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ADDIS ABABA UNIVERSITY

COLLEGE OF DEVELOPMENT STUDIES
CENTER FOR FOOD SECURITY STUDIES

SMALLHOLDER FARMERS ADOPTION OF CLIMATE SMART LIVESTOCK PRODUCTION SYSTEM: PRACTICES, STATUS AND DETERMINANTS IN HIDEBU ABOTE WOREDA, NORTH SHEWA ZONE, CENTERAL ETHIOPIA

Bassa Mamo

A Thesis Submitted to Center for Food Security studies, College of Development Studies, Addis Ababa University in Partial Fulfillment of the Requirements for the Degree of Master of Science in Food Security and Development

JUNE 2020

ADDISABABA, ETHIOPIA

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Advisor: Desalegn Yayeh (PhD)

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ADDISABABA, ETHIOPIA

Declaration

This is to certify that the thesis Proposal prepared by Bassa Mamo, entitled: Smallholder Farmers Adoption of Climate Smart Livestock Production Practices: Status and Determinants in Hidebu Abote Woreda, North Shewa Zone, Centeral Ethiopia submitted to Center for Food Security studies, College of Development Studies, Addis Ababa university in partial fulfillment of the requirements for the degree of master of science in food security and development complies with the regulations of the university and meets the accepted standards with respect to originality and quality.

Signed by:

Advisor Name: ________________________ Signature_______________ Date ________________

Student Name: ________________________ Signature_______________Date _________________

ADDIS ABABA UNIVERSITY

COLLEGE OF DEVELOPMENT STUDIES

CENTER FOR FOOD SECURITY STUDIES

This is to certify that the thesis proposal prepared by Bassa Mamo Tola entitled **Smallholder Farmers Adoption of Climate Smart Livestock Production System: Practices, Status and Determinants in Hidebu Abote Woreda, North Shewa Zone, Centeral Ethiopia** and submitted in partial fulfillment of the requirement for the degree of master of science in food security and development complies with the regulations of Addis Ababa University and meets the accepted standards with respect to originality and quality.

Signed by the examining committee:

External Examiner: ______________________Signature ___________Date _______________

Internal Examiner: ______________________ Signature ___________ Date _______________

Advisor: ______________________________ Signature ___________ Date_______________

Chairman ______________________________Signature ___________ Date_______________

Acknowledgement

First my innumerable praise to the Almighty GOD for giving me the opportunity, capacity and guidance throughout my life. My foremost appreciation and thanks goes to my advisor Dr Desalegn Yayeh for his intellectual simulation, valuable, helpful and constructive comment, suggestions and overall assistance from the early stage to the completion of this paper. He always has a great understanding and good solutions for my entire problem.

I express my sincere gratitude and heartfelt appreciation to Gadisa Girma for his guidance and encouragement in the completion of this thesis work. He was so helpful and I had full freedom to communicate him any time and in any place, which was so nice of him. He deserves big respect and thanks. My heartfelt gratitude also goes to my indebtedness and heartfelt thanks to Ifa Demissie, Girma Tolcha and Gizachew Negashu for their advices and a lot of good ideas in directing and supporting me all through this research work.

I am also grateful to farmers, development agents, and experts of Hidabu Abote district and livestock and fishery development office staff members and management as the whole for their sincere cooperation in arranging and helping all the necessary directions during data collection which was the base for this thesis writing. Without their cooperation and tireless effort, the quality data wouldn't have been collected at the right time. Finally, I would like to extend my appreciation to all my families for their outstanding moral as well as material support throughout this work.

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Abbreviation

AGP:	Agriculture Growth Program
CASCAPE:	Capacity Building for Scaling Up of Evidence Based Best Practices in Agricultural Production in Ethiopia
CSA:	Climate Smart Agriculture
FAO:	Food and Agricultural Organization of the United Nations
FDRE:	Federal Democratic Republic of Ethiopia
FGD:	Focus Group Discussion
GDP:	Gross Domestic Product
GHG:	Greenhouse Gas
GTP:	Growth and Transformation Plan
HAWANRO:	Hidabu Abote Woreda Agriculture and Natural Resource Office
HAWLFDO:	Hidabu Abote Woreda Livestock and Fishery Development Office
IPCC:	Intergovernmental Panel on Climate Change
KII:	Key Informant Interview
MICCA:	Mitigation of Climate Change in Agriculture
NGO:	Non-Governmental Organization
SDG:	Sustainable Development Goal
SLM:	Sustainable Land Management
THI:	Temperature Humidity Index
TLU:	Tropical Livestock Units
UNICEF:	United Nation International Children Fund

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Abstract

Livestock production plays an important role in Ethiopian economy. However, climate change presents a range of challenges for animal in the country. The adoption of climate smart livestock 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 livestock production practices in Hidabu Abote Woreda, Centeral Ethiopia. Three-staged sampling techniques were used to select the targeted area and sample household respondents. A total of 233 sampled households were selected using simple random sampling method and household survey was conduct with pre-tested structured questionnaire. Key Informant Interviews and Focus Group Discussions were also conducted to complement the study. Various descriptive and inferential statistic techniques were applied to analyze the collected survey data. Ordered logistic regression model was also used to analyze the determinant factors which affect the adoption status of the sampled household. Descriptive result shows that commonly adopted practices are composting (85.41%) and manure management (70.39%) while the least adopted technologies were bio-gas generation (3.86%) and rotational grazing (22.32%).The adoption status of the sampled household were also categorized into low (19.74%), medium (67.81%) and high adopter (12.45%).High cost of improved breed, use of manure for fuel, free grazing and lack of information and awareness are the major constraints to adopt technology. The result of ordered logistic regression revealed that education, grazing land, total livestock holding and extension contact contributed significantly and positively to adoption status, while distance from water source had a significant and negative effect adoption status of climate smart livestock production practices. From the result, it is possible to conclude that livestock farmers having more grazing land, higher educational level, more livestock holding and good extension contact are more likely to adopt climate smart livestock production practice whose water source are far from their home are less likely to adopt climate smart livestock production practices in the study area. The policy measures derived from the results include: livestock raring should get more attention, increasing the frequency of extension contact, improving grazing land practices, expanding education, and providing sufficient water supply for the farmers to improve the adoption status of climate smart livestock production practices.

Key Words*:* Adoption, Climate Smart, Constraints, Hidabu Abote, Livestock, Ordered Logit

1. INTRODUCTION

1.1. Background and justification of the study

Food and Agricultural Organization of the United Nations (FAO) (2013) estimates that agricultural production has to increase by 60% by 2050 to satisfy the expected demands for food and feed across the world. Most of the additional 2 billion people will live in developing countries (Williams *et al.*, 2015). At the same time, 70% of the people (against the current 50%) will be living in urban areas by 2050 (UN, 2014). Agriculture has changed throughout history. There are currently over 7.3 billion people in the world, with unexpected population over 8.5 billion by 2030 and 9.7 in 2050 but today the only 2% the population produced food for the World to consume. Agriculture in Africa has a massive social and economic foot print. More than 60% the population of Sub-Saharan African smallholder farmers, and about 23% of SSAs GDP comes from Agriculture. Yet Africa's full agricultural potential remains untapped (FAO, 2018). Agriculture is the backbone of Ethiopia‘s economy. At national level the sector accommodates 85% of employment and contributes to 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 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 (CO2), methane (CH4) and nitrous oxide (N2O)(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).

CSA is an approach to dealing with the interlinked challenges of climate change, environmental sustainability and food security in a holistic and effective manner. FAO formulated the idea of climate smart agriculture 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, on three main aims (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).

CSA 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. CSA has a proven potential to improve adaptive capacity and resilience then by 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 (Clements *et al*., 2011).

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 activities (Milder *et al*., 2011).

A study done by Jirata *et al*. (2016) 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.

There were insufficient empirical studies and scientific evaluation of context based Climate Smart livestock 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 existing research gap this study is aimed to identify the status of adoption, analyze determining factors and challenges in adopting Climate Smart livestock production practices and forward problem oriented context specific strategic action to enhance adoption and scaling up/out the practice by smallholder farmers in Hidebu Abote *Wored*a, North Shoa Zone, Oromia National Regional State, Ethiopia.

1.2. Statement of the Problem

Climate change and variability has direct and indirect effects on livestock production through adverse impact on natural resource bases and ecosystem services which the livestock sector is 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 livestock health. In reverse, business as usual 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) (IPCC, 2007). It 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).

CSA production as an approach to help, 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. 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 sufficient research findings on CSA practices in Ethiopia for the different agro-ecology, soil type, rainfall pattern, farming system, temperature and moisture ranges (Jirata *et al*., 2016). 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.

Williams *et al*. (2015) also 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. Absence of research-based evidence on adoption hinders the ability of decision makers to target CSA implementation to areas most at risk.

The concept of the new approaches of CSA is not well introduced among the local community and different stakeholders in the study area but few programs are being tried to be applied by government and non-government organizations. Extension program in the Growth and Transformation Plan (GTP I and II), 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 Hidebu *Woreda*. According to the Hidebu Abote GTP-II (2016) the AGP-II program has a Climate Smart Livestock production component with intervention in the area of feeding, manure management, animal health service, breed improvement and herd management. 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).

The long-term grid meteorological data (1983 to 2016) obtained from National Metrological Agency of Ethiopia indicates that the area gets most of its rainfall (about 69.4%) in summer. The long-term annual total rainfall is computed to be about 1,196mm, the rainiest months being July and August. The *woreda* gets about 16.5% of the rainfall in autumn season; while 13.6% in spring season. The key informants indicate that sometimes the summer rain lasts for five months (June to October); while sometimes it rains only for two months (July and August). Spring rain is also very variable. Sometimes it rains throughout the whole season (March, April and May); while at times no rain for the entire season. The informants indicate that the number of rainy days within a year varies from place to place and this number slightly decreases as one goes down to the lowlands in the northern part of the study area. Concerning trends of temperature, the long-term annual maximum temperature is computed to be 28.4^{o}C, the annual average minimum temperature is 14.5^{o}C and the average of the two is found to be 21.4^{o} C. This shows that there is an existence of climate change and variability in the study area. So climate smart livestock production practice is one of an approach which reduces vulnerability and mitigates climate change in the *woreda*.

With the purpose to extend the experience and fill the research gap this study is aimed to identify the adoption status, determining factors and constraints in adopting Climate Smart

Livestock production practices delivered by government and partner organizations and then formulate appropriate evidence based and context-specific strategic actions to enhance the adoption and scaling up/out of climate smart livestock production practices.

1.3. Objectives of the study

1.3.1. General objective

The overall objective of this study is to assess the status and challenges of adoption and identifies the determining factors in adopting Climate Smart livestock production practices in Hidebu Abote *Woreda* North Shewa Zone, Oromia National Regional State, Ethiopia.

1.3.2. Specific objectives to:

1. describe the smallholder farmers ‘adoption status of Climate Smart livestock production practice in the context of the study area.
2. identify factors determining the adoption of climate smart livestock production practices in the study area
3. asses the key constraints to smallholder farmers in adopting Climate Smart livestock production practices in the study area

1.4. Research question

1. What is the status of adoption of climate smart livestock production practices at farm level?
2. To what extent smallholder farmers are practicing climate smart livestock production practices?
3. What are the determining factors in adopting climate smart livestock production practice
4. What are the key challenges in adopting climate smart livestock 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 will help 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 then by promote adoption rate of climate smart livestock production practice. Best practice will be scaled up/out in similar context. 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. 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 ordered logit regression model. The spatial scope is limited to the Hidabu Abote *Woreda* due to the existing livestock production potential, adverse impact of climate change and variability, population pressure, the research interest to make comprehensive investigation, existence of relative climate smart interventions.

1.7. Limitation of the study

It has also delimitation in that it focused on to investigating the issue under study only from livestock production system of the agriculture sector point of view. Thus, this research being one of the few preliminary works, it has limitation in generalizing findings to broader scope. Due to time and financial constraints, the study was restricted to 233 samples of households in terms of size and the data collected was also restricted only within the 3 sampled *kebeles*.

2. LITERATURE REVIEW

2.1. Theoretical review

2.1.1. Climate Change and Livestock Production

Livestock production in Ethiopia is an essential part of agriculture sector and the contribution of animals and their products to the agricultural economy accounts for 40%, excluding the values of traction 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 supplying 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 litters 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 livestock 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($CO2$), methane ($CH4$) and nitrous oxide ($N2O$)(IPCC, 2007b)

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 production in particular is not only being affected by climate change but also contributes to climate change through releasing greenhouse gasses (GHGs). 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 CO2 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 (IPCC, 2007b).

The global emission contribution of dairy farming, 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).

2.1.2. The impact of climate change on livestock

Climate change poses serious threats to livestock production. However, these impacts are difficult to quantify due to the sector’s uncertain and complex interactions between agriculture, climate, the surrounding environment and the economy. Increased temperatures, shifts in rainfall distribution and increased frequency of extreme weather events are expected to adversely affect livestock production and productivity around the world.

These adverse impacts can be the direct result of increased heat stress and reduced water availability. Indirect impacts can result from the reduced quality and availability of feed and fodder, the emergence of livestock disease and greater competition for resources with other sectors (Thornton, 2010; Thornton and Gerber, 2010; FAO, 2009b).

The effects of climate change on livestock are likely to be widespread. The most serious impacts are anticipated in grazing systems because of their dependence on climatic conditions and the natural resource base, and their limited adaptation opportunities (Aydinalp and Cresser, 2008). Impacts are expected to be most severe in arid and semi-arid grazing systems at low latitudes, where higher temperatures and lower rainfall are expected to reduce yields on rangelands and increase land degradation (Hoffmann and Vogel, 2008).

The direct impacts of climate change are likely to be more limited in non-grazing systems mostly because the housing of animals in buildings allows for greater control of production conditions (Thornton and Gerber, 2010; FAO, 2009b). In non-grazing systems, indirect impacts from lower crop yields, feed scarcity and higher energy prices will be more significant. Climate change could lead to additional indirect impacts from the increased emergence of livestock diseases, as higher temperatures and changed rainfall patterns can alter the abundance, distribution and transmission of animal pathogens (Baylis and Githeko, 2006).

2.1.3. Climate Smart Agriculture

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). 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.

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). 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. 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).

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. 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 FAO (2008b) Livestock(specifically livestock 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.

2.2. 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 to Jalon *et al*. (2016) all types of capitals (physical, financial, human, social and political), 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 Grey and Kilawe 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 targets to identify the status, determining factors and challenges in adopting the climate smart Livestock production practices and recommends the strategies and actions to alleviate the challenges of smallholder farmers and then improve the adoption status.

2.3. Conceptual framework of the study

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.

2.3.1. Innovation-diffusion model

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.

2.3.2. Scaling up

Scaling-up is indicating an increase in the number of beneficiaries of an innovation. It usually meant delivering or enacting an innovation in a way that increased the number of people benefiting from it while ensuring the original design and measures were maintained . The ability of an innovation shown to be efficacious on a small scale or under controlled conditions to be expanded under real world conditions to reach a greater proportion of the eligible population, while retaining effectiveness. Scaling up is also an innovation brings to m ind something growing in size, getting bigger (Milat*et al.*, 2014).

2.3.3. Change theory

Change theory is an approach to developing, implementing and evaluating programmes of development, and has been applied across a wide range of programmatic contexts. Broadly, change theory can support the development of interventions, bringing together key stakeholders within the planning phase to scrutinize and address proposed approaches to achieving impact. It can also provide a rich process and impact framework to guide implementation and evaluation, addressing barriers to implementation, and incorporating the rationale behind approaches taken and contextual influences(DeSilva *et al*,. 2014).

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).

Based on the different review of literature made above, the adoption decision of climate smart livestock production practices can be affected by a wide range of factors. From the general reviews, the various factors can be grouped as: socioeconomic factors, demographic factors, institutional and infrastructural factors. The factors related to the socioeconomic characteristics include; landholding, grazing land, total livestock holding and livestock income. Demographic characteristics include, sex, family size, education level and experience. Moreover, the institutional factors include extension contact, saving and credit services, information on climate change and infrastructure includes distance from home to water source. Figure 1 below shows the interaction of these factors that are considered to have a various degrees and directions of effect on the farmers' adoption decision on climate smart livestock production practices.

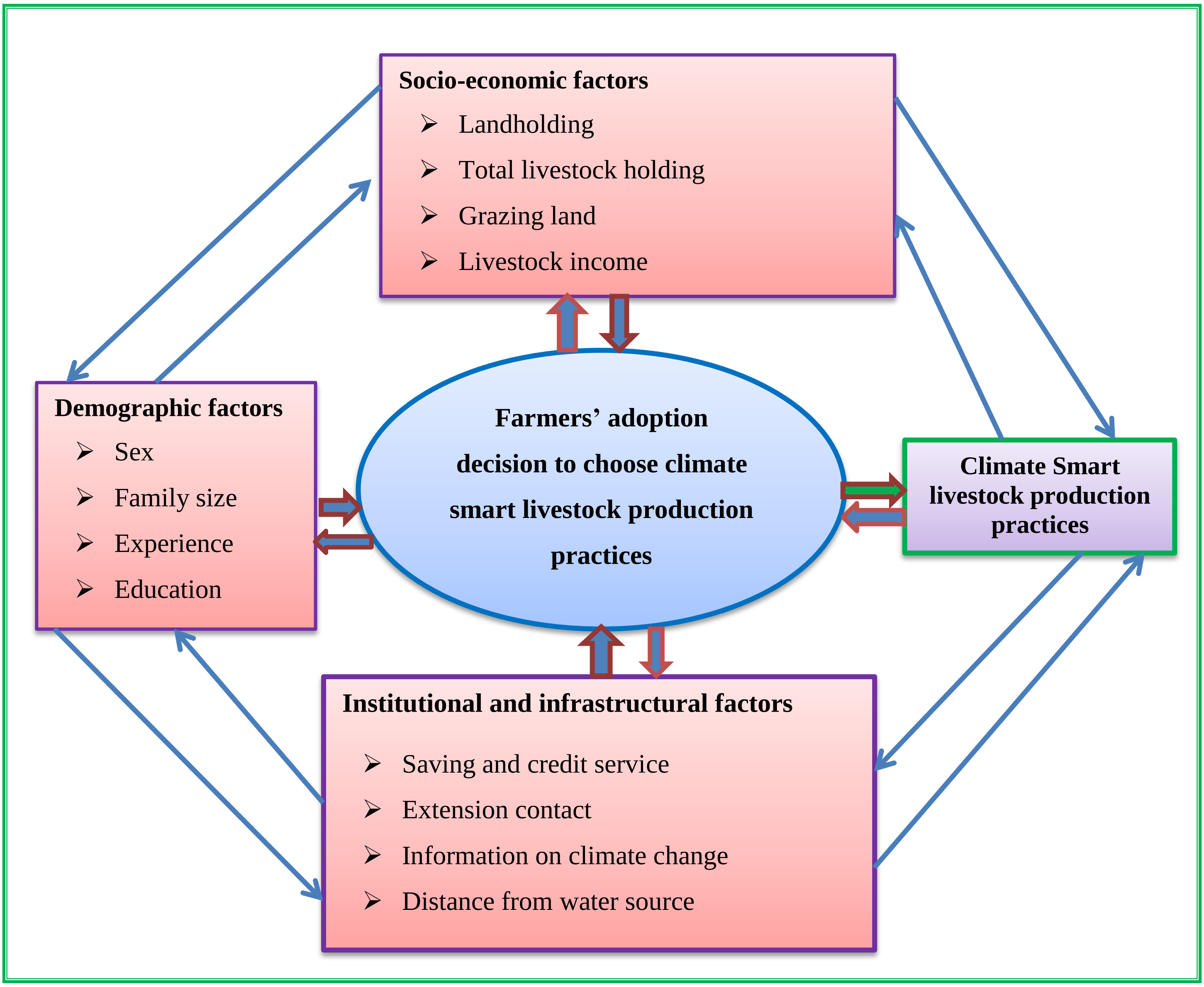

Figure 1: Conceptual framework of the study

Source: Adapted from Malefiya (2017)

3. RESEARCH METHODOLOGY

3.1. Description of the study area

3.1.1. Climate and geographical features

Hidabu Abote district is located in North Shoa Zone, Oromia Regional State, Ethiopia. There are 19 *kebeles* and 1 urban *kebele* in the district. The district capital town, Ejere, is located 42 km far from the town of North Shoa (Fitche) and 147 km from Addis Ababa. It is bordered by Dera district in North, Degem district in South and East, Wera Jarso district in West. Altitude in Hidabu Abote ranges from 1160m to 3000m above sea level (masl). Most parts of the district lay between 1387 and 1543; and 1849 and 2067m a.sl. Astronomically, Hidabu Abote district extends from 9047′15″- 100 0′45″N and 38026′ 15″-38038′45″ E. The minimum temperature is 13^0c and maximum temperature is 20^0c. Soil types are; sandy soil 14%, clay soil 51% and silt soil 35%. The PH of the soils in Hidabu Abote ranges between 4.5 and 6.8. However, the commonly observed problem related to aluminum and magnesium toxicity as a result of low PH is minimal. The average annual rainfall of the district is 800 - 1200mm with variability. It is bimodality distributed in which the small rains are from March to April and the main rainy season from July to September (HADANRO, 2019).

3.1.2. Population and economic activities

The total population of the district were 104,442 from which 51,030 (48.8%) were males and 53,412(51.2%) were females and the number of agricultural households were 15,086 from this 13,396 (88.8%) male headed and 1690 (11.2%) female headed. The total area of the district is 50870.39 ha. From the total area, 32,917(64.7%) ha is used for agricultural land. In the study area, agriculture contributes much to meet major objectives of farmers such as food supplies and cash needs. The sector is characterized by it is rain-fed and subsistence nature with traditional farming techniques. It is the mixed farming type where crop and livestock productions are undertaken side by side. The dominant crops grown in the study area are *teff*, sorghum, wheat, chickpea, faba bean and lentils. The number of livestock resources in the study area were; cattle (81156), sheep (23899), goats (47596), horses (439), donkeys (12528), mules (173), poultry (43814) and honeybee colonies (15648) (HALFRDO, 2019).

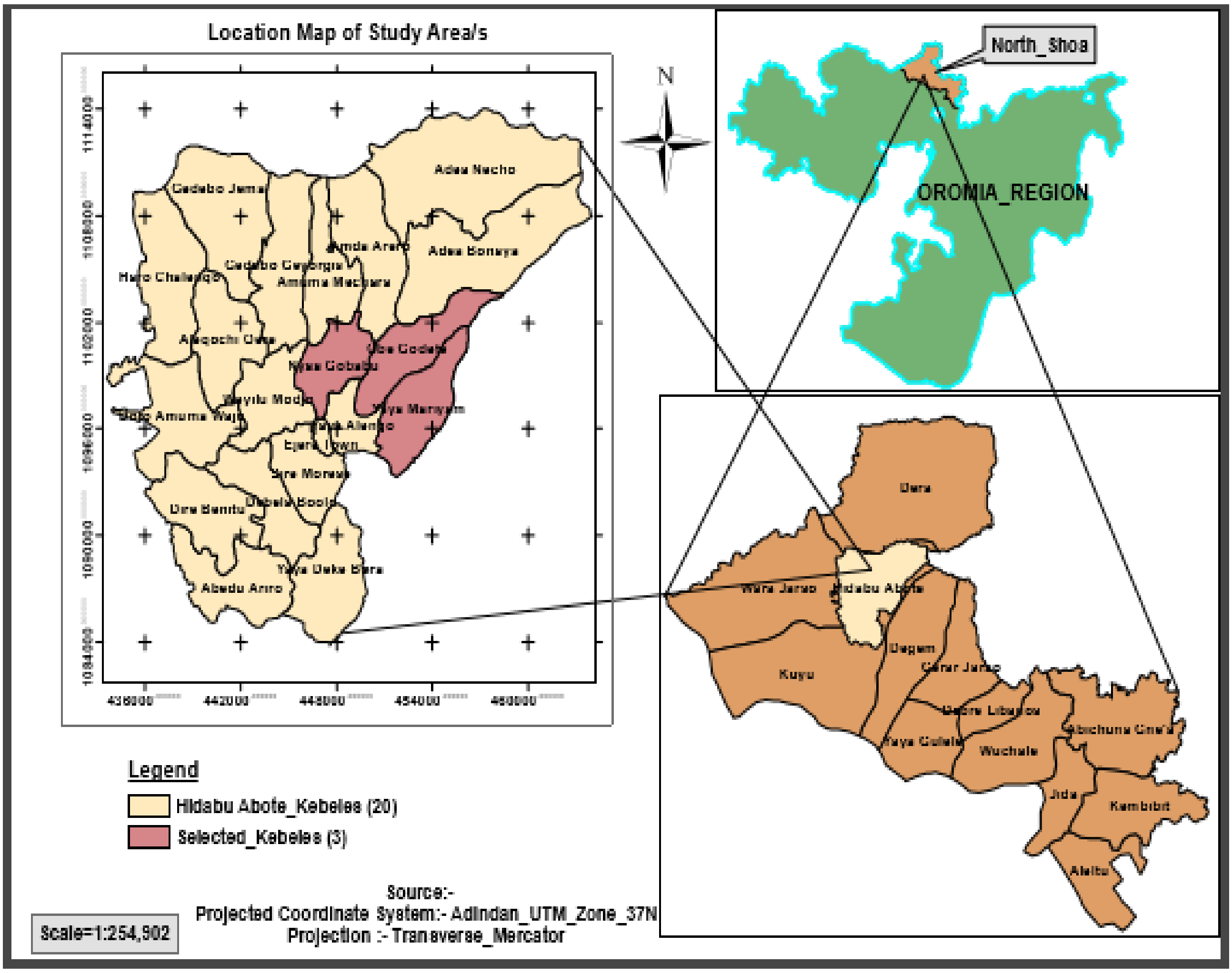

Figure 2: Map of the study area

Source: GIS (2020)

3.2. Sampling frame and sample size determination

This study follows multi-staged sampling technique, where a combination of sampling techniques was used to select the study site and participants. Purposive sampling method was employed to select the study *Woreda* and the three *kebeles* namely Yayamarami, Kobigodeti and Gneagebabu intentionally due to their livestock production potential and climate change related risks. The study sites are also affected by population pressure. There are ongoing government and NGO climate smart livestock production programs. Smallholder livestock producing farmers were selected using simple random sampling technique for household survey. The Key Informants (five members in each *kebeles*) and focus group participants (six up to seven members in each *kebeles*) were also selected purposively due to their skill and knowledge to explain the status and challenge related to CSA in livestock production. Yamane (1967) provides a simplified formula to calculate sample sizes. This formula was used to calculate the sample size as shown below in Table 1.

$$\mathrm{n} = \frac{N}{1 + N(e)^2} = \frac{1447}{1 + 1447(0.06)^2} \approx\ 233$$

Where n is the sample size, N is the population size (1447), and e is the level of precision (6%).

Table 1: Sampled households in selected *kebeles*

Name of sampled *kebeles*	Total household	Sampled household	% from sample size
Yaya marami	540	87	37.34
Kobi godeti	462	74	31.76
Gnea gebabu	445	72	30.90
Total	1447	233	100

Source: HALFRDO (2020).

3.3. Research design

Descriptive research design was appropriately applied in this research. Descriptive research set out to describe and to interpret the questions and looks at the study units with the aim to describe, compare, contrast, classify, analyse 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.

The regression model 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 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, field observations were techniques for data collection.

In the quantitative research method household survey on the basis of structured questionnaire interview was conducted by researcher and enumerators. These mixed approach research design is 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 livestock production practices.

3.4. Data sources and tools

The research was accomplished using primary and secondary data sources, which are qualitative and quantitative nature. The primary data necessary to achieve the designed objectives were obtained from sample households through semi structured questionnaire for sampled household and checklist for focus group discussion and key informants interview. Secondary data was collected from relevant sources such as, articles, proceedings, journals, scientific reports, MoA, CSA, Zonal and district annual reports were vital to the study.

Primary data was focused on household characteristics (demographic, socio-economic, and institutional); livestock production, adoption of specific climate smart livestock 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 was generated from Key Informant Interviews, Focus Group Discussions, household survey questionnaire and field observations.

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 pre 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 was recruited and trained before conducting the survey and supervised during the data collection to reduce error. These selected enumerators are supervisor and development agents from Animal Husbandry and Fishery Resource office working in the sample *kebeles.*

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* was selected purposively to complement the data collected through household survey. The key informants were *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 were helpful to 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 livestock production practices the farmers commonly adopt to respond to climate change problem, the adoption challenges and farmer‘s source of information about climate change.

Homogenous focus group discussions (FGD) were also used to verify the information given by an individual farmer during the survey and to catch an important issue that was not raised by respondent farmers. Six (two in each *kebeles*) FGD session were organized. Government and NGO staff, women group and innovative farmers (in each *kebeles*) was organized with 6-7 members in a group for Focus Group Discussions (FGDs).Women groups discussions was 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 is 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 livestock production practices farmers adopt to respond to climate variability problem and why farmers do not adopt any climate smart livestock production practices was incorporated in the checklist. Finally, adoption challenges and strategic solutions with the supporting roles of institutions required were interviewed.

Field observation on characteristics of grazing management, watering points, herd management, bio-gas generation and other climate smart livestock 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.

3.5. Method of data analysis

To address the objectives of this study, both descriptive statistics and econometric methods of the data analysis was employed. After coding and feeding the collected primary data into the computer, STATA version 15 was used for analysis.

3.5.1. Descriptive statistics

Descriptive statistics such as mean, minimum, maximum, percentages, frequencies and standard deviation are applied to describe demographic, socio-economic, farm characteristics, institutional characteristics in the study area

3.5.2. Econometric analysis

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

Econometric data analysis model was used to identify factors affecting smallholder farmers ‘decision to choose climate smart Livestock production practices to response to climate change and variability. Ordered logit regression model was used to identify and interpret main socio-economic factors affecting adoption of climate smart livestock production practice. This model suits such type of analysis as it permits the analysis of categorical variables, allowing the determination of choice probabilities for different categories. The ordered 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 (Long and Freese, 2014).

The assumption to use this model is that farmer‘s decision of adoption of climate smart livestock production practice is influenced by different socio-economic, demographic and institutional factors. Inferential statistic like the one way ANOVA-F test and 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.

According to Long and Freese (2014), the ordered logit regression model is expressed as:

$$\mathrm{P(Yi > j)} = g(X\beta j) = +\frac{\exp(\alpha j + Xi\beta j)}{1 + \{\exp(\alpha j + Xi\beta j)\}}, \qquad j = 1.2,..,M-1$$

where M is the number of categories of the ordinal regressed. From the equation stated above, the probabilities that Y will take on each of the values 1,… M are equal to:

$P(Yi = 1) = 1 - g(Xi\beta j)$

$P(Yi = j) = g(Xi\beta j), J = 2, \dots, M - 1 P(Yi = M) = g(Xi\beta M - 1)$

$Yi = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \cdots \beta_n X_n + \mu i.$

The dependent variable Yi = level of usage of climate-smart livestock production practices (high user = 3; medium user = 2; low user = 1). $X_1 \ldots X_n$ represents the explanatory variables; $\beta_1 \ \ldots \ \beta_n$ represent the parameters of the explanatory variables; and β_0 represents the intercept, while μi represents the error term.

3.6. Variable description and hypothesis

3.6.1. Dependent variables

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 livestock production practices. A total of 8 climate smart livestock production practices (improved breed, composting, manure management, fodder planting, feed conservation, rotational grazing, biogas generation and destocking) were used for calculation of the adoption quotient.

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

Depending on the adoption quotient, sampled household were divided into three categories for analysis such as low adoption = < (Mean – SD), medium adoption = (Mean ± SD) and high adoption = > (Mean + SD); and also the same three categories applied for ordered logistic regression analysis (Farid *et al.*, 2015).

3.6.2. Independent Variables

The independent variables that are hypothesized to affect the smallholder farmers' adoption of climate smart Livestock 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 livestock production practices by smallholder farmer practices.

1. 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 effect 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. In the study it was hypothesized male are in a better position to practice diverse adaptation strategies than the female-headed ones.

2. Education level of the household: This is a continuous variable which measured in school years of sampled household. Literate household heads are able to acquire and process information easily which may lead to more adoption of climate smart livestock 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). So education of household head is expected to be related positively since education is important to engage income earning potential of household.

3. Family size: It 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. In this study, if the majority of the family members are including active labour force age, the household will have enough labour 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.

4. Livestock income: It is a continuous variable which is defined as the total income that the sampled households get from livestock production which is measured in birr. 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.

5. Saving and Credit use: It is a dummy variable taking the value 1 if the farmers use saving and 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 was hypothesized that there is a positive relationship between use of saving and credit and adoption of climate smart agricultural practices.

6. Extension contact: This is a dummy variable which takes 1 if a sampled house hold got extension service and 0 otherwise per a year. Extension services are an important source of information on husbandry practices and technical support to livestock production in the context of climate smart livestock 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 (Development Agent) visits, using different extension teaching methods like attending demonstrations and field day can help the farmers to adopt climate smart livestock production 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 livestock production practices than others (Quddus, 2012). Therefore, this variable is expected to have a positive effect on farmer‘s choice of climate smart livestock production practices.

7. 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. 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 smart livestock production practices and hence chooses the ones that enable them to cope better with changes in climate (Abrham *et al.*, 2017).

Regarding to the study area it was hypothesized to affect adoption of climate smart livestock production positively.

8. Total livestock holding: it is continuous variable refers to the total number of animals possessed by the household measured in tropical livestock unit (TLU). 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). In the study area it was hypothesized to affect adoption of climate smart livestock production positively.

9. 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.

10. Grazing land: It is defined as the total grazing land of the sampled household. This is a continuous variable measured in hectares. Farmer who has large grazing land has the opportunity to adopt climate smart livestock production. So this variable is expected to have positive effect on adoption of livestock production practices in the study area.

11. Distance to the water source: This is continuous variable measured in walking minutes from the residence of farm household to the water source area. We expect that the farmer whose water source is far from his residence is less likely to continuously follow up his/her livestock as compared to those whose water source nearer to their home. Thus, it is expected that farmers who live near to their water source are likely to have regular follow up of their livestock, hence motivated to respond to climate change on their livestock activities (Malefiya, 2017). Therefore, this study hypothesized that distance from home to the water source has negative relation with adoption of climate smart livestock production practices.

12. Experience: It is a continuous variable and refers to the total years that the household participated on livestock production, which is measured in years. Having more experience and knowledge on livestock production methods, would increase the probability of the farmers to participate in climate smart livestock production. The more the farming experience, the higher the likelihood of accumulation of physical and social capital. The accumulation of physical and social capital can offer farmers' better exposure and capacity to adopt new or recommended climate smart livestock production or techniques (Onyeneke *et al*., 2018). As one gets skillful in the methods of livestock production, he/she would be better in using climate smart livestock production practices. In this study, it was hypothesized that households who have more experience or more participation on livestock production practices have positive effect on adoption of climate smart livestock production practices.

Table 2: Summary of Variable definition

Types of variables	Definition	Types variables	Measurement	Expected sign
Sex	Sex of the sampled household	Dummy	1 for male,0 female	+
Education	Education level of sampled household	continuous	School years	+
Family size	Family size of sampled house hold	Continuous	AE	+
Livestock income	Livestock income earned from livestock	Continuous	Birr	+
Saving and Credi use	Saving and Credit use of the sampled household	Dummy	1 for saving and credit use and 0 for not use	+
Extension contact	Extension service of the sampled household	Dummy	1 for extension contact ,0 for not contact	+
Information on climate change	Information on climate change by sampled household	Dummy	1 have information,0 not have information	+
Landholding	Total number of land that sampled household have	Continuous	Ha	+
Livestock holding	Total livestock hold by sampled household	Continuous	TLU	+
Grazing land	Total grazing hold by sampled household	Continuous	Ha	+
Distance from water source	Distance from the nearest water source	Continuous	Walking minute	-
Experience	Experience of sampled household on livestock production practices	Continuous	Years	+

Source: Own definition based on literature (2020)

4. RESULT AND DISCUSSION

4.1. Descriptive Analysis Results

Before discussing results obtained from the econometric models, it is important to briefly present demographic, socio-economic, farm and institutional characteristics of the sampled farmers in the study area, since they affect the quality of the management of the farmer directly or indirectly and are believed to have effect on adoption of climate smart livestock production practices. In addition, it would help to draw a general picture about the study area and sampled households.

4.1.1. Demographic and Socio-Economic Characteristics

Sex of the household head

Table 3 below shows that the household‘s adoption status of climate smart livestock production practices in the study area. About 26.18% of the sample households were female headed and the remaining 73.82% were male headed households. More over from the total female 24.59% are categorized in low adoption, 63.93% are in medium adoption and 11.48% are in high adoption level. Male heads households were also categorized in low, medium and high adoption level with percentage of 18.02%, 69.19% and 12.76% respectively. The result of the Chi-square shows insignificant relationship of sex with adoption level (X^2=1.229, P=0.541) but the majority of male sampled households (69.19%) were in medium level of adoption status as compare with female headed household.

Saving and Credit service

From Table 3 below 40.77% and 59.23% of sampled households were saving and credit beneficiaries and non-beneficiaries respectively. The majority of saving and credit beneficiaries (72.63%) were categorized under medium adoption level while 20% and 7.37% were categorized in low and high adoption level. More of credit non users (64.49%) were also in medium adoption level while 19.57% and 15.94% were in low and high adoption status respectively. The result of the Chi-square test shows statistically insignificant relationship between the credit users and adoption status(X^2=15.426, P=0.144) but we can see the majority of medium adopters were credit users which shows the importance of credit in positively influencing the adoption status.

Extension service

Development agents have been giving extension services in their respective field of specializations. They are required to advice and follow up farmers on livestock production practices in a modern way to increase the production and productivity by using different technologies. Table 3 illustrates that from the total respondents 69.67% were extension users in medium adoption level, 16.59% and 13.74% were in low and high adoption level respectively. Furthermore from extension non users 50% of the sampled households were in medium adoption level and 50% were in low adoption level, but there were no sampled households who categorized in high adoption level. There is significance statistical difference between farmers choice of climate smart livestock production practice at less than 0.01 (1%) significance with regards to extension service (X^2= 5.038, P=0.000). This shows that extension service is a basic determining factor for adoption of climate smart livestock production practices and extension users were use more technology as compared with extension non users. This is due to the fact that farmers who had extension service could lead them to use of livestock production management techniques and use inputs in appropriate way. The present result is in line with the finding of Quddus (2012) who proved that if the farmers get better extension services, they are expected to adopt climate smart livestock production practices than non-users

Climate information

From the total respondents 75.54% have climate information and 24.46% have no climate information in the study area. Additionally 72.72% have climate information and categorized under medium adoption level and the rest were in low and high adoption status which is 14.77% and 12.5% respectively. Moreover from the respondents who have no information, 52.63% were in medium adoption level, 35.09% and 12.28% were in low and high adoption level respectively. The chi square test implies that there is a statistically significance between sampled households who have climate information and no climate information regarding to adoption of climate smart livestock production practices in the study area at 1% significance level (X^2=11.566, P=0.003) (Table 3). The possible reason is that farmers who have climate information like global warming, methane gas (CH4), carbon dioxide (CO2) and Nitrous oxide (N_2O) can use more climate smart livestock production practice than those who have no climate information.

Table 3: Descriptive Statistics for dummy variables

Variables		Adoption								X^2	Sig
	Description	Low		Medium		High		Total			
		Count	%	count	%	count	%	Count	%		
Sex	Female	15	24.59	39	63.93	7	11.48	61	26.18	1.229	0.541
	Male	31	18.02	119	69.19	22	12.76	172	73.82		
Saving and Credit service	No	27	19.57	89	64.49	22	15.94	138	59.23	3.878	0.144
	Yes	19	20	69	72.63	7	7.37	95	40.77		
Extension service	No	11	50	11	50	0	0	22	9.44	15.426	0.000***
	Yes	35	16.59	147	69.67	29	13.74	211	90.56		
Climate information	No	20	35.09	30	52.63	7	12.28	57	24.46	11.566	0.003***
	Yes	26	14.77	128	72.72	22	12.5	176	75.54		

Note: *** represents significance at 1% probability levels
Source: Own survey (2020)

Age of the sampled household

Table 4 below shows that the average age of the sample household heads was 45.82, with a minimum of 23 and maximum of 77 in years. The result implies that that the sample households are dominated by relatively middle adulthood farmers who are still within the economically active group. For this particular study Santrock, (2011) psychological age classification was applied. Hence, early adult hood (20 to 40‘s years), middle adulthood (41 to 60‘s years) and late adulthood (60 years and above) were the respondents age groups.

The age of the household head represents the experience in farming and the work force for the adoption of climate smart livestock production practices. As indicated in the Table 5 the mean age of respondent that fall in the adoption categories of low, medium and high are 44.37, 45.96 and 47.41 respectively. The one way ANOVA result indicate that there is significant mean difference between the groups of adoption categories at less than 0.01 significance level(F=2.011, P =0.001) with regards to age of the sampled household in years (Table 5). This result implies that middle adult age significantly determines the adoption level and is important factor to enhance adoption of climate smart livestock production practices.

Education level of sampled household

Education is an instrument to improve the quality of labour through improving the managerial skill and the tendency to adopt new technologies. Education together with increased experience could guide farmers to better manage their livestock production which improve their productivity and also enhances the acquisition and utilization of information on improved technologies by households as well as their innovativeness. The average years of schooling in the study area was 3.63, with a minimum of 0 year (illiterate) and maximum of 13 year of schooling.

The cross-tabulation indicates that the mean level of education level for the respondent family members that fall in the adoption categories of low, medium and high were 2.61, 3.64 and 5.21. The one way ANOVA result in the Table 5 shows that there is significant mean difference between the groups of adoption categories at less than 10% significance level(F=1.589, P =0.090) with regards to education level of the sampled household in the study area. The possible reason is that 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. 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.

Family size of sampled household

The average family size of the sample household heads was 5.42, with a minimum of 1.6 and maximum family size of 12.15 in terms of Adult equivalent (AE). The result implies that the mean household size in the study area is relatively higher than the national average agricultural household size which is about 5.2 persons per household (Essa, 2011).

The cross-tabulation indicates that the mean adult equivalent (AE) for the respondent family members that fall in the adoption categories of low, medium and high were 4.93, 5.44 and 6.08 with standard deviation of 2.06, 1.94 and 2.54 respectively. The result of one way ANOVA in Table 5 shows that there is statistical mean difference between the groups of adoption categories at less than 5% significance level(F=1.469, P =0.021). The average family size of the households shows the potential labor endowment in the study area. The members of the households are the potential labor force for the farming activities of the households, which could facilitate CSA adoption by the farming households, particularly CSA practices that are labor-intensive.

Land holding

Land is the main resource needed by the farmers to earn their livelihoods. Farmers use most of their land for crop production and livestock production. The average land of the sample households was 2.6 ha with a minimum of 0.25ha and maximum of 5.4ha (see Table 4). The result implies that households in the study area have relatively larger land size compared to that of the national average of landholding size which is 1.2 ha (Essa, 2011).

The cross tabulation shows that the mean land holding for the respondents falls in the adoption categories of low, medium and high were 1.88, 2.03 and 2.52 with standard deviation of 1.03, 0.87 and 1.25 respectively. The result shows there is a significant relationship between climate smart livestock production practices adoption in all categories at 10% significance level (F=1.327, P=0.087) with regards to landholding in the study area. This shows that secured land access is a basic determining factor for adoption of climate smart livestock production practices. Land holding is obviously a fundamental natural resource to run farming. 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.

Grazing land

Grazing land is the main resource needed by the farmers to feed their livestock which is the main source of feed by providing different fodder, grasses and etc. The average total grazing land of the farm households was about 0.46ha with a minimum of 0 ha and 2ha (see Table 4). From Table 5 below shows that the mean grazing land for the respondents falls in the adoption categories of low, medium and high were 0.29, 0.46 and 0.69 with standard deviation of 0.26, 0.33 and 0.45 respectively. The result of one way ANOVA shows that there is a highly significant mean difference between climate smart livestock production practices adoption in all categories at 1% significance level (F=2.669, P=0.000) with regards to landholding in the study area.

Livestock holding

Given a mixed farming system in the study area, livestock has imperative contribution for household income and food security. The type of livestock kept by sample farmers includes cow, oxen, bull, horse, mule, donkey, calf, goat, heifer and chicken. On average, the livestock holding of the sampled farmers in the study area was 5.77 per household with a minimum of 0.84 and maximum of 13.15 in TLU (Table 4).

The mean livestock holding of the respondent households in Tropical Livestock Unit (TLU) are 4.71, 5.84, and 7.14 for low, medium and high adoption categories with the standard deviation of 2.37, 2.62 and 1.89 respectively. The result of the study shows there is a highly significant relationship between climate smart livestock production practices adoption in all categories at 1% significance level (F=2.361, P=0.000) (Table 5).This indicates that farmers who have more livestock can participate in climate smart livestock production practices.

Livestock income

The average yearly livestock income of the sampled farmers in the study area was Birr 11300.48 with standard deviation of 13926.64. The maximum livestock income was Birr 66000 with minimum of Birr 0.The result indicates that household can generate more income from livestock production in the study area.

When the cross-tabulation is analysed the mean livestock income for the respondents that fall in the adoption categories of low, medium and high are Birr 9976.09, 10762.74 and 16331.03 respectively. In a similar manner the standard deviation of livestock income for low, medium and high adoption categories are 17229.11, 12087.03 and 16734.72 respectively. The one way ANOVA result in the Table 5 shows that there is significant mean difference between the groups of adoption categories at less than 5% significance level(F =1.477, P=0.019). This result implies that livestock income has a significant role to determine the adoption level and is important factor to enhance adoption of climate smart livestock production practices.

Distance from home to water source

The distance between the home and the water source site is assumed to be determining factor for adoption of the climate smart livestock production practices. Table 4 shows the mean distance from home to the nearest water source was 13.7 walking minute with a minimum of 2 and maximum of 60 walking minutes.

The average distance from home to nearest water source of the respondent households in walking minute are 18.46, 12.70, and 11.55 for low, medium and high adoption categories with the standard deviation of 12.96, 10.24 and 8.33 respectively. The result of the study shows there is insignificant relationship between climate smart livestock production practices adoption in all categories (F=1.218, P=0.22) (see Table 5).

Experience of the sampled household

This variable is captured by the level of years the household head spent in livestock production, which may accumulate experience of livestock production over time due to learning by doing. The more experienced the farmer is the more users of new technology. The average years of farming experience in the study area was 12.39 years, with a maximum of 52 and minimum of 2 years (Table 4)

From Table 5 below shows that the mean experience of the sampled households falls in the adoption categories of low, medium and high were 12.19, 12.10 and 14.24 with standard deviation of 4.89, 5.26 and 8.91 respectively. The result of one way ANOVA shows that there is a highly significant mean difference between climate smart livestock production practices adoption in all categories at 5% significance level (F=2.056, P=0.004) with farmers farm experience the study area. This is due to as one gets skillful in the methods of livestock production, he/she would be better in adopting climate smart livestock production practices.

Table 4: Summary of continuous variables

Variable	Measurement	Mean	Std. Dev.	Min	Max
Age	Year	45.82	11.08	23	77
Education	School years	3.63	3.91	0	13
Family size	AE	5.42	2.06	1.6	12.15
Landholding	ha	2.6	0.99	0.25	5.4
Grazing land	ha	0.46	0.35	0	2
Livestock holding	TLU	5.77	2.57	0.84	13.15
Livestock income	Birr	11300.48	13926.64	0	66000
Distance from water	Walking minute	13.70	10.85	2	60
Experience	Years	12.39	5.78	2	52

Source: Own survey (2020)

Table 5: Climate smart livestock production practices adoption status in relation to continuous explanatory variables

Variables	Adoption	Mean	Std.Dev.	F-value	P –value
Age	Low	44.37	11.27	2.011	0.001***
	Medium	45.96	10.86		
	High	47.41	12.08		
Education	Low	2.61	3.01	1.589	0.090*
	Medium	3.64	3.94		
	High	5.21	4.57		
Family size	Low	4.93	2.06	1.469	0.021**
	Medium	5.44	1.94		
	High	6.08	2.54		
Landholding	Low	1.88	1.03	1.327	0.087*
	Medium	2.03	0.87		
	High	2.52	1.25		
Grazing land	Low	0.29	0.26	2.669	0.000***
	Medium	0.46	0.33		
	High	0.69	0.45		
Livestock holding	Low	4.711	2.37	2.361	0.000***
	Medium	5.84	2.62		
	High	7.14	1.89		
Distance from water	Low	18.46	12.96	1.218	0.226
	Medium	12.70	10.24		
	High	11.55	8.33		
Experience	Low	12.19	4.89	2.056	0.004***
	Medium	12.10	5.26		
	High	14.24	8.91		
Livestock income	Low	9976.09	17229.11	1.477	0.019**
	Medium	10762.74	12087.03		
	High	16331.03	16734.72		

Note: *, ** and *** represents significance at 10%, 5% and 1% probability levels, respectively.

Source: Own survey (2020)

4.1.2. Smallholder farmers' perception on climate variability and its adverse impact

It is important for this study to assess the smallholder farmers' perception in relation to climate variability as well as its associated adverse impact with livestock production during the last 20 years before directly engaged on surveying household adoption status of the climate smart livestock production practices. The smallholder farmers' 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 livestock production practices (Zighe, 2016). Hence, the general climate variability its associated adverse impact on the cattle production sector were conducted and the results was summarized as it is described in Table 6 and 7 below.

According to Table 6 below 87.98% of the interviewed households responded for temperature increase and 6.44% responded that there was a decrease of temperature as well as the remaining 5.58% responded that there was no change of temperature over the last two decades in the study area. When it comes to rainfall amount 12.45%, 84.98 % and 2.58% of the responded household said that there was increase, decrease and no change respectively over the past 20 years. Considering perception of sampled household on drought 84.12%, 6.44% and 9.44% of responded household said that there was increase, decrease and no change respectively. In a similar way flood 61.80%, 28.33% and 9.87% of the sampled household responded that there was increase, decrease and no change respectively in past two decades. Moreover, related to area covered by forest and water availability 18.88%, 77.68%, 33.43% and 14.59, 76.82% and 8.58% of the sampled household replied that there was increase, decrease and no change respectively.

Generally, the majority of household claimed that temperature, drought, and flood become increases as well as, amount of rain fall, area covered by forest and water availability become shortening over the last 20 years. 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. These findings are agreed 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 6: Household' perception on local climate variability

Perception of respondents	Increasing		Decreasing		No change	
	Frequency	%	Frequency	%	Frequency	%
Temperature change	205	87.98	15	6.44	13	5.38
Rainfall amount change	29	12.45	198	84.98	6	2.58
Drought change	196	84.12	15	6.44	22	9.44
Flood change	144	61.80	66	22.33	23	9.87
Area covered by forest change	44	18.88	181	77.68	8	3.43
Water availability change	34	14.59	179	76.82	20	8.58

Source: Own survey (2020)

The results in Table 7 below indicate that 80.26% and 90.13% of the respondent mentioned increase of both livestock feed and water shortage during the past 20 years due to climate variability. In a similar way 76.82%, 77.25%, and 74.25% of the respondent perceived that over the last 2 decades there was an occurrence of disease and parasites, increase in livestock heat stress and decrease in livestock reproduction respectively.

Key informant interviews (KIIs) and focus group discussions (FGDs) made with different model farmers, women groups, government development agents and *woreda* revealed the same results of climate variability adverse impacts on the livestock production practices. 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. Due to poor feed availability livestock nutritional content deteriorate, disease (foot and mouth disease, black leg and pastorolosis, fungus), parasites(ticks and flea), animal growth stunted , lactation interval become shortened , mating time become lengthened, which all together adversely impacted the milk and meat production and productivity.

This result related 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 livestock production sector on which the smallholder depend for their livelihood and source of income in many ways.

Table 7: Households' perception on climate change adverse impacts

Perception of respondents	Increasing		Decreasing		No change	
	Frequency	%	Frequency	%	Frequency	%
Water shortage	187	80.26	35	15.02	11	4.72
Occurrence of livestock disease and parasite	179	76.82	48	20.62	6	2.58
Livestock feed shortage	210	90.13	18	7.73	5	2.15
Livestock heat stress	180	77.25	24	10.30	29	12.45
Reproduction	52	22.32	173	74.25	8	3.43

Source: Own survey (2020)

4.1.3. Climate Smart livestock Production Practices Adoption status

Sample respondents, key informants and focus groups have described that there is climate variability in the study area. This climate variability has brought an adverse impact on the smallholders livestock production system. In response to these adverse impacts both government and non-governmental organizations working in the area had encouraged climate smart livestock 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 years. Government animal husbandry and fishery resources office, agriculture and natural resource office, Agricultural Growth Program (AGP) and NGO supported Sustainable Land Management (SLM), Climate Smart Agriculture (CSA), Alliance Green Revolution in Africa(AGRA) are some of the climate smart livestock production promoting organizations and programs in the study area. It has also been known from KIIs and FGDs results that local smallholder livestock producers were practicing indigenous adaptive strategies like manure management, rotational feeding, feed conservation and others to cope up with the adverse impact of climate change. The eight climate smart livestock production practices that have been promoted by development actors and adopted by smallholder livestock herders at different level are rotational grazing, improved fodder, destocking, feed conservation, composting, manure management, genetic breed improvement and bio-gas generation.

Table 8 below revealed that the widely adopted practices are composting (85.41%) and manure management practices (70.39%) and the less adopted one is bio-gas generation (3.86%). Adoption of destocking (63.95%), improved breed (60.09%), fodder (29.18%), rotational grazing (22.32%) are intermediary adopted climate smart livestock production practices. As it can be seen from the same Table in all practices male households are the major adopters. The result 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 8: Types of climate smart livestock production practices commonly practiced in the study area

Types of climate smart practices	Adopters						Non adopters					
	Female		Male		Total		Female		Male		Total	
	Count	%	Count	%	count	%	count	%	count	%	count	%
Improved breed	34	55.74	106	61.63	140	60.09	27	44.26	66	38.37	93	39.91
Manure management	37	60.66	127	73.84	164	70.39	24	39.34	45	26.16	69	29.61
Fodder planting	20	32.79	48	27.91	68	29.18	41	67.21	124	72.09	165	70.82
Feed conservation	34	55.74	121	70.35	155	66.52	27	44.26	51	29.65	78	33.48
Composting	47	77.05	152	88.37	199	85.41	14	22.95	20	11.63	34	14.59
Rotational grazing	12	19.67	40	23.26	52	22.32	49	80.33	132	76.74	181	77.68
Biogas generation	5	8.2	4	2.33	9	3.86	56	91.8	168	97.67	224	96.14
Destocking	37	60.66	112	65.12	149	63.95	24	39.34	60	34.88	84	36.05

Source: Own survey (2020)

In the study area respondents are grouped 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 in table below. The result of analysis of adoption quotient of smallholder farmers indicates that the minimum adopted practices are 0 (0%) and the maximum adoption practice is 7 (87.5%).The mean adoption quotient is 0.4796 (47.9%) and standard deviation is 19.96 (Table 9) which show that there is an encouraging adoption practice which needs to be scaled up/out in the study area

Table 9 : Summary of adoption quotient of sampled households(in percentage)

Variable	Observation	Mean	Std. Dev.	Min	Max
Adoption quotient	233	47.96	19.96	0	87.50

Source: Own survey (2020)

Table 10 below shows that 46 (19.74%), 158(567.81%) and 26(12.45%) of the respondent categorized under low, medium and high adoption level respectively for Chi square and Ordered logistic regression model. This indicates that the majority of the respondents are categorized under medium adoption level while the minority of adopters categorized under higher adoption category.

Table 10: Adoption categories of sampled households

Adoption status	Frequency	Percentage
Low	46	19.74
Medium	158	67.81
High	26	12.45
Total	233	100

Source: Own survey (2020)

4.1.4. Key constraints to smallholder farmers in adopting climate smart livestock production in the study area

Adoption smallholder livestock producing farmers faced a number of challenges in the study area. The major challenges that affected these farmers from adopting the practices are identified and presented in Table 11 below. According to the results of respondents, key informant interviews (KIIS) and focus group discussions (FGDs) the general challenges in adopting climate smart livestock production practice by smallholder farmers are high cost of improved breed, low availability of feed, use of manure for fuel and crop residue for animal feeding, problem of free grazing, low awareness, small grazing land and lack of finance are the major ones in the study area. 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 stated different primary constraints as a reason for not practicing improved breed. Improved livestock breeding practice has a potential to address the three pillars of climate smart livestock 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). According to the results from the household survey 93(39.91%) of the respondent did not adopt improved breed mainly due to high cost of improved breed (38.71%), lack of technical practice (15.05%), low awareness about AI (11.83%), low availability of feeding (21.51%), far distance from the health service (8.6%) and lack of interest (4.3%) (see Table 11).

Composting is one of the climate smart livestock 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 (N2O) released by application of inorganic fertilizer, and stabilize the soil moisture and organic matter content (FAO, 2013). Related to preparing compost in the study area as indicated in Table 11, from the total non-adopters 34(14.59%) of respondents are not using compost in the study area. The main reasons areu se of manure for fuel and crop residue for animal feeding (47.06%), shortage of compost materials (23.53%), lack of labour (17.65%), un availability of water (8.82%) and low awareness (2.94%). This practice is the dominantly adopted practice where 199 (85.41%) respondents reported to practice it in the farming season. The result is in confirmation with Nyengere (2015) that identified family labour and poor awareness as major constraints that determines adoption of composting.

Proper feed conservation to livestock production 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 (CH4) gas released per head of animals in the effort to mitigate greenhouse gas release to the ambient atmosphere (IFAD, 2010). The study result in Table 11 indicates 78 (33.48) of the respondent didn‘t adopt the practice mainly due to limited of feed storage (67.95%) and low awareness (32.05%).

Fodder is defined as planting trees together with crops on the farm. These are trees that produce or are primarily used for fodder (for animal feed), or fuel wood production or that provide other benefits such as reducing runoff or erosion, increase water percolation, enhancing soil fertility, providing shade, fencing and wind break. Beside their use, they have 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 fodder planting in the area according to key informants and focus group discussions. In the study area from the total non adopters 165 (70.82%) is not using fodder planting. This is mainly due to problem of free grazing (58.19%), land allocation for crop production (13.36%), small land (7.88%), unavailability of water through a year (12.73%), unavailability of improved fodder seed (4.24%) and other (0.6%) (Table 11). The result is in agreement with that of Mutambara, Dube and Mvumi (2012) which identified land size and availability of information as determining factors for adoption.

Proper pasture management through rotational grazing would be the most cost-effective way to mitigate GHG emissions from fodder 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 grazing. According to the results from the household survey which indicated in Table 11 below 181(77.68%) of the respondent did not adopt rotational grazing practice mainly due to poor awareness and knowledge on benefit (23.76),small grazing land (53.59),weak land use policy enforcement (11.6%) and communal ownership of grazing land(11.05%). 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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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 problem emanating from the smoke.

The study result in the Table 11 indicates only 9 sampled household were adopted and the remaining 224 (96.14%) of the respondent didn‘t adopt the practice mainly due to lack of information and awareness (45.54) lack of finance(43.75%), small quantity of manure (8.93%) and other (1.79). This technology is the least adopted (3.86%) practices in the study area. Beside the household survey result government 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 major constraint for adoption.

Livestock are unable to find adequate feed and grow weak and die from malnutrition or disease. Availability of supplementary grain and fodder on the local market may decrease. As a result, livestock prices drop too low and the price of grain climbs to high. Emergency destocking programmes allow for the removal of animals before they die. Destocking of livestock is the reduction of the number of livestock especially during shortage of feed, dry season in order to adjust the number of livestock with their feed capacity. According to the Table 11 below 84(36.5%) of the respondent did not adopt destocking of livestock practice. The main reasons are low awareness on destocking (69.05%), cultural attitude (25%) and other (5.95%)

Table 11: The main constraints in adopting climate smart livestock production in the study area

Types of climate smart livestock production practice	Major constraints	Count	%
Main reason not to use improved breed	High cost of improved breed	36	38.71
	Lack of technical practice	14	15.05
	Low awareness about AI	11	11.83
	Low availability of feed	20	21.51
	Far distance from the health service	8	8.60
	Lack of interest	4	4.30
	Other	0	0
Main problems to prepare compost	Use manure for fuel and crop residue for animal feeding	16	47.06
	Shortage of compost materials	8	23.53
	Lack of labour	6	17.65
	Un availability of water	3	8.82
	Low awareness	1	2.94
	Other	0	0
Reasons not to use fodder plantin g	Problem of free grazing	96	58.19
	Land allocation for crop production	27	16.36
	Small land	13	7.88
	Unavailability of water through a year	21	12.73
	Unavailability of improved fodder seed	7	4.24
	Other	1	0.60
Main problem of not use feed conservation	Limited of feed storage	53	67.95
	Low awareness	25	32.05
Reasons not to use rotational graz ing	Poor awareness and knowledge on benefit	43	23.76
	Small grazing land	97	53.59
	Weak land use policy enforcement	21	11.60
	communal ownership of grazing land	20	11.05
	Other	0	0
Reasons not to practice biogas	Lack of information and awareness	102	45.54
	Lack of finance	98	43.75
	Small quantity of manure	20	8.93
	Other	4	1.79
Reasons not to use destocking	Low awareness on destocking	58	69.05
	Cultural attitude	21	25.00
	Other	5	5.95

Source: Own survey (2020)

4.2. Econometric Analyses

4.2.1. Factors affecting adoption of climate smart livestock production practices

Diagnostic test

Ordered logit regression model was applied to estimate the determinants of farmers‘choices of adopting climate smart livestock production practices that aimed to reduce the adverse impact of climate change and variability. The dependent variable of the model is the category of users of CSA practices (high, medium and low). Before running the ordered logistic regression model, different econometric assumptions were tested using appropriate techniques. The existences of multicollinearity between the explanatory variables were checked by using VIF for continuous variable while the coefficient of contingency was used for dummy variable. As the rule of thumb VIF values, less than 10 is said to be weak association among explanatory variables.

Therefore, in this study, the computational results of the VIF for continuous variables is lower than 1.58 and the mean/average of VIF is 1.26, confirmed the non-existence of severe multicollinearity problem among the continuous predictor variables, and were included in the model (Appendix table 3). Besides, the values of contingency coefficient regarding dummy variables were less than 0.29 (Appendix table 4) which is less than the rule of thumb of 0.75 implying that a weak degree of association among the variables considered. Moreover, from Table 12 below Prob > chi2=0, which indicates the fitness of the model during analysis.

Hence, the parameter estimates of the ordered logit 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.

Education: The result of ordered logit regression model in Table 12 below shows that educational status is statistically significant and has a positive influence on the level of adoption of climate smart livestock production practices at 1% (P=0.003). It indicates that as sampled household educated more there is the more likely to be in the higher category and less likely in the lower category. The marginal effect in Table 13 shows that as education increase by one school year keeping other variables constant, the probability to be in the lower adoption level decrease (less likely in the low adopter category) by 1.5%, the probability in medium category increase (more likely in the medium category) by 0.6% and the probability in the higher category increase (more likely in the higher category) by 0.9%.

This is due to relatively better educated farmers are engaged in the adoption of new technology. The result also revealed that better exposure to education increases farmers' better understanding of the benefits and constraints of climate smart livestock production practice. A positive impact of education on technology acquisition is generally expected as it enhances farmer's ability to acquire and analyze new ideas, and provides specific or general skills that contribute to livestock productivity.

Similar to the finding of this study, (Daniel and Muluget, 2017; Workneh, 2015; Eric ,2012) reported that education gives farmers the ability to perceive, interpret and respond to new information much faster than farmers with lower education level (non-educated). Thus, those household heads with better education level have a higher probability of adopting best practices.

Grazing Land: This variable has a statistically significant and positive influence on the level of adoption of climate smart livestock production practices at 1% (P=0.003) as indicated in Table 12 below. The result indicate that farmers who have larger grazing land are more likely to be in the higher category and less likely in the lower category to adopt climate smart livestock production in the study area. Furthermore the marginal effect in Table 13 indicates that as grazing land increase by one hectare assuming other factors constant the probability to be in a lower category decrease by 18.7%, the probability to be in the medium category increase by 7.3% and the probability to be in the higher category increase by 11.3%. This is due to grazing land is the main source of feed like different fodder, grasses and etc which increase the probability of farmers to adopt new technology.

Total livestock holding: As expected total livestock holding was found to be positively and significantly associated with adoption status at 10% (P=0.064) significance level. The finding implies that farmers who have more livestock are more likely to be in the higher category and less likely in the lower category to adopt climate livestock production in the study area. The marginal effects in Table 13 also shows that as livestock increase by one unit keeping other variables constant the probability to be in the lower category decrease by 1.6%, the probability to be in the medium category increase by 0.6% and the probability to be in the higher category increase by 1%.

The possible reason is livestock are important providers of manure for compost preparation, as farmers' hold more livestock; by far they are encouraged to prepare and apply compost in their farmlands. Also, livestock holding in rural Ethiopia in general and in the study area in particular is considered as indicator of income level and hence wealth status of the households. It shows farmers financial ability to buy even different inputs for farmlands. On the other hand, some of the livestock type like donkey and horse are still important means of transports for goods and human being in the study area. So, a farm household having a number of livestock is not challenged in applying compost to their farmlands. So a large number of livestock presences in study area increase the probability to adopt climate smart livestock production practices. The result is agreed with that of Workneh (2015) ; Mengistu and Bauer (2011) .

Extension contact : The result of ordered regression model in Table 12 revealed that there is a positive and statistically significant effect of extension contact on adoption status at 1% (P=0.008) significance level. The result indicates that farmers who contact extension experts are more likely to be in the higher category and less likely in the lower category to adopt climate livestock production in the study area. Moreover the marginal effect in Table 13 shows that a change of extension contact from who do not get extension to who get extension service (from 0 to 1) assuming other factors constant the probability of the sampled household to be in the lower category would be decrease by 25%, the probability of the farmers to be in the medium category increase by 18% and the probability to be in the higher category increase by 7% in the study area.

The possible explanation is that extension services are important sources of information and knowledge for rural farmers. It is expected that frequent contact with extension agents would brighten the chances of awareness of climate change and CSA practices that can be adopted to adapt to climate variability and shocks. Besides, farmers, through extension services, can learn climate change mitigation measures and strategies that can enhance resilience. Based upon the innovation diffusion theory, farmers who have contacts to extension services tend to be more progressive and receptive to new innovation. Farmers with more access to information and technical assistance on agricultural activities have more awareness about the consequence of climate change. Agricultural extension services serve as a crucial source of information on climate change, climate change adaptation and resilience, as well as livestock management practices. Additionally, as the extension workers frequently visit and follow up farmers more, farmers may obtain important and influential information. This result agrees with the finding of Onyeneke *et al.* (2018) who confirmed that contact with extension agents increases the likelihood of the adoption of CSA practices. More over this finding also consistent with those of Daniel and Mulugeta (2017) and Workneh (2015) who analyzed the adoption of soil and water conservation techniques and composting in south wollo zone of Amhara region and Beseku district of Oromia region repectively. Also, Wang *et al*. (2016); Eric (2012) and Somada *et al*. (2002) reported similar findings on composting technology adoption in China, Kenya and Burkina Faso respectively.

Distance from water source: It affects adoption status negatively and significantly at 1% (P=0.003) significance level as indicated in Table 12 below. According to the result of ordered logit regression model the more distance from the resident of the sampled household the more likely in the lower category and the less likely in the higher category. The marginal effect also implies that a unit increase (1 walking minute) from the resident to the nearest water source the probability of the farmers to be in the lower category would increase by 0.5%, the probability of the farmers to be in medium category would be decrease by 0.2% and the probability to be in the higher category would be decrease by 0.3% in the study area (Table 13).

This is due to the fact that if there is far distance from the household home to water source, it is more difficult to manage the livestock. This could be attributed to the fact that the farther the water source from the respondent's residence, the greater would be the cost of consuming time (opportunity cost), management and supervision. This implies that farmers whose water sources are far from their homesteads would likely adopt fewer CSA practices. This could be attributed to the challenges they would be facing in exercising proper and effective management as a result of stress posed by distance when compared with their counter parts who live closer to their water source.

More over the farmer whose water source is far from his residence is less likely to continuously watering his/her livestock as compared to those whose water source nearer to their home. Thus, it is expected that farmers who live near to their water source are likely to have regular watering of their livestock, hence motivated to respond to climate change on their agricultural activities. The result is similar with the finding of Malefiya (2017).

Number of obs = 233

LR chi2 (12) = 57.56

Prob > chi2 = 0

Pseudo R2 = 0.1465

Log likelihood = -167.65183

Table 12: Result of ordered logistic regression model

Adoption status	Coef.	Std. Err.	z	P>z
Sex	0.174	0.354	-0.49	0.623
Education	0.118***	0.040	2.94	0.003
Family size	0.058	0.081	0.71	0.475
Landholding	0.166	0.192	-0.87	0.386
Grazing land	1.470***	0.499	2.94	0.003
Total livestock holding	0.128*	0.069	1.85	0.064
Livestock income	0.000	0.000	0.57	0.567
Credit use	0.079	0.310	-0.25	0.802
Extension contact	1.396***	0.529	2.64	0.008
Distance from water source	-0.043***	0.014	-3	0.003
Climate information	0.112	0.366	0.31	0.76
Experience	0.039	0.027	1.44	0.15
/cut1	1.233	0.737		
/cut2	5.360	0.837		

Note: *** and * Significant at 1% and 10% level respectively

Source: Model result (2020)

Table 13: Marginal effects after ordered logit model

Adoption status	Marginal Effect (dy/dx) for low adopter	Marginal Effect (dy/dx) for medium adopter	Marginal Effect (dy/dx) for high adopter
Sex	0.021	-0.008	-0.014
Education	-0.015	0.006	0.009
Family size	-0.007	0.003	0.004
Landholding	0.021	-0.008	-0.013
Grazing land	-0.187	0.073	0.113
Total livestock holding	-0.016	0.006	0.010
Livestock income	0.000	0.000	0.000
Saving and credit use	0.010	-0.004	-0.006
Extension contact	-0.250	0.180	0.070
Distance from water source	0.005	-0.002	-0.003
Climate information	-0.014	0.006	0.008
Experience	-0.005	0.002	0.003

Source: Model result (2020)

Table 14 below shows that the mean predicted value of low, medium and high adoption category are 0.197(19.7%), 0.68 (68%) and 0.133 (13.3%) which is almost similar with the mean value explained in Table 10 above. This indicates that the model correctly predicted the value.

Table 14: Predicted probability for adoption category

Variable	Obs	Mean	Std.Dev	Min	Max
predicted probability (low)	233	0.197	0.168	0.004	0.829
predicted probability (medium)	233	0.680	0.127	0.167	0.775
predicted probability (High)	233	0.123	0.120	0.003	0.794

Source: Model result (2020)

5. CONCLUSION AND RECOMMENDATION

5.1. Conclusion

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. This study fills this gap by identifying the factors aff ecting the level of adoption of climate-smart livestock production practices by small-scale farming households in North Shewa Zone, Hidabu Abote *Woreda*. Climate smart livestock production practices adopted by smallholder farmers in respect to livestock farming in the study area were composting, manure management, feed conservation, destocking, improved breed, fodder planting, rotational grazing and biogas generation. Composting 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 wider adoption of composting and manure management and limited adoption of bio-gas generation practices indicates 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 benefits in the long run.

Moreover different climate smart livestock production constraints were identified by the sampled households, FGD and KII in the study area. These are mainly high cost of improved breed, low availability of food, use of manure for fuel and crop residue for animal feeding, problem of free grazing, low awareness, small grazing land and lack of finance.

There were significant differences of farmers'choice of climate smart livestock production practices with regards to explanatory variables such as, education level, grazing land, livestock holding, extension contact and distance from water source. Education level, grazing land, extension contact and total livestock holding have positive and significant effect on adoption of the climate smart livestock production practices, where as distance from water source has negative and significant effect on adoption of the improved practices. Therefore it could be concluded that livestock herders having higher education level, grazing land, total livestock holding, extension contact are more likely to adopt climate smart livestock production practices where as farmers whose water source are far from their home are less likely to adopt climate smart livestock production practices .

5.2. Recommendation

The result of the study provides information and got some policy recommendations to policymakers and extension workers on how to improve adoption of climate smart livestock production practices. Accordingly, the following recommendations are made.

- It is imperative for government (such as Hidabu Abote *woreda*, zonal, regional and federal livestock fishery development offices) and non- government development organizations such as SLM, AGP, Worldvision and SNV should have to collaborate in strengthening the existing initiatives and works to alleviate the identified challenges faced by smallholder farmers in adopting the climate smart livestock 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 livestock breed), expand information, awareness and knowledge base, enforce land use policy and other supportive institutions, and develop basic infrastructures.

- Improving and strengthening contact with agricultural extension agents, increased exposure to media, and raising awareness on the impacts of climate change are critical in promoting the level of adoption of CSA practices. The implication of this is that adequate attention should be paid to extension services among small-scale farmers in in the study area as frequent extension visits and services may primarily be very effective in mainstreaming the adoption of livestock production practices among small-scale farmers.
- Education is fundamental in improving the adoption of climate smart livestock production practices. Hence, strengthening adequate and effective basic educational opportunities for farmers in the study area is required. Furthermore giving practical

training (capacity building) and creation of awareness and knowhow about the application of inputs and different farming system for the smallholder farmers should be done. The regional government should have responsibility to keep on the provision of education in this area so that farmers can use the available inputs more effectively under the existing technology.

- Given the mixed farming system in the study area, farmers with large number of livestock were relatively better in adoption of climate smart livestock production practices. Hence, there is a need to design appropriate policy and strategies for improving livestock production systems by solving the shortage of feed and providing various technical and advisory support services, which in turn would enhance the adoption of climate smart livestock production practices.

- Grazing land is the significant and most determinant to adopt climate smart livestock production practices. So adequate and proper management of grazing land should be done by the farmers and concerned body since more and properly managed grazing land provide sufficient food for the livestock as well as it can reduces land degradation and overgrazing.

- Distance from water source also one of the main factors to adopt climate smart livestock production in the study area. So the regional, zonal as well as *woreda* government should give attention on the availability and quality of water to provide sufficient water supply which enables the farmers can easily get the water near to their home for their livestock in order to save their time and manage their livestock properly.

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APPENDICES

Appendix table 1: Conversion factor used to calculate man and adult equivalent.

Age group (years)	Man Equivalent(ME)		Adult Equivalent(AE)	
	Male	Female	Male	Female
<10	0	0	0.6	0.6
11-13	0.2	0.2	0.9	0.8
14-16	0.5	0.4	1	0.75
17-50	1	0.8	1	0.75
>50	0.7	0.5	1	0.75

Source: Storck (1991 as cited in Wassie, 2014).

Appendix 2: Conversion factors used to estimate Tropical Livestock Unit equivalents.

Animal category	TLU	Animal category	TLU
Cow and oxen	1	Sheep and goat young	0.06
Bull	1	Horse and mule	1.1
Calf	0.25	Donkey (young)	0.35
Heifer	0.75	Donkey (adult)	0.7
Sheep and goat(adult)	0.13	chicken	0.013

Source: Storck *et al*.(1991)

Appendix table 3: VIF for continuous variables used in the model

Variable	VIF	1/VIF
land holding	1.58	0.630917
Livestock holding	1.42	0.76453
Livestock income	1.27	0.788829
Grazing land	1.36	0.737458
Family size	1.25	0.799089
Experience	1.09	0.918041
Education	1.08	0.927307
Distance from water source	1.01	0.987624
Mean VIF	1.26	

Source: Model output (2020)

Appendix 4: Contingency coefficients for dummy variables used in the model

	Sex	Extension	Climate change information	Saving and credit
Sex	1			
Extension contact	0.1416	1		
Climate change information	0.1607	0.2943	1	
Saving and credit	-0.0622	0.0807	0.0252	1

Source: Model output (2019)

Appendix table 5: Marginal effects after ordered logistic regression model

Marginal effects after ologit
y = Pr(adstatus==1) (predict, outcome(1))
= .14913981

variable	dy/dx	Std. Err.	z	P>|z|	[95%	C.I.]	X
sex*	.0214276	.04237	0.51	0.613	-.061623	.104479	.738197
edu	-.0150023	.00517	-2.90	0.004	-.025136	-.004868	3.6309
famsize	-.0073214	.01024	-0.71	0.475	-.027397	.012754	5.41631
landhold	.0210624	.02433	0.87	0.387	-.026631	.068756	2.06472
grazin~n	-.1865991	.06456	-2.89	0.004	-.313136	-.060063	.458262
TLU	-.0162705	.00881	-1.85	0.065	-.033546	.001005	5.77521
livincom	-8.66e-07	.00000	-0.57	0.567	-3.8e-06	2.1e-06	11300.5
credit*	.0099271	.03972	0.25	0.803	-.067927	.087781	.407725
extese~i*	-.2496571	.11808	-2.11	0.034	-.481091	-.018224	.905579
distwa~r	.0053937	.00182	2.96	0.003	.001817	.00897	13.6953
climinfo*	-.0144502	.04833	-0.30	0.765	-.109179	.080278	.755365
experien	-.0048917	.00341	-1.44	0.151	-.011567	.001784	12.3863

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

. mfx,predict(outcome(2))

Marginal effects after ologit
y = Pr(adstatus==2) (predict, outcome(2))
= .76661767

variable	dy/dx	Std. Err.	z	P>|z|	[95%	C.I.]	X
sex*	-.0075415	.01368	-0.55	0.582	-.034359	.019276	.738197
edu	.0058818	.00332	1.77	0.076	-.000626	.01239	3.6309
famsize	.0028704	.00419	0.69	0.493	-.005341	.011082	5.41631
landhold	-.0082577	.01019	-0.81	0.418	-.028226	.01171	2.06472
grazin~n	.0731582	.04099	1.78	0.074	-.007185	.153501	.458262
TLU	.006379	.00445	1.43	0.152	-.002344	.015102	5.77521
livincom	3.39e-07	.00000	0.55	0.579	-8.6e-07	1.5e-06	11300.5
credit*	-.0039576	.01618	-0.24	0.807	-.035676	.027761	.407725
extese~i*	.1800114	.10474	1.72	0.086	-.02527	.385293	.905579
distwa~r	-.0021147	.00117	-1.80	0.071	-.004412	.000182	13.6953
climinfo*	.0060392	.02151	0.28	0.779	-.036115	.048193	.755365
experien	.0019178	.00158	1.21	0.225	-.00118	.005016	12.3863

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

. mfx,predict(outcome(3))

Marginal effects after ologit
y = Pr(adstatus==3) (predict, outcome(3))
= .08424252

variable	dy/dx	Std. Err.	z	P>|z|	[95%	C.I.]	X
sex*	-.0138861	.02927	-0.47	0.635	-.071245	.043472	.738197
edu	.0091205	.00322	2.83	0.005	.002811	.01543	3.6309
famsize	.004451	.00626	0.71	0.477	-.007825	.016727	5.41631
landhold	-.0128046	.01487	-0.86	0.389	-.04195	.016341	2.06472
grazin~n	.1134409	.04078	2.78	0.005	.033522	.19336	.458262
TLU	.0098915	.00545	1.81	0.070	-.00079	.020573	5.77521
livincom	5.26e-07	.00000	0.57	0.567	-1.3e-06	2.3e-06	11300.5
credit*	-.0059694	.02364	-0.25	0.801	-.052296	.040357	.407725
extese~i*	.0696457	.02032	3.43	0.001	.029817	.109474	.905579
distwa~r	-.0032791	.00116	-2.83	0.005	-.005551	-.001007	13.6953
climinfo*	.0084109	.02698	0.31	0.755	-.044462	.061284	.755365
experien	.0029739	.00209	1.42	0.155	-.001124	.007071	12.3863

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

Appendix table 6: Survey Questionnaire

COLLEGE OF DEVELOPMENT STUDIES

CENTER FOR FOOD SECURITY STUDIES

QUESTIONNAIRE

Dear respondent,

My name is Bassa Mamo. I am a postgraduate student at Center for Food Security Studies, College of Development Studies, Addis Ababa University. Currently, I am doing my MSc thesisentitled 'Smallholder Farmers Adoption of Climate Smart Livestock Production: Practices, Status and Determinants in Hidebu Abote Woreda, Oromia Region, Central Ethiopia. The main objective of this questionnaire is to collect primary data to undertake an assessment on Smallholder Farmers Adoption of Climate Smart Livestock Production: Practices, Status and Determinants. Your responses to the questions are valuable and will be held in utmost confidentiality to be used only for the analysis of this research. You will not be identified by name in any case. You have been selected randomly from different Keeble's. If you accept to participate in this research, you will be doing so voluntarily and there will not be any monetary returns. You are also free to refuse to respond to any questions, you do not feel comfortable answering or to withdraw from the research all together. This interview will take about an hour of your time to respond to the questions.

Date of the interview ---(DD/MM/YYYY)
Interviewer name ---
Supervisor name ---
Checked on--(DD/MM/YYYY)
Woreda ------------------------------Kebele-------------------------------Village---------------------------
Agro ecology: 1. Dega ------------% 2. Weynadega -------------- % 3. Kolla --------------------%

Thank you in advance for your cooperation

Part one: Demographic characteristics of the respondent

1. Sex of the household head 1= Male headed 0= Female headed
2. Age of the household head. -------------------------

3. Education level of the household head. 0=Not read and Write 1=Informal education 2=Formal education

3.1. If yes, Q3 is formal, enter grade completed -------------------------------

3.2. Maximum education level in the household ---------------------------

4. Marital status of the household head 1=Married 2=Divorced 3=Widow/widower 4=single 5. Polygamous

5. Religion 1.orthodox 2.waqefata 3. Muslim 4. Protestant

6. Family size

Age	Male	Female	Total	Number of household members engaged in Climate Smart Livestock Production activity
<15				
15-64				
>64				
Total				

Part two: Socioeconomic characteristics of the household

1. Do you have livestock? 1) Yes 0) no

1.1. If yes, indicate number and types of livestock you owned in the following table:

Types of Livestock	Number of Livestock	Livestock Sold		
		Number	Average Unit Price (ETB)	Total price
Oxen	Indigenous			
	Improved			
Cow	Indigenous			
	Improved			
Heifers	Indigenous			
	Improved			
Bull	Indigenous			
	Improved			
Horse				
Donkey				

Sheep				
Goat				
Chicken	Indigenous			
	Improved			
Beehives	Traditional			
	Transitional			
	Modern			

2. Do you have own land? 0. No 1 Yes

2.1 If Yes, Question number.2 how many hector (timad) of land do you have? __________

2.2. How do get the land: 1.Allocated by government 2. Rented from individual farmer 3. Inherited

3. Which farming activities are you following currently? 1. Only crop production 2. Livestock rearing 3. Mixed farming (Crop production and. livestock rearing)
4. Land use type and area coverage

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

5. 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
6. How much income can you generate from livestock production during last production year (i.e. 2011/12)? Please specify in Birr:

s/n	Livestock type	No of livestock sold	Average price (Birr)	Income earned (birr)	
1	Cow				
2	Oxen				
3	Heifer				
4	Bull				
5	Sheep				
6	Goat				
7	Chicken				
8	Horse				
9	Donkey				
10	Others				

7. Do any members of your family have any sources of off-farm income? 1 Yes 0 No
8. How many members of your family engage in off-farm activities? ________________
9. If yes in question No.8 please fills the following table

s/n	Off- farm activities	Income gained per year
1	Remittance	
2	Petty Trade	
3	Handouts from relatives/other	
4	Hand craft	
5	Aid from governments	
6	Others(specify)	
7	Total	

IV .Institutional Factor Related Questions

1. Did you use any type of credit? 0 No 1 Yes
2. If yes Q.1 for what purposes do you obtained credit?
3. For concentrate preparation
    1. For genetic breed improvement
    2. For biogas preparation
    3. To gain animal health services
    4. To buy agro-forestry and fodder seed/ seedling and farm tools
    5. To fill up family requirement
    6. Petty trade
4. 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 (Specif)
5. Do you have contact to agricultural extension services? 0 No 1 Yes
6. If yes Q 5 how many times extension workers visit in a month ____
7. What types of advices did you get from extension workers?
    1. Improved feed management 2. Improved animal health service 3. Manure management
    3. Integrated crop livestock management 5. Improved breeding 6. Herd management 7. Others (please specify
8. How long does it take to reach your farm from your home?

Distance (in KM ____________ In terms of time it takes (in min)______________________

9. How long does it take to reach the water point for livestock and domestic consumption from your home? Distance (in KM ____________ In terms of time it takes (in min)_________________
10. Where you use veterinary service for animal health and breading service?____________
11. How long does it take to reach veterinary post/clinic from your home?

Distance (in KM ____________ In terms of time it takes (in min)______________________

12. 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).........?
13. Is there a road access in your *kebele*? 0 No 1 Yes
14. If yes to Q.13 what type? 1. Asphalt 2. All weather road 3. Dry weather road
15. What is your usual means of transportation to the market? 1=Car; 2=Motor bike; 3=Bus/public transport; 4= Bicycle; 5=Walk; 6=pack animals 7=Other (specify)
16. Cost of transport *[one way]*: Birr__________________
17. How do you have access to climate change information? 1 low 2 medium 3 High
18. If yes Q17 what types of communication devices you have?
    1. TV 2 Radio 3 mobile phone 4 other (specify)
19. Do you perceive that there is climate change & it is adversely impact the livestock productionin your locality? 0 No 1 Yes
20. If yes to Q.19 what are weather events of climate change in your locality?

    ____
21. Have you get information about any one of climate smart livestock production practices?
    1. 0 No 1 Yes
22. If the answer to Q 21 is yes from where did you get information about climate smart livestock production practices 1. Extension agent 2. From other farmers 3. Mass media (Radio,TV Neighbors 4. Local leaders 5. Woreda government expert 6. From NGOs 7. From market place 8. Others(Specif
23. In response to climate change, have you taken any climate smart livestock production practices in order to reduce the adverse impacts of climate change? 0 No 1 Yes Since when?

    _____
24. If your answer is yes in question 23 have you employed any of the following climate smart livestock production practices in your farm in the past decade?

s/n	Climate Smart livestock production practices	Awareness Of the practice		Developed willingness or interest		Have you tried		Adopt	
1	Feed management	Yes	No	Yes	No	Yes	No	Yes	No
2	Grazing management								
3	Adjust stocking densities to feed availability								
4	Rotational grazing								
5	Pasture management & nutrition								
6	Improved species of fodder, legumes								
7	concentrates								
8	Agro-forestry& nursery								
9	Genetic breed improvement(AI, Selection)								
10	Improving animal health service(Vaccination, treatment								
11	Integrated crop livestock management (manure for fertilizer, residue for compost, etc...)								
12	Livestock manure management								
13	Composting								
14	Bio-gas generation								

25. If your answer No in question 23 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
    7. Others (specify

26. Did you ever participate in any climate smart livestock production practices capacity building activities like trainings, awareness creation and demonstration activities in the

last decade? 1 = Yes; 0 = No; List them___________________________

27. Where do you feed your livestock? [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

28. Have you planted fodder on your farm currently? ___________ 1=Yes 0=No
29. If YES, what types of improved fodders have you grown on your farm and their production levels?

Types of fodder	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

30. What criteria are important to you when choosing the type of fodder to plant? *[rank from 1=*

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)___________

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

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)____________________

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

____

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

33. If your answer to Q.56 is No,what is the reason? 1. Limited labour 2. Limited finance 3.No awareness 4.Other (Specify)__________________
34. Do you practice rotational feeding for your livestock production? 0 No 1 Yes

35. If your answer for question number 34 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)

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

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

38.If your answer for question number36 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

4. If other reasons, please specify

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

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

1. No information about the importance of animal health services 2. Financial limitation

41. Distance of the service from my far4. No technical advice 5.I use traditional treatment methods 6. If other reasons, please specify

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

43.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= other

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

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) _

45.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) ____________

46.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)______________________________________

47.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)______________________________________

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

49.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)

50.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) ___________

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 livestock production and livelihood of farmers in your area?

   ____
3. What is your perception regarding the effect of traditional or business as usual livestock 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 livestock production practices to response climate related problems as per your knowledge? 0 No 1 Yes
5. If yes Q. 4 is Yes what types of climate smart livestock production practices used? Please mention the most common climate smart livestock 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 livestock production practices exists?
8. What do you suggest to be done to reduce the impacts of climate change in yours *Woreda*? By whom?

FGD GUIDING QUESTIONS

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 livestock production and livelihood of farmers in your area?
3. What is your perception regarding the effect of traditional or business as usual livestock production practice by the community on exacerbating climate change through green house gas release (GHG)?
4. What are the climate smart livestock production practices promoted by the development partners in the *Woreda*? Which practice by which partner? How did you promote the climate smart livestock 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 livestock 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 livestock 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 favourable 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 activity