas generation	No	8	88.9	25	80.6	7	87.5	33	94.3
	Yes	1	11.1	6	19.4	1	12.5	2	5.7

Source: Field survey results, 2018

In the study area, all sample respondent farmers adopt at least two climate smart cattle production practice in combination during the same cropping season at the same time rather than choosing only one climate smart cattle production practice as best practices. This is a good experience that has to be scaled up/out since the CSA approach itself is designed to identify and enable implementation of strategies that explicitly account for each of the objectives(productivity, adaptation and mitigation), reducing tradeoffs and enhancing synergies between them, across varying conditions (Lipper, 2014). This study grouped the respondents based on the adoption quotient derived from calculated adoption scores and compared the result with arithmetic's of adoption mean and standard deviation that is mentioned under the subtitle of variables description in this document. Table 13 shows 24(28.9%), 44(53%) and 15(18.1%) of the respondent categorized under low, medium and high adoption level respectively for Chi-square and Multinomial logistic (MNL) regression analysis.

Table 13.Respondent household adoption categories

	Frequency	Percent
Low	**24**	**28.9**
Medium	**44**	**53.0**
High	**15**	**18.1**
Total	**83**	**100.0**

Source: Field survey results, 2018

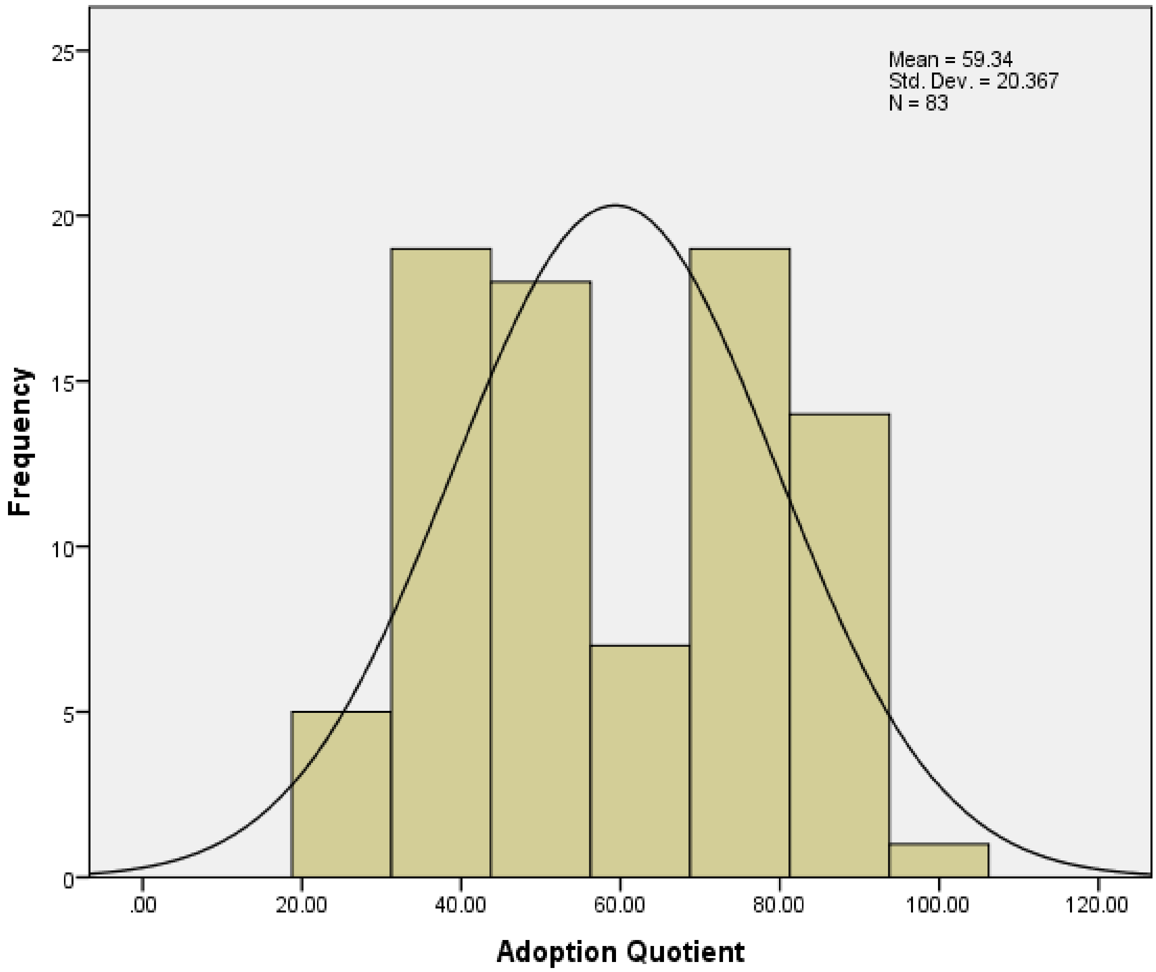

Figure 4: Adoption quotient of smallholder farmers

Source: Own survey result, 2018

The result of analysis of adoption quotient of smallholder farmers in Figure 4 above indicates that the minimum adopted practices are two and the maximum number of practices adopted is 8.The majority of adopters are categorized in medium level while the minority of adopters categorized under higher adoption category. The mean adoption quotient is 59.34 and standard deviation is 20.367 which show that there is an encouraging adoption practice which needs to be scaled up/out to similar context.

Feed conservation helps to bridge the gap between livestock feed requirements and the production of feed. If good quality feed is conserved, the nutritional gap between high quality (wet season) and low quality (dry season) forage may also be bridged. Hay produced from natural grasses, improved forage legumes and browse legumes is the most appropriate conserved forage for small-scale fattening or dairy production in Ethiopia (Alemayehu, 2002). Forage conservation is especially important for dairy production because it ensures a supply of balanced nutrients for dairy animals throughout their lactation period.

Feed conservation is a good climate smart cattle production strategy adopted by farmers especially during dry season to adapt and cope up with feed scarcity. It is also a good strategy to mitigate climate change impact because when the proportion of concentrate in the diet is higher, the emissions of CH_4 gas released to the ambient atmosphere become lower. Improved livestock diets, as well as feed additives, can substantially reduce CH_4 emissions from enteric fermentation and manure storage (FAO, 2006a).

According to the key informant interview results made with government animal and fishery resource office experts and *kebele* leaders the major feed sources, in the order of importance, are crop residue, natural pasture, concentrates, non-conventional feed resources, and fodder trees. Key informants reported that feed shortage occurs during the period between December to May and conservation feeding is one of the feeding strategy used to curb the shortage during this time. Conservation and concentrate feeding is the dominantly adopted practice (90%) and commonly practiced by most farmers throughout the year and mainly during feed shortage since the two *kebeles* are located in the peri-urban area of *Waliso* town where the concentrate feed supply and milk demand is high. This study result is in confirmation of the CSA (2012) result that identified livestock feed resources in Ethiopia are mainly obtained from natural and improved pastures, feed conservation(through hay making and crop residue), forage crops, agro-industrial by-products and non-conventional feeds.

The following Table 14 is a study area feed calendar which developed with key informants. The finding is supported with a study result reported by Tolera et al. (2012) which classified national livestock feed sources as natural pasture, crop residue, improved pasture forage and agro-industrial by-products, of which the first two are the most important contributors.

Table 14.Seasonal feed availability (feed calendar) of *Waliso Woreda*

Feed sources	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Crop residue												
Natural pasture												
Concentrate												
Non-conventional feed resources												
Fodder trees												

Remarks: Red color=low, Yellow color=medium, Green color=high and the blank or white =non availability

Source: Field survey result, 2018

Manure management is one of the climate smart cattle production management component that encompasses technologies like anaerobic digesters for biogas generation and fertilizer, composting, improved manure handling and storage, (Example: covering manure heaps in the pits and under shade) and application techniques (Example: rapid incorporation) (Chadwick *et al.*, 2011).

According to the survey results sample respondents practice different manure handling techniques like covering in a pit (29.3%), collect under shade (60%) and add ash (10.7%). Some practices of cattle manure collection, storage and application was traditionally used as an indigenous practices by local farmers for fertilization, fuel and income generation. GHG mitigation options include the capture of CH_4 by covering manure storage facilities (biogas collectors). The captured CH_4 can be flared or used as a source of energy for heating, cooking and lighting. Energy generated in this way can offset CO_2 emissions from burning fossil fuelsand fire wood. Generally this technology has a triple win of yield increment through organic fertilization, adaptation through soil moisture and microorganism stabilization and mitigation through methane (CH_4) gas reduction. The manure collection, storage and application practices are widely adopted (89.2%) by the respondents since it is traditionally well established practice and saves farmers from high cost of inorganic fertilizer use. Composting is widely government promoted practice in the area and adopted by household farmers in third stage (67.4%).

But the bio-gas generation technology adoption level is low in the study area (12%) mainly due to financial limitation (27%) and lack of awareness (22%). According to the survey results the current status of bio gas apparatus arethose functioning (7.2%), under construction (3.6%) andnot functioning (1.2%).

Figure 5. Bio-gas generation at *Badesa Koricha kebele*

Soil biomass production and vegetation increases and as a result livestock production will be enhanced when rotational, planned or adaptive grazing practices are adopted and disseminated among the small holder farmers. Proper pasture management through rotational grazing would be the most cost-effective way to mitigate GHG emissions from feed crop production and grass land carbon sequestration. Animal grazing on pasture also helps reduce emissions attributable to animal manure storage. Rotational grazing also prevents the problem of overgrazing which can cause land degradation and soil erosion (IFAD, 2010). Farmers respondent in the study area

(62%) used to practice rotational grazing and stall feeding (55.4%) due to land shortage and other indicated reasons.

Improved cattle breeding practices is adopted by sample respondents (54%) mainly through Artificial Insemination (97.5%) according to the household survey result. The mean number and standard deviation of improved breeds adopted by sample household respondents are 3.29 and 2.2 respectively.

This practice was mainly supported by local government animal husbandryoffice and some innovative farmers accepted the technology because of the associated milk yield and attractive milk market opportunity in the nearby *Waliso* town.Local cattle breed that cross breed with improved genetic species have triple advantages of enhancing productivity, adaptation and mitigation strategic importance (Gill *et al.,* 2010).

Figure 6. Improved dairy cow feed at home in *Badesa Koricha Kebele*

Agro forestry and fodder tree planting practices are the two integrated multipurpose climate smart cattle production practices that serve as food, feed, fuel, fiber and fire wood and require resources like land, water, labour, knowledge and other capital to develop. It also as environmental conservation benefits like carbon sequestration, soil erosion protection, soil fertility improvement, water percolation, shade, medicine and other ecosystem and biodiversity services (Alemayehu,2002). Results from the sample respondents indicate agro forestry (51%) and fodder species (46.9%) were adopted at medium percentages.The mean number of agro forestry trees planted by respondents is 167.87 and the mean land area of respondents cultivated by fodder species is0.19076 hector**.** From the total respondent 75% reported planting agro forestry trees on farm boundary and 25% reported planting on terrace bank. Similarly the respondents planted fodder trees on farm boundary (75.6%), terrace bank (8.1%), fence(8.1%),farm land (5.4%) and bush land (2.7%). 72.8% of the respondents reported planting agro forestry before 7 years, 20.5% between 4-6 years and 6.8% between 1-3 years. Similarly 73% of respondents plated fodder trees before 7 years, 18.9% between 4-6 years, and 8.1% between 1-3 years.

According to the key informants interview and focus group discussion result the type of agro forestry and fodder trees in the study area are elephant grass, sassbania, oats, vetch, cow pea, peagampea, lablab, trulucern, lucenia, desmodium, fruits,ad others.

Figure 7. Back yard Elephant grass and *Sasbania tree in Obi Koji kebele*

In the technology adoption process farmers' awareness and interest are the pre-requisites for adopting that technology. The result in the appendices' Table 1 shows the adoption level of each of the eight practices in relation to weather they have or have not prior awareness and interest with regard to that practice. From the survey result it can be concluded that even though the farmers have awareness they may or may not develop interest or positive attitude to adopt. Again having both awareness and interest they might not practice the technologies due to issues of inputs availability and economic access.To mention as an example the entiresurveyed respondent (83) reported having awareness on conservation feeding practice but 81 respondents showed interest and 2 didn't express interest. Out of those who showed interest 74 adopted and 7 didn't adopted the practices. Those who didn't adopt are mainly due to limitation of finance and unavailability of inputs. This situation proves the conceptual framework discussed in the literature partwith regards to innovation-diffusion model (awareness or information), adoption perceptionmodel (attitude or interest) and the economic constraints model as determinants of adoption (Uaiene *et al.*, 2009; Evengelista, 2011).

4.1.4. Farmers' major constraints in adopting climate smart cattle production practice

In the process of decision making for adoption smallholder cattle producing farmers faced a number of challenges. The major challenges that prohibited these farmers from adopting the practices are identified and presented in appendices Table 3.According to the results of key informant interviews (KIIS) and focus group discussions (FGDs) the general challenges in adopting climate smart cattle production practice by smallholder farmers are lack of awareness and knowledge, poor attitude and attentions towards the innovations, limited finance and infra-structure,limited land size and land competition with crop production, weak extension services, poor technical and management support, limited inputs availability, input price inflation, weak policy support, and cultural barriers.

This finding is in agreement with the study of Williams,*et al.*(2015) that described the number of challenges faced climate smart agriculture in relation to the conceptual understanding, practice, policy environment and financing of the approach.

Proper pasture management through rotational grazing would be the most cost-effective way to mitigate GHG emissions from feed crop production and through grass land carbon sequestration. Animal grazing on pasture also helps reduce emissions attributable to animal manure storage (IFAD, 2010). Non-adopting smallholder respondent farmers in the study area mentioned different primary constraints as a reason for not practicing rotational feeding. According to the results from the household survey 31(37%) of the respondent did not adopt rotational feeding practice mainly due to poor awareness and limited knowledge on the benefit (28.6%), few livestock holding and availability of grazing area for the animals (28.6%), existence of grazing land communal ownership(17.9%), shortage of labour(10.7%), weak enforcement of land use policy (10.7%) and others(3.6%).The finding of the Alemayu (2002) supports this result in that overgrazing and absences of land use policy in Ethiopian are the major constraints in adopting planned pasture management practices.

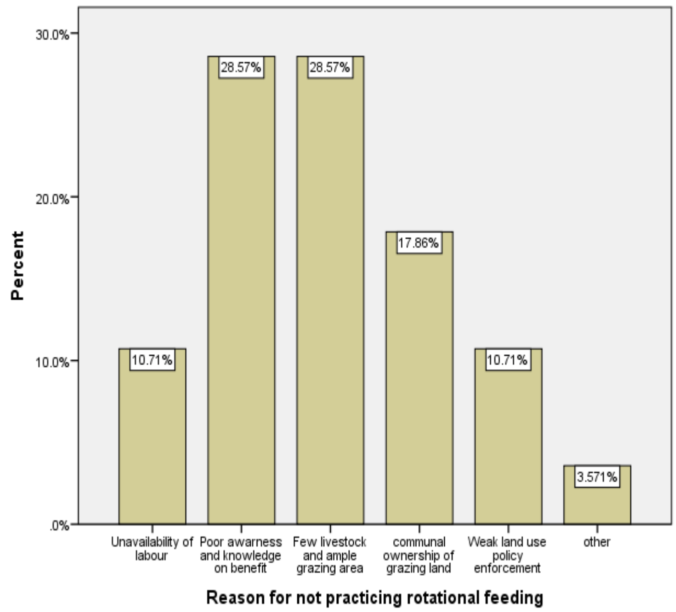

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Figure 8. Reason for not practicing rotational grazing

Out of the total sample respondent 44 (7 are female) of them reported non-adoption of improved fodder species mainly due to small plot of land (66%), lack of labour(12.8%), unavailability and inaccessibility of fodder seed/seedlings, planting and watering materials (6.4%), lack of information (6.4%), land competition for crops (6.4%) and problem of free grazing (2.1%) in that order of importance.This finding is in agreement with that of Mutambara, Dube and Mvumi (2012) which identified land size and availability of information as determining factors for adoption.

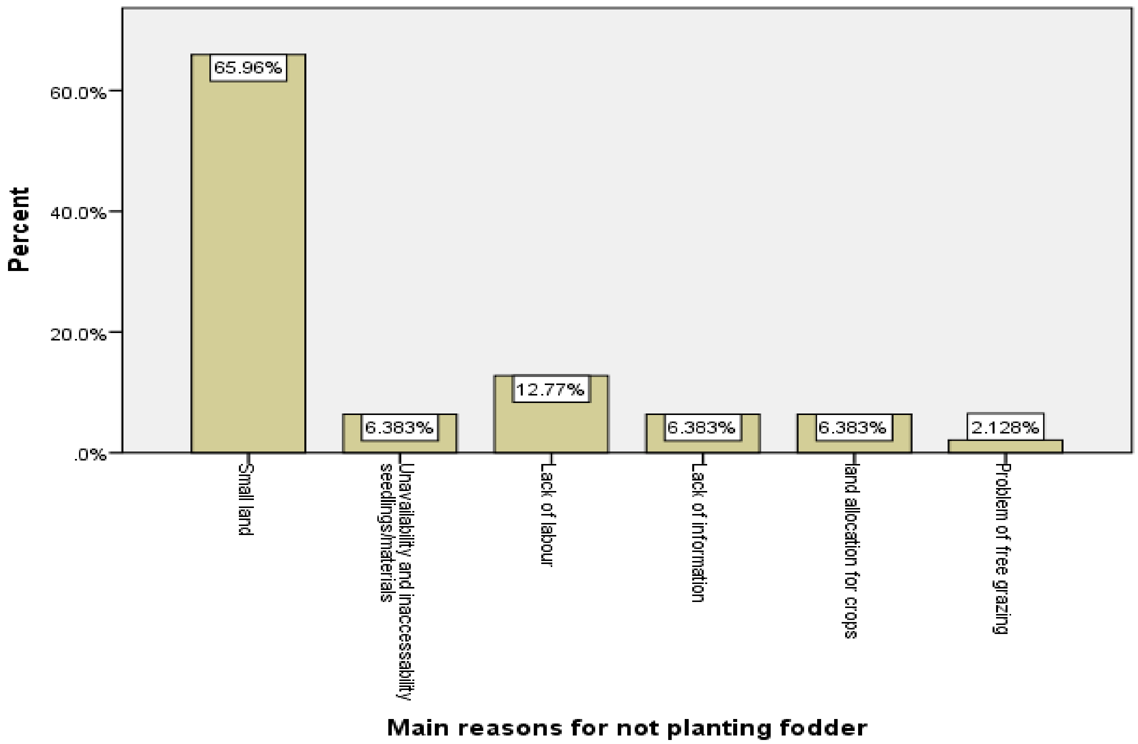

Figure 9. Main reason for not planting fodder

Proper conservation feeding to the dairy and beef cattle is efficient and productive feeding practice that enhances the yield and compensates the shortage of feed occurring during dry seasons which helps to adapt to climate change impacts. It also contributes to high animal feed conversion rate and then reduces the amount of methane (CH_4) gas released per head of animals in the effort to mitigate greenhouse gas release to the ambient atmosphere (IFAD, 2010). A total of 8 (3 of them female headed) sample respondent didn't adopt cattle feed conservation practices according to the survey report mainly because of limited finance (37.5%), lack of awareness (25%), limited availability of concentrate inputs(25%) and shortage of labour(12.5%). This practice is the dominantly adopted practice where 75 (90.4%) respondents reported to practice it in the farming season of 2016/17 year.

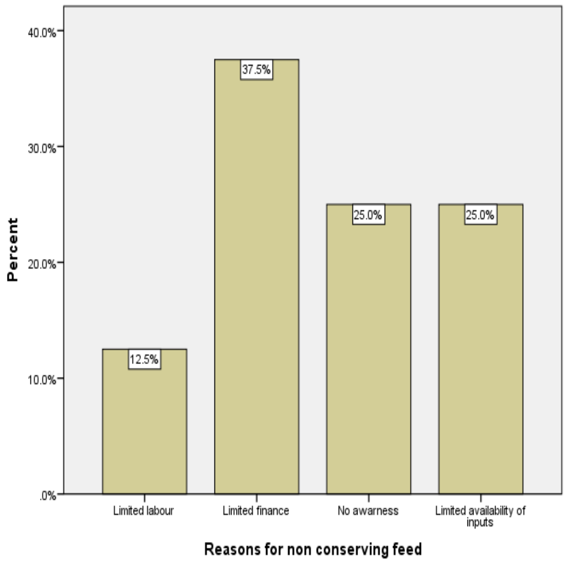

Figure 10.Reasons for not conserving feed

Agro forestry is planting trees together with crops on the farm. These are trees that produce or are primarily used for fruit, fodder, or fuel wood production or thatprovide other benefits such as reducing runoff or erosion, increase water percolation, enhancing soil fertility,providing shade, fencing, wind break and providing medicines. Beside its uses as food, fodder, fuel and fiber agro forestry has a huge potential to adapt adverse impact of climate change and mitigate the long term climate change impact through carbon sequestration (Alemayehu, 2002). Local farmers traditionally used to practices agro forestry in the area according to key informants and focus group discussions.

Result in the appendices Table 3 indicates that out of the total sample respondent 39(6 are female) respondents reported non-adoption of agro forestry practices on their farm as climate smart cattle production practice mainly because of the free grazing(43.6%), poor management(15.4%), hindering cultural attitude(12.8%), unreliability of rain fall and water supply(2.6%) and other factors like limited plot of land, weak land use policy enforcement(25.6%).

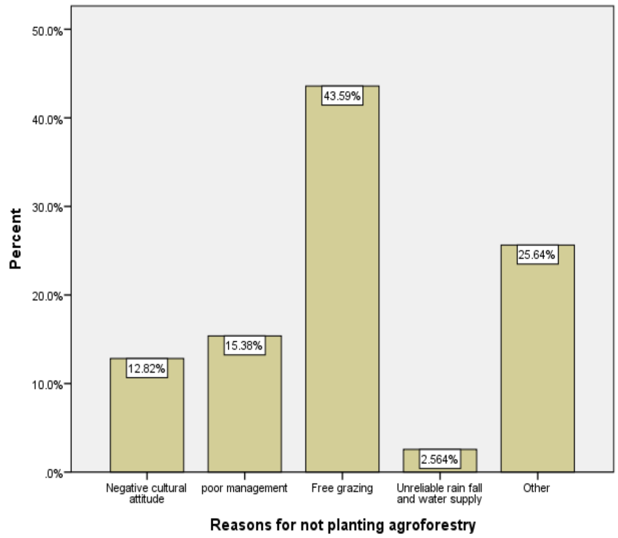

Figure 11. Reasons for not planting agro forestry

Improved cattle breeding practice has a potential to address the three pillars of climate smart cattle production(productivity and income,adaptation and mitigation) and widely promoted in the study area by government and non-governmental organizations since for long period of time according to key informant interviews (KIIs). Even though there is an encouraging adoption status in the study area about 42(50.6%) of the respondent reported that they didn't adopt the practice mainly due to expensiveprice of the improved heifers and financial limitation(61.8%), fear of risk (31%), feed shortage(4.8%) and poor technical knowhow(2.4%).This finding of the cattle breeding practices adoption constraint is supported by FAO (2015) which mainly put investment cost as main barrier

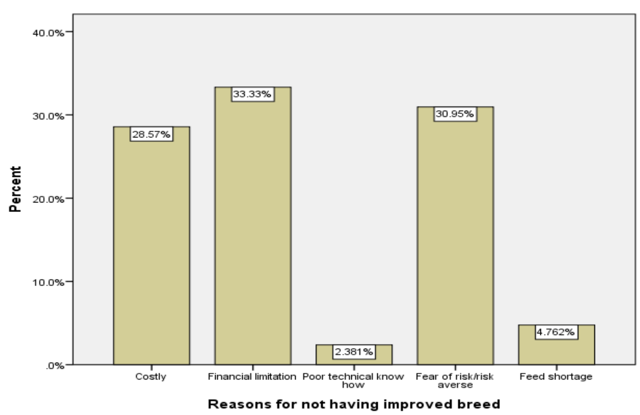

Figure 12. Reasons for not having improved breed

Composting is one of the climate smart cattle production practices widely promoted by concerned government sector program like regular extension program, Sustainable Land Management(SLM) and Agricultural Growth Program(AGP) during the past few years.Composting has an advantage of cost effective soil fertility improvement to increase the crop yield, reduce the greenhouse gas concentration through methane reduction, offset nitrous oxide (N_2O) released by application of inorganic fertilizer, and stabilize the soil moisture and organic matter content(FAO,2013). Despite these advantages 28(34%) of sample respondents didn't adopt composting due to poor awareness and limited knowledge (39.3%),lack of labour (32.1%),small manure quantities (14.3%),unavailability of water for compost preparation (3.6%),farm land distance to apply compost on the field (3.6%) and others(7.1%).This study result is in confirmation with Nyengere (2015) that identified family labour, poor awareness, low level of education and income as major constraints that determines adoption of composting.

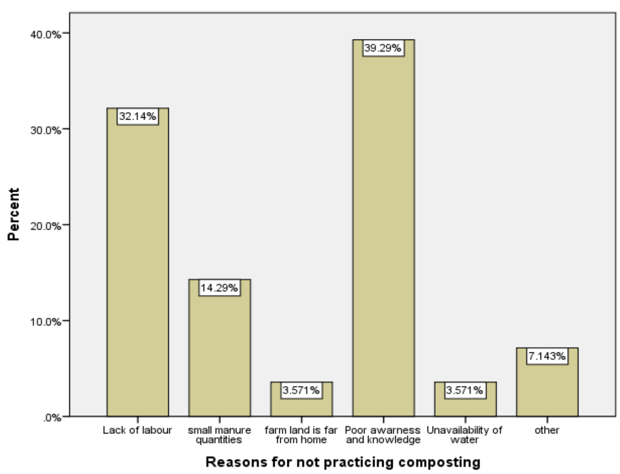

Figure13. Reasons for not practicing composting

Biogas units can be used to convert human and animal waste into a mixture of methane and carbon dioxide that can be used for lighting, heating and cooking (Melaku, 2017).According to the result from the key informant interviews this technology also save labour (especially women and girls productive labour), protects deforestation by substituting fire wood, improve garden vegetable production through the usage of by-products/slurry/ from biogas generation as organic fertilizer and also protect women from the health adverse impact of smoke. This technology was promoted in the two targeted *kebeles* by government energy sector. The study result in the appendices Table 3 indicates 73(88%) of the respondent didn’t adopt the practice mainly due to lack of finance(41.1%), lack of information and awareness(30.1%), lack of knowledge on installation method(9.6%),limited manure quantity due to cattle size (5.5),lack of labour(1.4%) and others(12.3%).Beside the household survey resultgovernment energy resource expert as a key informant responded that shift in household livestock number, management and technical capacity are additional challenges in adopting and maintaining bio gas technology.The finding of the study is in line with FAO (2013) literature that mentioned high investment costs as majorconstraintforadoption. Additionally,the study of Melaku (2017) reveals that the size of cattle holding, working age, gender, access to electricity, access to credit services, and livestock mobility influence household energy choices.

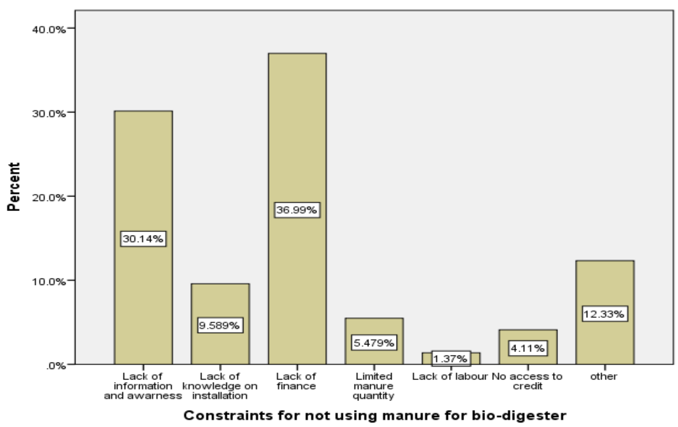

Figure 14.Constraints for not using manure for bio gas digester

4.2. Inferential analysis results

4.2.1. Factors affecting adoption of climate smart cattle production practices

Multinomial logistic regression (MNL) model was applied to estimate the determinants of farmers’ choices of adopting climate smart cattle production practices that aimed to reduce the adverse impact of climate change and variability. In this analysis, “medium level option” was used as base category and the estimated coefficients compared with the base category. The problem of multicolinearity among the explanatory variables was tested using variance inflection factor (VIF) and Contingency Coefficient (CC) for continuous and dummy explanatory variables, respectively. There was no multicolinearity problem for categorical variables (including the dummy variables) and mulicolinearity detected in continuous explanatory variables. Hence, the parameter estimates of the MNL model were used to provide the direction of the effect of the independent variables on the dependent (response) variable, whereas estimates represent neither the actual magnitude of change nor the probabilities. The marginal effects of marginal probabilities are a function of probabilities and measures expected change within the probabilities. In the subsequent section, only the variables that were statistically significant at less than or equal to 10% probability levels are interpreted and discussed.

As can be seen in Table 15 multi-colinearity was observed between family size in adult equivalent (AE) and household head age, livestock holding in Tropical Livestock Unit (TLU) and adult equivalent (AE), distance of farm from home and livestock holding in Tropical Livestock Unit (TLU). Generally, it is predicted that there is a positive relationship between adult equivalent and age which is significant at the 0.01 level and they are very important variables that might also affect the decision to adopt climate smart strategies to climate variability. Therefore, both were considered in the MNL model reported here instead of excluding them from the interpretation and discussions. Tropical livestock unit (TLU) and adult equivalent are also significantly correlated at significance level of 0.01 and adult equivalent (AE) explanatory variable is considered in the interpretation since it is more important in influencing the adoption and TLU is omitted. The distance between farm site and home and TLU is also significantly correlated to each other at 0.05 significance level. Both have insignificant relationship with the adoption level and didn't consider for discussions.

The findings of the MNL model (Table 17) indicate that age is negative and insignificantly related to farmers' adoption strategies to climate change effects at lower adoption level. This implies that the probability of adopting the practices insignificantly decreases the older a respondent farmer at lower adoption level. But the age is negatively and significantly related to adoption of climate smart cattle production practices within the higher adoption category at 5% significance level (p=0.043). The result of the marginal effect in Table 17 indicates as age increase by a one year keeping other variables constant the probability of adoption in higher category decreases by 90.4%. This implies that as farmers get older in age they resist to take new and improved practices. It can be predicted that such farmers have less interest or less incentives in taking climate change adaptation and mitigation measures. Moreover, these older farmers may be more “set in their ways”, interested in following traditional methods familiar to them rather than adopting modern farming techniques.

The earlier researcher hypothesis and study result are the same and also agrees with Umunakwe*et al*. (2014) who said that younger farmers are more likely to adopt climate smart agricultural practices since they are economical active ages. Additionally Teklewold *et al*. (2013) concluded that an increase in age of the household head reduce the probability of adopting CSA practices.

The household family size (AE) has a negative and significant relationship with adoption response variable at 0.05 significance level (p=0.017) in the lower adoption category, but has a positive and insignificant relationship with adoption level in the higher category. As one unit increment of family size in adult equivalent the probability of being in a lower category of adoption decreases by 63.3% as compared to medium adoption category.

The argument is that the negative association is due to: (1) if there are sufficient opportunities for off-farm labor, which would increase household liquidity at a greater rate than on-farm activities, then there will be a flight to quality of a household’s labor endowments and a reduction in actual internal labor availability; (2) if subsistence farming is predominant among the households in the sample, then the same labor shortages assumed to be hindering adoption in income-generating agricultural activity may not be present;(3) a majority of the additional family members are children and/or the elderly, therefore I may assume an overestimate of labor availability using household size. Other studies, such as that of Quayum and Ali (2012) have shown that family size was negatively and significantly related to adoption of technologies, but there is no definitive causation shown in the literature reviewed for preparing this work.

Illiteracy is positively related to adoption at lower adoption level and significant at less than 0.01 (p=0.009).The result indicate that as level of education changes from non-formal to illiterate level the probability of becoming lower adoption category from medium category is 37.115 times greater. This result is similar to the descriptive statistics where more illiterate respondents are found in the lower category of adoption. The result implies that illiteracy is a major determining factor that hinders farmers from becoming higher level of adoption status.

The results agreed with the findings by Kanyama-Phiri *et al.* (1994) who said education has an essential aspect in technology adoption because it changes farmers` perception on culture, social and tradition hindrances to adoption hence the higher the education level attained the lower hindrances to adoption. The results also corroborate with those of Ajayi *et al.* (*2003*) who observed that education level of the farmer influences adoption of new agricultural technologies.

Absence of access to credit service has positive and significant relationship for the respondent to be in lower adoption category when compared to medium adoption category at 0.1 significance level. The marginal probability of becoming lower adoption category from medium adoption category is 3.249 times higher for non credit service users as compared to credit service users. According to the result from the previous descriptive statistics 54.2% of the respondent didn’t access credit service due to different reasons where most of them are in low and medium adoption categories as compared to higher category. This shows that access to credit is a vital tool that will enable a low user of climate smart cattle production practices to rise up to being a high user. When farmers are given access to credit, it will enable them to acquire more technology which might be expensive to purchase. As researcher expected before start conducting this study, the access to credit service has positive relation with adopting the practices and this result agrees with the findings of Amao and Ayantoye (2015), who opined that access to credit in the form of soft loans, can be used to expand production through the purchase and use of modern improved inputs.

Farmer to farmer extension contact as a variable is positively related to farmers' choice of climate smart cattle production practice at 0.05 significance level for higher adoption category. According to the result in the table 16 as compared to farmers who are not engaged with other farmers for experience sharing, the marginal probability of being in higher adoption category is 0.876 times higher for those who are engaged with other farmers for experience sharing, keeping other variables constant. The result of the study confirms the earlier expectation of the researcher. Farmers experience sharing with other farmers in the form of field days and farm demonstration is an effective dissemination method of improved farm practices that can easily convince farmers and develop their trust for adoption.The study result agrees with the findings of Mohammed Nasir Uddin (2014) thatmembership and engagement in a cooperative encourages farmers to engage in a united strategiesorientation; farmers involved in cooperatives share knowledge and innovation ideas, discuss problemsand challenges with others, and engage in collaborative decision-making. Farmer to farmer is a social networking or social asset from which farmers benefit to adopt climate smart cattle production practices.

Table 15. Correlation test result for continuous explanatory variables

Correlations

	Age of respondent	AE Adult equivalent	TLU Livestock size	Distance between home and farm site in kms	Market distance from home in kms
Age of respondent	**1**				
	83				
AE	**.355****	**1**			
	.001				
	83	**83**			
TLU Livestock size	**.121**	**.294****	**1**		
	.274	**.007**			
	83	**83**	**83**		
Distance between home and farm site in kms	**.093**	**.089**	**.260***	**1**	
	.403	**.422**	**.017**		
	83	**83**	**83**	**83**	
Market distance	**.028**	**.082**	**.014**	**-.057**	**1**

from home in kms	**.802**	**.458**	**.903**	**.608**	
	83	**83**	**83**	**83**	**83**

Interpretation: **. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).
Sample size(n)= 83

Table 16. Model Fitting Information

	Model Fitting Criteria	Likelihood Ratio Tests		
Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	**166.731**			
Final	**119.480**	**47.251**	**32**	**.040**

Table 17. MNL Regression Parameter Estimates

Adoption	Variables	Coefficient	Std. Error	Sig.	Change in marginal probability
Low	Intercept	2.542	2.527	.315	
	Age	-.035	.036	.331	.965
	AE	-.457	.191	.017	.633
	TLU	-.033	.210	.875	.967
	DistFarm	.522	.423	.217	1.686
	Mktdist	-.204	.246	.409	.816
	[Sex=0]	-1.057	1.059	.318	.348
	[Sex=1]				
	[Eduction=1]	3.614	1.375	.009	37.115.
	[Eduction=2]	1.347	1.253	.282	3.847
	[Eduction=3]				
	[Land=0]	18.872	7580.395	.998	1.598
	[Land=1]				
	[IncomeS=1]	1.221	1.551	.431	3.392

	[IncomeS=2]	-.683	1.374	.619	.505
	[IncomeS=3]	2.190	1.483	.140	8.937
	[IncomeS=4]				
	[Credit=0]	1.178	.715	.100	3.249
	[Credit=1]				
	[Extcont=0]	1.150	1.187	.333	3.158
	[Extcont=1]				
	[FtoFtact=0]	-.882	.837	.292	.414
	[FtoFtact=1]				
	[WhetInfo=0]	-16.262	.000	.	8.660

Adoption	Variables	Coefficient	Std. Error	Sig.	Change in marginal probability
High	Age	-0.102	0.05	0.043	0.903
	AE	.107	.159	.504	1.112
	Mktdist	-.305	.279	.276	.737
	[Sex=0]	-.071	.977	.942	.932
	[Sex=1]				
	[Eduction=1]	1.947	1.648	.238	7.005
	[Eduction=2]	1.493	1.392	.283	4.452
	[Eduction=3]				
	[Land=0]	.426	.000		1.532
	[Land=1]		.	.	.
	[IncomeS=1]	18.527	5956.989	.998	9.314

	[IncomeS=2]	17.013	5956.989	.998	7.985
	[IncomeS=3]	18.018	5956.989	.998	8.127
	[IncomeS=4]	0^b	.	.	.
	[Credit=0]	-.035	.827	.967	.966
	[Credit=1]				
	[Extcont=0]	.772	1.407	.583	2.164
	[Extcont=1]				
	[FtoFtact=0]	2.088	1.064	.050	.124
	[FtoFtact=1]				
	[WhetInfo=0]	-17.717	.000	.	2.021
	[WhetInfo=1]				

Contin
ued…

5. Conclusions and Recommendations

5.1. Conclusions

The result of the study in the targeted area indicated that all sample respondents reported climate variability and 98.8% of them perceived adverse impact of this climate variability on the smallholder cattle production during the last 20 years. The information from key informants and focus group discussions strengthened the same finding of survey respondents. The smallholder famers have been using traditional and innovative climate smart cattle production practices to mitigate and cope up with the climate variability induced whether events such as temperature increase, heat stress, rainfall shortage and variability. Various combined climate smart cattle production practices were used by the smallholder farmers in response to altered cattle farming. All respondents farmers in the two study *kebeles* have adopted at least two mutually re-enforcing and integrated climate smart cattle production practices promoted and supported by government and partner organizations since the production year of 2010/11.These are feed conservation, manure management, composting, rotational feeding, improved breed, agro forestry, fodder tree and bio-gas generation in that order of adoption priority. Feed conservation was ranked as the first among adoption practices followed by manure management, while bio-gas generation was ranked as least adopted. Male headed household are the major adopters in all practices and most adoptions are categorized under medium level according to adoption quotient calculated based on each respondents adoption score.

The results show that there is a good start to scale up/out the practices to other similar farming spectrum. The wider adoption of conservation/concentrate feeding and manure management and limited adoption of bio-gas generation practices implies that smallholder farmers are commercially oriented and resource efficient. This indicates the existence of potential in expanding dairy and beef cattle farming through capacitating poor, women headed, unemployed youth and limited land owners of smallholder farmers to boost their productivity and income, strengthen their adaptive capacity in the short and medium terms and enhance the mitigation co-benefits in the long run. The rank in adopting the practices has the implication for practitioners to prioritize the initiatives during the plan for intervention. For example there could be a market potential for private concentrate feed producers and fertile ground for development partners to further expand the manure management practices in the effort to mitigate carbon emissions and boost organic fertilization for vegetable production and income generation.

Furthermore, according to all targeted data sources different adoption constraints were identified. These are mainly lack of finance, lack of information and awareness, fear of risk, free grazing, lack of labor, limited land and other assets, crop land competition, poor infrastructure, cultural hindrance and weak institutional support.

This study also sought to determine the factors that influence the smallholder farmers' adoption of climate smart cattle farm husbandry practices. The results showed that there were significant differences of farmers' choice of climate smart cattle production practices with regards to explanatory variables such as household head age, education level, land access, credit service access, farmer to farmer extension contact and family size. Several factors such as family size, education level, access to credit service, access to land and farmers to farmers extension contact have positive and significant effect on adoption of the climate smart cattle production practices, where as household age has negative and significant effect on adoption of the improved practices. Therefore it could be concluded that cattle herders having higher productive family size, educational status, access to credit service, access to land, good social networking and younger in age are more likely to adopt climate smart cattle production practices.

5.2. Recommendations

The major policy implication arising from the results of this study is that efforts has to be made to strengthen and encourage the adoption of the priority climate smart cattle production practices and should be targeted towards the more disadvantaged smallholder households in similar farming context.

It is imperative for government and non- government development organizations to collaborate in strengthening the existing initiatives and works to alleviate the identified challenges faced by smallholder farmers in adopting the climate smart cattle production practices. These identified challenges that deserve attention for collaboration are complementing the startup capital requirement of risk adverse smallholder farmers (especially in expanding improved dairy cattle breed), expand information, awareness and knowledge base, enforce land use policy and other supportive institutions, and develop basic infrastructures.

Government and non –governmental organizations also have to facilitate and support varied extension approaches such as expanding availability and access to credit services, establish and strengthen forum for farmer to farmer experience sharing, expand formal and non-formal education and trainings, organizing youth as small and microenterprise (SME) around allocated plot of land focusing on rural women, unemployed youth and those with weak livelihood asset base to stimulate and nurture the adoption process.

Further research with wider scope is recommended to be conduct on statistically insignificant variables in this study like income diversity, extension service contact, whether information, distance to farm and market place and household livestock holding size to develop a more robust understanding of how these factors influence adoption behaviors. A study of adoption extent, intensity, the number of technical components adopted from the recommended package, continuity and livelihood impact is also recommended by this research in order to investigate the sustainable, more productive use of innovation and associated causations.

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AppendicesA:Tables

Table 1.Respondents awareness, interest and adoption of climate smart cattle production practices

						Count	%
Awareness on rotational grazing	No	Interest on rotational grazing	No	Adoption of rotational grazing	No	**3**	**100.0%**
					Yes	**0**	**0.0%**
			Yes	Adoption of rotational grazing	No	**0**	**0.0%**
					Yes	**0**	**0.0%**
	Yes	Interest on rotational grazing	No	Adoption of rotational grazing	No	**6**	**100.0%**
					Yes	**0**	**0.0%**
			Yes	Adoption of rotational grazing	No	**22**	**29.7%**
					Yes	**52**	**70.3%**
						Count	%
Awareness on fodder species	No	Interest on fodder species	No	Adoption of fodder species	No	**6**	**100.0%**
					Yes	**0**	**0.0%**
			Yes	Adoption of fodder species	No	**2**	**100.0%**
					Yes	**0**	**0.0%**
	Yes	Interest on fodder species	No	Adoption of fodder species	No	**11**	**100.0%**
					Yes	**0**	**0.0%**
			Yes	Adoption of fodder species	No	**25**	**39.1%**
					Yes	**39**	**60.9%**
						Count	%
Awareness on feed conservation	No	Interest on feed conservation	No	Adoption of feed conservation	No	**0**	**0.0%**
					Yes	**0**	**0.0%**
			Yes	Adoption of feed conservation	No	**0**	**0.0%**
					Yes	**0**	**0.0%**
	Yes	Interest on feed conservation	No	Adoption of feed conservation	No	**1**	**50.0%**
					Yes	**1**	**50.0%**
			Yes	Adoption of feed conservation	No	**7**	**8.6%**
					Yes	**74**	**91.4%**
						Count	%
Awareness on agroforestry	No	Interest on agroforestry	No	Adoption of agroforestry	No	**4**	**100.0%**
					Yes	**0**	**0.0%**
			Yes	Adoption of agroforestry	No	**0**	**0.0%**
					Yes	**0**	**0.0%**
	Yes	Interest on agroforestry	No	Adoption of agroforestry	No	**9**	**100.0%**
					Yes	**0**	**0.0%**
			Yes	Adoption of agroforestry	No	**27**	**38.6%**
					Yes	**43**	**61.4%**

							Count	%
Awareness on improved breed	No	Interest on improved breed	No	Adoption of improved breed	No		**3**	**100.0%**
					Yes		**0**	**0.0%**
			Yes	Adoption of improved breed	No		**0**	**0.0%**
					Yes		**0**	**0.0%**
	Yes	Interest on improved breed	No	Adoption of improved breed	No		**7**	**100.0%**
					Yes		**0**	**0.0%**
			Yes	Adoption of improved breed	No		**28**	**38.4%**
					Yes		**45**	**61.6%**

						Count	%
Awareness on manure management	No	Interest on manure management	No	Adoption of manure management	No	**1**	**100.0%**
					Yes	**0**	**0.0%**
			Yes	Adoption of manure management	No	**0**	**0.0%**
					Yes	**0**	**0.0%**
	Yes	Interest on manure management	No	Adoption of manure management	No	**6**	**100.0%**
					Yes	**0**	**0.0%**
			Yes	Adoption of manure management	No	**2**	**2.6%**
					Yes	**74**	**97.4%**

						Count	%
Awareness on composting	No	Interest on composting	No	Adoption of composting	No	**4**	**100.0%**
					Yes	**0**	**0.0%**
			Yes	Adoption of composting	No	**0**	**0.0%**
					Yes	**0**	**0.0%**
	Yes	Interest on composting	No	Adoption of composting	No	**18**	**100.0%**
					Yes	**0**	**0.0%**
			Yes	Adoption of composting	No	**5**	**8.2%**
					Yes	**56**	**91.8%**

						Count	%
Awareness on Bio-gas generation	No	Interest on Bio-gas generation	No	Adoption of Bio-gas generation	No	**56**	**100.0%**
					Yes	**0**	**0.0%**
			Yes	Adoption of Bio-gas generation	No	**0**	**0.0%**
					Yes	**0**	**0.0%**

	Yes	Interest on Bio-gas generation	No	Adoption of Bio-gas generation	No	**15**	**100.0%**
					Yes	**0**	**0.0%**
			Yes	Adoption of Bio-gas generation	No	**2**	**16.7%**
					Yes	**10**	**83.3%**

Table 2. Extent of adopting climate smart cattle production practices

		Count	Percentage
Cattle feeding strategy	Install at home stead	**46**	**55.4%**
	Grazing on private land	**8**	**9.6%**
	Grazing on communal land	**29**	**34.9%**
Where fodder cultivated	Farm land	**2**	**5.4%**
	Farm boundary	**28**	**75.7%**
	Terrace bank	**3**	**8.1%**
	Bush land	**1**	**2.7%**
	Back yard	**0**	**0.0%**
	Fence	**3**	**8.1%**

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Land use option for fodder cultivation	**37**	**.001**	**.820**	**.19076**	**.249702**

		Count	%
Date fodder tree established	Before 1-3 years	**3**	**8.1%**
	Before 4-6 years	**7**	**18.9%**
	Before 7-9 years	**26**	**70.3%**
	Before 10 years & above	**1**	**2.7%**
Fodder seed source	Neighbor	**0**	**0.0%**
	Own seed	**1**	**2.7%**
	Government	**35**	**94.6%**
	NGO	**1**	**2.7%**
	other	**0**	**0.0%**
Fodder production level	Poor	**26**	**70.3%**
	Moderate	**8**	**21.6%**
	High	**3**	**8.1%**
Feed conservation method	No conservation	**0**	**0.0%**
	Hay making	**23**	**30.7%**
	Crop residue storage	**49**	**65.3%**
	Make silage	**2**	**2.7%**
	urea treatment	**1**	**1.3%**
	Mineral nutrient block	**0**	**0.0%**

	Other	**0**	**0.0%**
Land use option for agro forestry	Farm land	**0**	**0.0%**
	farm boundary	**33**	**75.0%**
	Terrace bank	**11**	**25.0%**
	Bush land	**0**	**0.0%**

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Number of agro forestry trees	**45**	**10**	**925**	**167.87**	**193.059**

		Count	%
Date agro forestry established	Before 1-3 years	**3**	**6.8%**
	Before 4-6 years	**9**	**20.5%**
	Before 7-9	**31**	**70.5%**
	Before 10& above years	**1**	**2.3%**
	Neighbor	**0**	**0.0%**
Source of agro forestry seedlings	Own nursery	**4**	**9.1%**
	Government nursery	**34**	**77.3%**
	Private nursery	**0**	**0.0%**
	Market	**2**	**4.5%**
	NGO	**4**	**9.1%**
	School nursery	**0**	**0.0%**
Agro-forestry production level	Poor	**24**	**54.5%**
	Moderate	**13**	**29.5%**
	High	**7**	**15.9%**

	N	Minimum	Maximum	Mean	Std. Deviation
Number of improved breed	**41**	**1**	**11**	**3.29**	**2.205**

Main method for getting improved breed	AI	**39**	**97.5%**
	Through bull	**0**	**0.0%**
	Purchase of calf	**1**	**2.5%**
	other	**0**	**0.0%**
Cow dung(manure) collection	No	**8**	**9.6%**
	Yes	**75**	**90.4%**
Main methods of manure management	Cover in apit	**22**	**29.3%**
	Collect under shade	**45**	**60.0%**
	Collect uncovered in the open	**0**	**0.0%**

	Compost it	**3**	**4.0%**
	Discard in surrounding area	**0**	**0.0%**
	Add ash	**5**	**6.7%**
	other	**0**	**0.0%**
	other	**2**	**7.1%**
Access to Bio-gas digester	No	**73**	**88.0%**
	Yes on planning	**2**	**2.4%**
	Yes in construction	**1**	**1.2%**
	yes functioning	**6**	**7.2%**
	Not functioning	**1**	**1.2%**

Table 3. Farmers' primary constraints in adopting climate smart cattle production practice

		Count	%
Main reasons for not planting fodder	Small land	**31**	**66.0%**
	Unavailability and inaccessibility seedlings/materials	**3**	**6.4%**
	Lack of labor	**6**	**12.8%**
	Lack of information	**3**	**6.4%**
	Availability of alternatives	**0**	**0.0%**
	Availability of crop residue	**0**	**0.0%**
	Limited availability of water	**0**	**0.0%**
	land allocation for crops	**3**	**6.4%**
	Problem of free grazing	**1**	**2.1%**
	Others	**0**	**0.0%**
Reasons for non-conserving feed	Limited labor	**1**	**12.5%**
	Limited finance	**3**	**37.5%**
	No awareness	**2**	**25.0%**
	Limited availability of inputs	**2**	**25.0%**
	other	**0**	**0.0%**
Reasons for not planting agro forestry	Negative cultural attitude	**5**	**12.8%**
	poor management	**6**	**15.4%**
	Free grazing	**17**	**43.6%**
	Unreliable rain fall and water supply	**1**	**2.6%**
	Lack of knowledge	**0**	**0.0%**
	Other	**10**	**25.6%**
Reason for not practicing rotational feeding	Unavailability of labor	**3**	**10.7%**
	Poor awareness and knowledge on benefit	**8**	**28.6%**
	Few livestock and ample grazing area	**8**	**28.6%**
	communal ownership of grazing land	**5**	**17.9%**
	Weak land use policy enforcement	**3**	**10.7%**
	other	**1**	**3.6%**
Reasons for not having improved breed	Costly	**12**	**28.6%**
	Financial limitation	**14**	**33.3%**
	No awareness about the benefit	**0**	**0.0%**
	No supply	**0**	**0.0%**
	Poor technical know how	**1**	**2.4%**
	Fear of risk/risk averse	**13**	**31.0%**
	Feed shortage	**2**	**4.8%**
	other	**0**	**0.0%**

		Count	%
Reasons for not practicing composting	Lack of labor	**9**	**32.1%**
	small manure quantities	**4**	**14.3%**
	farm land is far from home	**1**	**3.6%**
	Poor awareness and knowledge	**11**	**39.3%**
	Use manure for fuel and crop residue for animal feeding	**0**	**0.0%**
	Unavailability of water	**1**	**3.6%**
	other	**2**	**7.1%**

Constraints for not using manure for bio-digester	Lack of information and awareness	**22**	**30.1%**
	Lack of knowledge on installation	**7**	**9.6%**
	Lack of finance	**27**	**37.0%**
	Limited manure quantity	**4**	**5.5%**
	Lack of labor	**1**	**1.4%**
	No access to credit	**3**	**4.1%**
	other	**9**	**12.3%**

Reason for not accessing credit	Fear of inability to repay	**5**	**11.1%**
	High interest rate	**14**	**31.1%**
	Lack of collateral	**5**	**11.1%**
	I don't want	**21**	**46.7%**
	unavailability and inaccessibility	**0**	**0.0%**
	No information or awareness	**0**	**0.0%**
	others	**0**	**0.0%**

Appendices B: Conversion factors TLU and estimate adult equivalent

Appendices C: Table 1 Conversion factors used to determine Tropical Livestock Unit (TLU) of sample household

No	Livestock type	TLU
1	Cow /Oxen	1
2	Donkey /Horse	.7
3	Poultry	.013
4	Sheep/ Goat	0.13
5	Calf	0.25
6	Heifer	0.75

Source: Strock*et al*. (1991) cited by Lemmi (2013)

Appendix C: Table 2. Conversion factors used estimate Adult Equivalent (AE)

S/N	Age categories	Male	Female
1	<10	0.6	0.6
2	10-14	0.9	0.75
3	15-50	1	0.8
4	>50	1	0.8

Appendices C: Questionnaire schedule for household survey

ADDIS ABABA UNIVERSITY

Interview Schedule on

SMALL HOLDER FARMERS' ADOPTION OF CLIMATE SMART CATTLE PRODUCTION PRACTICES: STATUS, DETERMINING FACTORS AND CHALLENGES IN *WALISO* WOREDA, CENTRAL ETHIOPIA

The objective of this interview is to collect data for MSc research conducted for the purpose of education and all information provided will be simply used for education purpose and remain confidential. Your full support and willingness to respond to the question is very essential for the success of the study. Therefore, you are kindly requested to answer all questions and give clear and reliable information on the issues. Please feel free to convey the required information honestly. Thank you in advance for your cooperation.

Part I

I. General Information

Name of *Kebele*___________________

Name of respondent HH___________________________________ ID. Code_________________

Name of respondent(if not HH head): ________________ ID. Code_____________________

Date of Interview: _______________________________________

Enumerator's Name: ______________________________________

II. Household Demographic Factor Related Questions

Sex of household head or respondent 1 male 0 female	Age (years)	Number of years live in this area	Level of Education	Marital status	Number of family Members			
					Age	**M**	**F**	**Total**
					<15			
					15-64			
					>64			

Education level: 0=None 1=Adult education 2= Primary (grade 1-4) 3=Primary(grade 5-8) 4= Secondary(9-10) 5=Secondary (11-12) 6= College or TVT 7= University 8=other (specify) ____________________

Marital status: 1 = Married; 2= Single; 3 = Divorced; 4 = Widowed; 5 = other (specify) ________________

III. Socio-Economic Factor Related Questions

1. Do you have livestock? 0. No 1.Yes
2. If the answer to Q.1 is yes how many of the following types of livestock do you have and died in the production year (2008/09 E.C)? Please fill the following columns.

S/N	**Livestock Type**		**Quantity (head)**	**Died**	**Reason**
1	Cow	Traditional			
		Improved			
2	Ox	Traditional			
		Improved			
3	Calf	Traditional			
		Improved			
4	Heifer	Traditional			
		Improved			
5	Horse				

6	Donkey				
7	Poultry	Traditional			
		Improved			
8	Sheep	Traditional			
		Improved			
9	Goat	Traditional			
		Improved			
10	Beehives	Traditional			
		Transitional			
		Modern			
11	Others (specify)				

2. In case you own dairy cattle, please specify the type and give us some information regarding milk production and marketing

Cattle type	**Dairy cattle number**	**Season of the year**	**Average milk per animal per day(litres)**	**Amount sold(litres/ day)**	**Amount consumed** (Lit/day)	**Where milk sold***	**Why this selling option?****	**Price per litre(birr)**	**Income earned (birr)**
Traditional		Dry							
		Wet							
Improved		Dry							
		Wet							

*1= Individual consumers 2=Traders 3= Institutions (schools, hospitals)
4 = Hotels 5= Processors 6= Supermarkets 7= Other (specify)
____

* * 1= Better price 2= Prompt payment 3= Less distance/transport cost 4= Less quality restrictions 5= Other (specify) ____________________________

3. In case you own & sold beef cattle in 2008/09 production year, please specify the type and give us some information regarding marketing

Beef cattle type	Technology	Total owned	Numbers sold	Average unit price	Total income earned
Ox	Traditional				
	Improved				
Cow	Traditional				
	Improved				
Bull	Traditional				
	Improved				
Heifer	Traditional				
	Improved				

4. Do you have own land? 0. No 1 Yes
5. If Yes, Q no.6 how many hector (timad) of land do you have? __________
6. How do get the land: 1.Allocated by government 2. Rented from individual farmer 3. Inherited
7. What is the main type of ownership for the land you have? *[select one]*

1=Traditional/communal; 2=Freehold without title; 3= Freehold with title;

4= Leasehold/Rented in; 5= Other (specify)____________________________________

9. Which farming activities are you following currently?

1. Only crop production
2. Livestock rearing
3. Mixed farming (Crop production and. livestock rearing)

10. Who is the main decision-maker regarding different farming activities? *[record one,]*______________________

1=HH head; 2=Spouse; 3= Son; 4= Daughter; 5=Farm worker; 6= Participatory 7=Other (specify)___________________

11. Land use type and area coverage

Land use type	**Area in hectare**
Cultivable area	
Grazing area	
Homestead	
Bush	
others	
Total	

12. How many household members are working on-farm (number)?________

13. Did you hire staff/laborer on your farm? *[tick once]*

1 = Yes 0 = No

14. If YES, how many and for how long?

*Hired laborers*_____ *months*______

15. What is your source of income?

1. Only Agriculture 2. Agriculture and off-farm 3. Agriculture and Non- farm

4. Agriculture, off farm and non-farm

16. How much income can you generate from your farming activities during last production year (i.e. 2008/09)? Please specify in Birr:

A. From crop production

S/N	Types of crop grown	Area cultivated	Quantity produced in quintals	Quantity consumed (Qt)	Quantity sold (quintal)	Average price for each crop (Birr/quintal	Estimated income earned per year (Birr)
1	Teff						
2	Wheat						
3	Barely						
4	Chickpea						
5	Field Beans						
6	Lentil						
7	Sorghum						
8	Maize						
9	Beans						
10	Others(specify)						
Total							

B. From livestock production

S/N	Livestock Type	No -of livestock sold	Average Price (birr)	Income earned (birr)
1	Cow			
2	Oxen			
3	Heifer			
4	Calf			
5	Bull			
6	Sheep			
7	Goat			
8	Poultry			
9	Horse			
10	Donkey			
11	Others			

17. Do any members of your family have any sources of off-farm income? 1 Yes 0 No

18. How many members of your family engage in off-farm activities? _______________

19. If yes in question No.17 please fills the following table.

S/N	Off-farm activities	Income gained per year
1	Renting animals	
2	Agricultural wage labour	
3	Hair dressing	
4	In- house weaving	
5	Local alcohol brewing	
6	Hand craft	
7	Renting land	
8	Sales of timber and charcoal	
9	Others(specify)	
	Total	

20. Do you have any non-farm income source? 0 No 1 Yes

21. If yes to Q. 20 please file the following table based on the instruction.

S/N	Non-farm activities	Income gained per year(birr)
1	Remittance	
2	Petty Trade	
3	Handouts from relatives/other persons	
4	Aid from governments	
5	Others(specify)	
Total		

IV .Institutional Factor Related Questions

22. Did you use any type of credit? 0 No 1 Yes

23. If yes Q.20 for what purposes do you obtained credit?

1. For concentrate preparation
2. For genetic breed improvement
3. For compost preparation

4. For biogas preparation

5. To gain animal health services

6. To buy agro-forestry and fodder seed/ seedling and farm tools

6. To fill up family requirement

7. Petty trade

8. Others (specify)

24. If No, Q .22 why you do not take credit

1. Fear of inability to repay

2. High interest rate

3 .Lack of collateral

4. I do not want to take

5. Unavailable on time

6. No information or awarness

7. Others (Specify)

25. Do you have contact to agricultural extension services? 0 No 1 Yes

26. If yes Q 25 how many times extension workers visit in a year ____

27. What types of advices did you get from extension workers?

1. Improved feed management2. Improved animal health service3. Manure management

4. Integrated crop livestock management 5. Improved breeding 6. Herd management7. Others (please specify) ____

28. Are you a member of any formal/informal institution in your village? 0 No 1 Yes

29. If yes Q 25 please fill the following table

S/N	**Institutions/ social Relations**	**Member**	**Role in social relation**
1	Idir		
2	Iqueb		
3	Farmer's cooperative		
4	Women association		
5	NGOs		
6	Youth association		
7	Credit and saving association		
8	Others(specify)		

30. What types of benefits do you get from in the participations of social relation?

1. Providing compensation (insurance) 2. Sharing of farm equipment

3. Sharing of knowledge and information about climate smart cattle production practices

4. Providing credit 5. To save money and time 6.Input and technical support

31. How long does it take to reach your farm from your home?

Distance (in KM _____________ In terms of time it takes (in min)________________________

32. How long does it take to reach the water point for cattle and domestic consumption from your home?

Distance (in KM _____________ In terms of time it takes (in min)________________________

33. Where you use veterinary service for animal health and breading service?_____________

34. How long does it take to reach veterinary post/clinic from your home?

Distance (in KM _____________ In terms of time it takes (in min)________________________

35. How far the market where you buy your agricultural inputs and sale products (e.g. seeds/seedlings, farm tools, etc)? Distance in KM............ ……… In terms of time it takes (in minutes)................?

36. Is there a road access in your *kebele*? 0 No 1 Yes

37 If yes to Q.36 what type? 1. Asphalt 2. All weather road 3. Dry weather road

38. What is your usual means of transportation to the market? *[select one]*

1=Car; 2=Motor bike; 3=Bus/public transport; 4= Bicycle; 5=Walk; 6=pack animals 7=Other (specify)

39. Cost of transport *[one way]*: Birr___________________

40. How do you have access to climate change information? 1 low 2 medium 3 High

41. Do you have any communication devices like TV, radio, mobile phone, so on? 0 No 1 Yes

42. If yes Q 41 what types of communication devices you have?

1. TV 2 Radio 3 mobile phone 4 other (specify)

V. Question on Adoption of Climate Smart Cattle Production Practices

43. Do you perceive that there is climate change & it is adversely impact the cattle productionin your locality? 0 No 1 Yes

44. If yes to Q.43 what are weather events of climate change in your locality? ________________

45. Have you get information about any one of climate smart cattle production practices?

0 No 1 Yes

46. If the answer to Q 37 is yes from where did you get information about climate smart cattle production practices?

1. Extension agent
2. From other farmers
3. Mass media (Radio,TV)

4. Neighbors

5. Local leaders

6. Woreda government expert

7. From NGOs

8. From market place

9. Others(Specify)

47. In response to climate change, have you taken any climate smart cattle production practices in order to reduce the adverse impacts of climate change? 0 No 1 Yes Since when? _____

48. If your answer is yes in question 47 have you employed any of the following climate smart cattle production practices in your farm in the past decade?

S/N	**Climate Smart Cattle production practices**	**Awareness Of the practice**		**Developed willingness or interest**		**Have you tried**		**Adopt**	
		Yes	No	Yes	No	Yes	No	Yes	No
1	Feed management								
	1.1. Grazing management								
	1.1.1. Adjust stocking densities to feed availability								
	1.1.2. Rotational grazing								
	1.2. Pasture management & nutrition								
	1.2.1. Improved species of fodder, legumes								
	1.2.2. Concentrates								
2	Agro-forestry& nursery								

3	Genetic breed improvement(AI, Selection)								
4	Improving animal health service(Vaccination, treatment)								
5	Integrated crop livestock management (manure for fertilizer, residue for compost, etc...)								
6	Livestock manure management								
7	Composting								
8	Bio-gas generation								

49. If your answer No in question 47 why you are not taking?

1. Lack of accurate and timely information and technical advisory services about climate change
2. Lack of quality agricultural inputs(improved seed variety, vaccines & drugs, improved breeds, farm equipments, etc.)
3. Lack of knowledge

4. Shortage of farming land

5. Inadequate empowerment of women and youth,
and tenure and access to land and water resources

6. Shortage of finance to purchase agricultural input

6. Others (specify

50. Did you ever participate in any climate smart cattle production pratice capacity building activities like trainings, awareness creation and demonstration activities in the last decade? 1 = Yes; 0 = No; List them____________________________

50.Where do you feed your cattle? *[rank from 1= most important to 3=least important]*

1	
2	
3	

1 = In stall at homestead 2 = Grazing on private land 3 = Grazing on communal land

51. Have you planted fodder on your farm currently? ____________ 1=Yes 0=No

52. If YES, what types of improved fodders have you grown on your farm and their production levels?

Fodder types	**Growing** (1=Yes; 0=No)	**Where cultivated***	**Area cultivated** (acres)	**When established** (month & year)	**Sources of seed****	**Production level*****

*1=Farm land 2=Farm boundary 3=terrace bank 4=Bush land
**1=Neighbor 2=Own seed 3=Support by government 4=Support by NGO 5=Market 6=Other (specify)
***1=Poor 2=Moderate 3=High

53. What criteria are important to you when choosing the type of fodder to plant? *[rank from 1= most important to 3=least important]*

1	
2	
3	

1= High yielding; 2=Fast growth; 3= Animal produce more milk and fattening; 4=Disease/pest tolerant; 5= Easy to harvest and feed to animal; 6=Availability/cost of seed/planting material; 7=Advice from extension workers; 8= climate tolerant; 9=Other (specify)________________________________

54. What determines the total area of the farm you put under improved fodder production (rank from1=most important to 3=least important)

1	
2	
3	

1=Farm size 2=Number of livestock 3=Labour availability 4=Amount of seed/planting materials available 5=Other (specify)

55. If you have not planted fodder what are the reasons? (rank from 1=the most important to 2=the least important)

1	
2	
3	

1=small land size; 2=lack of seed/planting materials 3=lack of labour 4=Costly to buy 5=lack information on fodder types to plant 6=lack of money for establishment 7=Availability of alternatives such as grazing pastures 8=Cheaper purchase of fodders 9=Limited availability of water 10. other (specify)____________________

56. How do you conserve feed for your livestock? *[note multiple]*

____

0=No conservation; 1= Bale hay; 2= Make silage; 3=Other (specify) ___________________

57. If your answer to Q.56 is No,what is the reason? 1. Limited labour 2. Limited finance 3.No awareness 4.Other (Specify)__________________

58. Have you planted any agro forestry trees on your farm currently? ___________ 1=Yes 0=No

59. If NOT, why?1= Lack of preferred seedlings; 2=High cost of seedlings; 3= Small land size; 4=Tenure insecurity 5= Unreliable rainfall; 6= Lack of knowledge and information 7=Opportunity cost 8=other (specify) ____________________

60. If YES, what types of agro forestry trees have you grown on your farm and their production levels?

Agroforestry tree types	Growing (1=Yes; 0=No)	Where cultivated*	Number of trees	When established (month & year)	Sources of seedlings**	Production level***
Leucaena trichandra						
Sesbania sesban						
Tree Lucerne						
Crevillia						
Other:						

** 1 =*	*Farm land*	*2 =*	*Farm boundary*	*3=*	*Terrace bank*	*4=*	*Bush land*
***1=*	*Neighbor*	*2*	*Own nursery*	*3 =*	*Government nursery*	*4 =*	*Private Nursery operator 5= Market*

****1= Poor 2 = Moderate 3 = High*

61. What criteria are important to you when choosing the type of trees to plant? *[rank from 1= most important to 3=least important]*

1	
2	
4	

1= Period to maturity; 2= Number of uses; 3=Availability of seedlings; 4= Tolerance to dry spells; 5=Other (specify) ______________________

62. What are the benefits of agro forestry trees (including nursery) that you have on your farm? [*rank*] ____________

1	
2	
3	

1= Source of fuel wood; 2= Source of construction materials; 3=Source of income; 4= Improve scenery 5=Fresh air 6= animal feed 7=Other (specify) __________

____

63. Have you established agro forestry and fodder tree nursery on your farm? ______ 1=Yes 0=No

64. If NOT, why? __________ 1=Unavailability of seeds; 2= Lack of knowledge on nursery management; 3= Lack of labour; 4= Lack of reliable water; 5= Availability of seedlings from other nursery operators; 6= Poor market for seedlings; 7= Other (specify)

65. If YES, what are the 3 MAIN CHALLENGES you have faced in tree nursery management? [*rank from*

1	
2	
3	

1= most important to 3=least important]

1= Unavailability of seeds; 2= Poor germination; 3=Unreliable rainfall; 4=Damage by pests/diseases; 5= Lack of market for seedlings; 6= Other (specify)

____

66. Do you practice rotational feeding for your cattle production? 0 No 1 Yes

67. If your answer for question number 66 is No" what do you think the reasons?1. Unavialbility of labour 2. Poor awareness of the benefit 3. Few livestock and ample grazing area 4.other (specify)

68. Do you practice adjusting cattle size to feed availability (destocking) strategy in cattle production practice? 0 No 1 Yes

69. If your answer for question number 68 is No‟ what do you think the reasons?------------

70. Do you practice integrated crop-livestock production system in your farm? 0 No 1 Yes

71. If your answer for question number 70 is No‟ what do you think the reasons?_____

72. Do you apply any organic fertilizers such as animal manure, crop residues and compost in your farmlands? 0 No 1 Yes

73. If your answer for question number 72 is No‟ what do you think the reasons?

1. My farmlands are far from my home making the transportation laborious
2. The animal manures and crop residues are necessarily important for fuel and livestock feeding and also sold for market
3. I have not information about the importance of organic fertilizers
4. They are laborious to be made, but I am working alone so that I cannot do such activities
5. If other reasons, please specify

74. Do you use animal health service required for your dairy and beef cattle production? 0 No 1 Yes

75. If your answer for question number 74 is No‟ what do you think the reasons?

1. No information about the importance of animal health services2. Financial limitation
3. Distance of the service from my far4. No technical advice 5.I use traditional treatment methods 6. If other reasons, please specify

76. Out of your total dairy and beef cattle you have currently how many of them are improved breed? 1=I do not have improved breed 2=_________________

77. If No to Q.76 what are the reasons? 1=Costy 2= Finacial limitation 3=No awareness about the benefit 4= Unavailability 5=poor technical knowhow 6=fear of risk 7=other(specify)

78. If you have improved breed how did you get the service? 1=AI 2= Mated by improved bull 3=Bought the improved calf 4=other (specify)

79. Have you collected livestock manure from your farm in the production year ?1=Yes 0=No

80. If YES, how do you manage the manure produced by your livestock? [tick one answer one]

1= Cover in a pit; 2= Collect under shade; 3= Collect uncovered in the open; 4=Compost it; 5= Discard in surrounding area; 6= Add ash; 7= other _______________

81. What do you do with livestock manure? *[rank from 1= most important to 3=least important]*

1	
2	
3	

1= Used in food crop production; 2= Apply to fodder; 3= Use dry dung for fuel; 4= Use in biogas generation; 5= Use as construction material; 6= Sell to others; 7=other (specify) _

82. If you use your manure for crop production (including fodders), what is the most important benefit?*[select one]*______________________________________

1= Increased crop yields; 2= Low cost of production; 3= Increased farm income 4 =good for the environment; 5=other (specify) ___________

83. If you do NOT use manure for crop production (including fodders), what is the main barrier? *[Select one]*____

1= Lack of labor to collect or apply it; 2=Small manure quantities; 3= No livestock owned 4= Other specify)_____________________________________

84.Do you practice compositing? 1=Yes 0=No

85. If you do NOT practice compositing, why not?[*select one*]

1= Lack of labor to collect manure; 2=Small manure quantities; 3= No livestock owned 4=time consuming; 5= don't know how to do composting; 6=Other (specify)_____________________________________

86. Do you have a biogas digester? ____0=No; 1= Yes in planning; 2=Yes in construction; 3= Yes functioning

87. If you use your manure for biogas production, how has it benefitted your household? *[record multiple]*_______ 1=Less cooking time; 2= Reduced firewood use 3= Saved money that could be used to buy fuel wood or gas; 4 =Reduced smoke pollution; 5= Other (specify)

____

88. If you do NOT use your manure for biogas production, what is the main constraint that you face?*[select one]*_____________ 1= Lack of knowledge on biogas installation; 2=Lack of funds for biogas construction; 3=limited manure quantity; 4= Lack of labour for manure collection; 5= no access to credit; 6=Other (specify) ___________

Appendices D: Key Informant Interview questions

Name________________________________

Position/profession_____________________________

1. Would you like to explain the different climate change impacts which are frequently happen in your district or *Woreda*?

____

2. What are the effects of climate change on the cattle production and livelihood of farmers in your area?

____

3. What is your perception regarding the effect of traditional or business as usual cattle production practice among the community in exacerbating climate change in terms of green house gas release(GHG)?

4. Does the farmer use any climate smart cattle production practices to response climate related problems as per your knowledge? 0 No 1 Yes

5. If yes Q. 4is Yes what types of climate smart cattle production practices used? Please mention the most common climate smart cattle production practices practiced in this *Woreda*.

____

6. In your opinion what is the extent of adoption among the smallholder dairy and beef cattle producing farmers in the *kebele*?

7. What adoption challenges of these climate smart cattle production practices exists?

8. What do you suggest to be done to reduce the impacts of climate change in yours *Woreda*? By whom?

Appendices E: CHECKLIST FOR FOCUS GROUP DISCUSSIONS

INTRODUCTION

My name is Demissie Gelashe Feyisa and I am MSc student at Addis Ababa University. I want to conduct my graduation research on adoption status, determining factorsand challenges of adopting climate smart cattle production practice in *Waliso Woreda*. The result of the study helps for the uptake of these practices, potential for further adoption and lessons learned from the implementation of the activities contribute to up scaling the practices. We value each of your contributions and expect that you actively participate in the discussions as key stakeholders in this area. All information you provide will be treated absolutely anonymously and with highest confidentiality.

FGD GUIDING QUESTIONS

FGD1: Staff from government animal and fishery resource development office, agriculture and natural resource development office and NGOs

1.What are the climate change events or treats in the area during the last decade?(Explain in terms of drought, flood, prolonged dry spell, late on set of rains, early cessation of rain, increased seasonal temperature, increased evaporation).

2. What are the effects of climate change on the cattle production and livelihood of farmers in your area?

3. What is your perception regarding the effect of traditional or business as usual cattle production practice by the community on exacerbating climate change through green house gas release (GHG)?

4.What are the climate smart cattle production practices promoted by the development partners in the *Woreda*? Which practice by which partner? How did you promote the climate smart cattle production practices in the area& since when?

5. What improved practices are popular among farmers? In your estimation, what proportion of participating farmers in the study area has adopted at least one of the improved practices? What do you think are the main reasons for the uptake of these improved practices?

6. As per your knowledge what are the major determining factors for adoption and how they influence adoption?

7. Are there some improved practices that have been abandoned or dis-adopted? Which ones have not been adopted at all? What hinders their uptake within this farming system?
8. What institutional support would facilitate wider promotion of improved practices in this area? Which institutions/organizations are relevant to the promotions and implementation of improved cattle production practices? How are these institutions supporting the promotion of these practices in the study area?

9. What policy support could encourage successful application of improved cattle production practices in this area? Kindly share with us any information you have on any effort by the government (Regional and National levels) and NGO that would create a favorable environment for their uptake.

10. In your assessment, how prepared is the community or other stakeholders to continue with the promotion and up scaling of the improved practices in this area? What are you already doing that empowers the community to go on with the activities?

FGD2: Farmer trainers or DAs

1. Program: What are the improved or climate smart cattle production practices promoted by the development partners through the farmers groups? Which practices by which partner?

2. ADOPTION: Which of the improved or climate smart cattle production practices are being taken up by farmers? Since when? Extent of adoption according to your opinion? What do you

think are the main reasons? What socio-cultural/economic, institutional and demographic factors could be contributing to this?

3. BARRIERS: Why have some improved practices not been adopted, abandoned or dis-adopted? For those practices that have not been adopted at all, what do you think are the reasons? Kindly share with us the failure stories.

4. UPSCALING: What practices should be prioritized and why? What kind of support and by whom would be required for large-scale adoption? Any challenges you faced or suggestions for improvements?

FGD 3-4-5: Model dairy & beef cattle producing farmers (2FGDs for two *kebeles*, and 2FGD with a women group)

1.What are the climate change events or treats in the area during the last decade?(Explain in terms of drought, flood, prolonged dry spell, late on set of rains, early cessation of rain, increased seasonal temperature, increased evaporation).

2. What are the effects of climate change on the cattle production and livelihood of farmers in your area?

3. What is your perception regarding the effect of traditional or business as usual cattle production practice by the community on exacerbating climate change through green house gas release (GHG)?

4. What are the improved or climate smart cattle production practices promoted by the development partners? Which practice by which partner?

5. What improved or climate smart cattle production practices have been mostly up taken by farmers like you? Since when ? Extent of adoption according to your opinion? What encouraged them to adopt?

6. Which practices are abandoned or dis-adopted after some time of practicing them and why? Which ones were not adopted at all and what hindered their uptake? How can the adoption of these improved or climate smart cattle production practices be enhanced? Kindly share with us the failure stories.

7. What are farmers doing to empower themselves to continue implementing these improved practices (e.g. farmer-farmer extension, exchange visits, farmer trainers, group credit access, etc.)? What kind of support and by who is required to do more?

Appendices F: Check-list for observation

1. Manure management, composting and bio-gas preparation
2. Fodder and leguminous feed management
3. Feed conservation practices
4. Improved dairy and beef cattle breed status
5. Grazing field
6. Agro-forestry & nursery practice

Appendices G: Definitions of Terms and Concepts

Adaptation

Adaptation is "the process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects" (IPCC 2014, p. 118). Or simply: initiatives and measures to adjust to the consequences of climate change. In a context of CSA this could mean the adaptation of heat or drought resistant varieties.

Adoption of technology

The choice to acquire and use a new invention or innovation. Adoption process is a mental process through which an individual passes from first hearing a new idea to its final adoption. Adoption of innovations has been defined as the decision to apply an innovation and to continue to use it (Rogers and Shoemaker, 1971).

Climate change

Climate change refers to "a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer" (IPCC 2014, p. 120).

Article 1 of the United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as a change in the climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.

Climate Smart Agriculture

Climate-smart agriculture (CSA) is an integrative approach that aims to deliver food security in the face of climate change by sustainably increasing agricultural productivity, building the resilience of food systems and safety nets and reducing greenhouse gas emissions from agriculture (FAO,2013:Source book).

Greenhouse gas (GHG)

Greenhouse gas (GHG) emissions are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit infrared radiation from the earth, clouds and the atmosphere itself, causing the greenhouse effect. Water vapor (H_20), carbon dioxide (CO_2), nitrous oxide (N_20), methane (CH_4), and ozone (O_3) are the primary greenhouse gases in the earth's atmosphere. Moreover, there are a number of entirely human-made greenhouse gases in the atmosphere (IPCC 2013).

Food Security

The internationally accepted definition of food security comes from the Food and Agriculture Organization of the United Nations (FAO) World Summit on Food Security: "When all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (FAO, 1996).

Mitigation

Mitigation is a human intervention to reduce or prevent emission of greenhouse gases (e.g. by using renewable energies, improve energy efficiency, changing management practices or consumer behavior) or to protect (e.g. forests and oceans) or create carbon sinks (e.g. through conservation agriculture or agro forestry) (FAO, 2013).

Resilience

One definition of resilience is "the capacity of systems, communities, households or individuals to prevent, mitigate or cope with risk and recover from shocks" (FAO 2013, p. 19). It is the opposite of vulnerability and is related to adaptive or coping capacity.

Small holder farmers

Smallholders are characterized by having relativelylimited resources compared to other farmers. However, the definition of smallholders varies between countries and agro-ecological zones (FAO 2013). Within populated areas with favorable land conditions, smallholders are generally defined as cultivating less than one hectare of land. In semi-arid areas, they may cultivate 10 hectares or more, or a herd of 10 livestock. The Ethiopian case it is defined as being of two hectares or less (FAO, 2016).