EXPLORING THE PRACTICES AND CHALLENGES OF CLIMATE-SMART AGRICULTURE IN AGRO-PASTORAL LIVELIHOODS: A CASE STUDY OF HARSHIN WOREDA IN SOMALI REGIONAL STATE, ETHIOPIA.

MA THESIS

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We hereby certify that we have read and evaluated this Thesis entitled **"Exploring the practices and challenges of climate-smart agriculture in agro-pastoral livelihoods: A Case Study of Harshin woreda in Somali Regional State, Ethiopia."** "Prepared under my guidance by Kalid Mohamoud Tahir. We recommend that it be submitted as fulfilling the Thesis requirement for the Degree of Master of Art in Climate Change and Disaster Risk Management.

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DEDICATION

I Dedicate This Thesis Manuscript To My Lovely Mother Roda Cali And My Gorgeous Late Father Mohamoud Tahir For Showing Me The Real Values Of Education. I Feel Very Sad He Could Not Live Long To See That His Efforts Have Finally Come To Realization. I Ask Allah For Blessing Him With Mercy.

STATEMENT OF THE AUTHOR

By my signature below, I declare that this thesis is my own work. I have followed all ethical and technical principles of scholarship preparation, data collection, data analysis and completion of the thesis. Any scholarly matter that included in the thesis has been given recognition through citation.

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BIOGRAPHICAL SKETCH

The author Kalid Mohamoud Tahir was born in 1995 March in Harshin Somali Regional, Ethiopia, to his mother, Roda Cali. He attended Harshin Primary School for his primary education and then went on to Farah Nour Secondary School. After completing his secondary education, Kalid enrolled at Jigjiga University, where he pursued a degree in the School of Earth Science or Geology. He began his studies in 2016 and graduated in 2019. In 2020, Kalid started working at the Public Enterprises Support and Supervisors Authority in the Somali region. He continues to work at this organisation, leveraging his expertise and education in earth science and related fields. In 2021, Kalid also joined Haramaya University, Collage of Social Sciences and Humanities, School of Geography and Environmental Studies, master program of Climate Change and Disaster Risk Management, where he likely contributes his knowledge and skills to addressing climate-related challenges in the region.

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ACRONOMYS AND ABBREVIATIONS

ADLI:	Agricultural Development Led Industrialising
CAADP:	Comprehensive Africa Agriculture Development Programme
CBD:	Convention on Biological Diversity
CC:	Climate Change
CCA:	Climate Change Adaptation
CGIAR:	Consultative Group on International Agricultural Research
CSA:	Climate-Smart Agriculture
CSAIP:	Climate-Smart Agriculture Investment Plans
CSAP:	Climate-Smart Agriculture Adaptation Practices
DA:	Date Analyser
EPACC:	Ethiopian Programme of Adaptation to Climate Change
FAO:	Food and Agriculture Organisation
FDRE:	Federal Democratic Republic of Ethiopia
FGD:	Focus Group Discussions
GHG:	Greenhouse Gases
GTP:	Growth and Transformation Plan
IFAD:	International Fund for Agricultural Development
IPCC:	Intergovernmental Panel on Climate Change
KII:	Key Informant Interviews
MVP	Multivariate Probit
NAMA:	National Appropriate Mitigation Actions
NAPA:	National Adaptation Plan Action
PASDEP:	Plan for Accelerated and Sustained Development to End Poverty
PSM:	Propensity Score Matching
SNNP:	Southern Nations Nationalities Peoples
SSA:	Sub-Saharan Africa
UNCCD:	United Nations Convention to Combat Desertification

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ABSTRACT

This study investigates the practices and challenges of climate-smart agriculture (CSA) within agro-pastoral livelihoods in Harshin Woreda, Somali Regional State, Ethiopia, and a region particularly vulnerable to climate change. The primary objective was to assess the existing climate patterns, understand the impact of climate change on agro-pastoral communities, and identify the CSA practices adopted by these communities. Additionally, the study aimed to evaluate the barriers to implementing CSA practices and their effects on the livelihoods of agro-pastoral households. A mixed-methods approach was employed, combining quantitative and qualitative data collection techniques. Multivariate probit (MVP) was employed to identify factors influencing adoption of climate-smart agricultural practices, while the Propensity Score Matching (PSM) technique was used to evaluate the impact of adoption of climate-smart agricultural practices on the annual income of households in the study area. The study sampled 286 agro-pastoral households from Harshin Woreda, utilizing questionnaires, interviews, focus group discussions, and document analysis to gather comprehensive data. The analysis revealed significant climatic challenges, such as increasing temperatures and decreasing rainfall, which exacerbate the vulnerabilities of agro-pastoral communities. The study also identified key CSA practices, including crop rotation, water-efficient irrigation, and integrated soil fertility management, though the overall adoption rate remains low due to barriers such as limited access to resources, inadequate institutional support, and cultural resistance to change. The findings underscore the critical need for targeted interventions to enhance the adoption of CSA practices, which are essential for improving the resilience and sustainability of agro-pastoral livelihoods in the face of climate change. The research contributes valuable insights for policymakers and development practitioners, offering practical recommendations to strengthen CSA adoption. These insights are crucial for developing effective policies and programs that can mitigate the adverse effects of climate change on agro-pastoral communities in Ethiopia and similar regions. In conclusion, the study highlights the importance of addressing the barriers to CSA adoption through improved resource access, institutional support, and community engagement. These steps are vital for promoting sustainable agricultural practices and enhancing the resilience of vulnerable communities to the ongoing challenges posed by climate change.

Keywords: Agro-Pastoral Livelihoods, Climate Change, Climate-Smart Agriculture, Ethiopia,

1. INRTODUCTION

1.1. Background of the study

Globally, Climate-smart agriculture (CSA) aims to address climate change and food security by increasing productivity, reducing GHG emissions, and enhancing national food security goals. It targets increasing food yields, feeding nine billion by 2050, and mobilizing investments for farmers, affecting 70% of the world's poorest farmers (Chandra et al., 2018). Climate smart agriculture, launched in 2009, integrates adaptation and mitigation actions in agriculture for sustainable development and food security. It emphasizes agriculture's role in food security and calls for a comprehensive policy and technical intervention framework (Karlsson et al., 2018).

The expansion of CSA depends on improving perspective, enabling innovative methods and technology to enhance agricultural output and climate resilience, particularly if CSA is a viable means of securing food for the growing global population (Fusco et al., 2020). The effects of climate change are likely to be more serious among countries with fewer capacities to respond and adapt, and within these countries, among the poorest and most vulnerable. Climate change serves as an inhibitor to the attainment of food security and the fulfilment of development agendas in global economies (Von Braun et al., 2023).

However, Since CSA is an international project, it's crucial to compare farms globally. This could identify regions or countries where CSA is effective, highlighting areas for improving agricultural policies, landscape design, or farm design, or assessing a production system's performance relative to others. (Selbonne et al., 2023). Farmers' climate-smart agriculture (CSA) adoption is a major component in agricultural growth sustainability (Luu, 2020).

Climate-smart agriculture (CSA) is an important issue among Africa's national governments and international policy circles as a way to increase food productivity, strengthen smallholder farmers' resistance to climate change, and reduce greenhouse gas emissions. Even though it offers farmers various potential economic and environmental benefits, adoption among African smallholder farmers is low (Ogunyiol et al., 2022). Climate-Smart Agriculture (CSA) is one of the solutions that simultaneously address the issues of food security, climate change and agricultural productivity (Wekesa et al., 2018).

Agro-pastoral livelihoods in Africa are crucial for food security and socioeconomic development, as climate change affects agriculture, leading to low crop yields and undernutrition. These livelihoods integrate agriculture and pastoral activities, providing income diversification, community resilience, cooperation, employment, and economic growth (Nidumolu et al., 2022).

African countries have endorsed CSA as an approach to addressing agricultural productivity challenges, supporting adaptation strategies, and building resilience to climate change. However, a majority do not have national Climate-Smart Agriculture Investment Plans (CSAIPs). Additionally, CSA research in Africa is still developing, with only a few countries dominating the research outputs. For a successful implementation of CSA, a framework provided by the CSAIPs must be established to guide the processes (Barasa et al., 2021).

Agro-pastoral activities are vital in African countries to address challenges such as climate change and unpredictable precipitation patterns. These activities diversify income sources and food production systems, ensuring food security and resilience against climate-related risks. By combining crop cultivation and livestock rearing, farmers can adapt to climate variability, improve soil productivity, and preserve traditional knowledge, promoting sustainable land management among farmers. (Abegunde et al., 2019).

Sub-Saharan Africa (SSA) is highly vulnerable to climate variability, with the majority of its population relying on subsistence rain-fed farming for their livelihoods. In 2011, East Africa experienced the worst drought in 60 years, affecting 12 million people. The warning emphasizes the need for priority action in developing mitigation strategies to build resilient farming systems and landscapes, requiring collaboration across regional scientific and development communities (Hadgu et al., 2019).

Weniga Anuga et al., (2019) investigated using the World Bank's climate village model as a basis the adoption of CSA in some areas of Ghana. They discovered that the majority of farmers used CSA practises, which included using their own personal experience to forecast weather patterns, using radios and televisions to obtain weather information, regulating or controlling the use of irrigation techniques, minimum tillage, organic maturing and afforestation, and the adoption of these practises, which are frequently used in Ethiopia.

With the application of climate smart agriculture techniques, CSA as a method aids in the transformation and reorientation of the farming system at the household and landscape levels, to promote agro pastoral household subsistence in the face of the new realities of climate Change. Despite the advancement of many CSA technologies and practises, as well as the benefits they offer, widespread adoption of CSA practises is still difficult, particularly in Ethiopia and throughout Africa (Teklewold et al., 2019).

Ethiopia is vulnerable to climate change impacts, as it lacks access to adaptive capacity components like information, capital, and technology. Due to the recurrent decline in crop yields, loss of livelihood assets, the impacts of climate change are extremely sensible in rural smallholder farmers' context (Mihiretu et al., 2021). Ethiopia's drought has a spatial and temporal distribution over the past fifty years, with more frequent occurrences in the eastern, south eastern, and rift valley regions, with recurrence frequency varying (Mera, 2018).

The Somali Regional State in Ethiopia is a predominantly pastoral and agro-pastoral area, highly vulnerable to climate change due to its reliance on natural resources. The region faces repeated droughts and food shortages, raising concerns from both the government and humanitarian organizations. While pastoralists have historically adapted to climate change, recent increases in droughts, rainfall variability, and poor socioeconomic conditions have reduced their adaptability (Ayal, 2022).

"Therefore, this study aims to identify, analyse, and determine the unique challenges faced by agro-pastoral communities and the practices they employ to adapt to climate change while enhancing their livelihoods through climate-smart agriculture. However, a lack of knowledge and limited access to specific resources impede effective adaptation, which this study seeks to address in Harshin Woreda, Fafan Zone, Somali Regional State, Ethiopia."

1.2. Problem of the Statement

Climate change poses a significant threat to global food and nutritional security, particularly in areas where rainy agriculture is the primary source of income. Rising global food prices may also affect food pricing, potentially increasing earnings for environmental services provided by farmers, making climate change a significant global threat (Malhi et al., 2021). Also the Climate change poses significant threats to agriculture and food security, with global temperatures predicted to rise by 2.0 to 6.4°C and sea levels to rise by 59 cm by the end of the 21st century, affecting cropping systems, productivity, and food security (Alotaibi, 2023).

The assessment report of IPCC report predicts that climate change seriously affects the agro pastoral livelihood and could cause yields to decrease by as much as 50% in some highly vulnerable areas including sub Saharan Africa. Besides, cereal production growth for the range of crops in SSA is projected to decline by net 3.2 percent in 2050 due to climate change (Worku, 2018).

In Ethiopia various programs were established to promote the adoption of climate-smart practices; however, despite the use of effective, sustainable, and productivity-boosting technologies in these programs, adoption of these practices has remained low, especially among small-scale farmers (Jirata *et al.*, 2016). Ethiopia's economy is based mostly on agriculture, which is practiced by smallholder agricultural systems that are limited by resources, small land sizes, and rising soil quality degradation. The effects of climate change (e.g., the frequent occurrence of extreme weather events) exacerbate these problems (Gebeyanesh *et al.*, 2021).

Since Ethiopian pastoral communities mostly depend on rain-fed agriculture for their livelihood, they are at risk from climate change (Mekuyie & Mulu, 2021). Climate change poses a significant threat to food security, hindering progress in combating hunger and malnutrition. This report, combining IPCC, scientific findings, and FAO experiences, summarizes the cumulative effects of climate change on nutrition, agro-ecosystems, livelihoods, and food security. It suggests ways to adapt and build resilience, emphasizing the potential of climate change in agriculture sectors and the need for immediate action to mitigate its effects and ensure food security (Köhl et al., 2015).

Zerssa et al., (2021) examine the challenges facing smallholder farming systems in Ethiopia, such as small land size, lack of resources, and soil degradation, which are exacerbated by climate change. The researchers highlight the potential of climate-smart agriculture (CSA) practices, including integrated soil fertility management, water harvesting, and agroforestry, to address these constraints and improve drought resilience, crop yields, carbon sequestration, and household income. However, the researchers identify a key gap in that the adoption of these CSA practices by smallholder farmers is often limited, primarily due to land tenure issues, lack of knowledge, slow returns on investments, and insufficient policy support, suggesting the need for further measures to facilitate the uptake of CSA among smallholder farmers in Ethiopia.

According to a research conducted by FAO, (2017) Agriculture production is highly sensitive to the climate. It is affected by a variety of climate factors: long-term trends in average rainfall and temperatures; The study explores the impact of climate smart farming practices on general agriculture, focusing on the variability in precipitation and temperature, shocks during specific stages of plant development, and extreme weather events.

Pastoral and agro-pastoral communities are amongst the most vulnerable groups in the world to increased drought risks caused by climate change. Risk preferences play a key role in drought adaptation decisions, but little research has been done on risk preferences in (agro-) pastoral communities (Schrieks et al., 2024).

There are numerous strategies available for mitigating and adapting to climate change in various agricultural systems. The suitability of these options will vary according to the specific types of stress the system is facing, the farmers' coping and adaptive mechanisms, and the degree to which each climate factor affects yields. All crop production alternatives that are climate-smart, are built around the fundamental principle of sustainable Intensification. It guides decisions on how to overcome inefficiencies that result in yield and productivity gaps and minimize the negative environmental and social impacts of production. Therefore, within such findings, it is so difficult to separate apart the effects of CSA on the agro pastoral livelihood system within such finding.

While numerous studies have explored the potential of climate-smart agriculture (CSA) to address the impacts of climate change on agricultural systems, the specific challenges, strategies, and livelihood impacts associated with the adoption of CSA practices in agro-pastoral communities remain underexplored and requires further investigation in the existing literature. Addressing this research gap is critical, as agro-pastoral livelihoods are particularly vulnerable to the effects of climate change, and understanding the context-specific barriers and opportunities for CSA adoption is crucial for developing effective adaptation strategies (Tadesse & Ahmed, 2023)

Other research done by Kassa & Abdi, (2022) has explored the factors influencing the adoption of climate-smart agriculture (CSA) practices among smallholder farmers in different regions of Ethiopia. Their study found that access to agricultural extension services, access to credit, and tenure security were significant determinants of CSA adoption. However, a gap remains in understanding the factors influencing CSA adoption specifically in the Wondo Genet Woreda of southern Ethiopia

The limited adoption of climate-smart agriculture practices and technology in Harshin Woreda contributes to vulnerability in the region. Addressing this research gap is crucial to develop context-specific approaches that promote the adoption of climate-smart practices, enhance adaptive capacity, and reduce the negative impacts of climate change on food security and livelihoods. The lack of adoption of climate-smart agriculture practices in Harshin Woreda increases vulnerability. Closing this research gap will help develop targeted interventions to promote climate-smart practices, build resilience, and reduce the negative impacts of climate change on food security and livelihoods

The study aims to fill in some of the gaps about the sustainability of agro pastoral livelihoods and how they adapt to marginal and expected changes in CSA practises. Although an effort was made to identify the difficulties and strategies of climate smart agriculture for farmers' crop production, this assessment would not have been possible without workable adaptation measures to reduce the vulnerability of agro pastoral livelihoods, which are directly dependent on agricultural output.

1.3. Objective of the study

1.3.1. General Objective

The main objective of this study was to explore the practices and challenges of climate smart agriculture in agro-pastoral livelihoods: the case of Harshin Woreda in the Somali Regional State, Ethiopia.

1.3.2. Specific Objective

The specific objectives of this study were to:

- Analyse the existing climate patterns and trends in Harshin Woreda.
- Examine the impact of climate change on agro-Pastoral Livelihoods
- Identify the climate-smart agricultural practices adopted by agro-pastoralists in the study area.
- Assess the challenges of climate smart agriculture on agro pastoral livelihood in the study area.

1.4. Research Questions

This study tried to answer the following basic research questions:

- What are the existing climate patterns and trends in Harshin Woreda?
- How does climate change impact agro-Pastoral Livelihoods?
- What are the climate-smart agricultural practices adopted by agro-pastoralists in the study area?
- What are the challenges faced in implementing climate-smart agriculture on agro pastoral livelihoods in the study area?

1.5. Scope and Limitations of the Study.

The study was focused on the challenges and practices of climate-smart agriculture for agro pastoral livelihoods, since the region is vulnerable to drought. The study was conducted in a small geographical area, particularly only in three kebeles of harshin district , namely Qudhaca, Faraxliban, and Dabeyweyne, of agro-pastoral areas, by considering the prevalence of challenges and practices of climate-smart agriculture among agro-pastoral households in the Harshin district, Fafan zone, Somali region of Ethiopia.

The major limitation of this study was considering only three kebeles from a total of 21 rural kebeles, which may minimize precision. Due to resource and time constraints, it was difficult to cover more kebeles and increase the sample size of households. There may be plenty of factors that influence the implementation of CSA methods, but this study was limited to socio-economic, demographic, and institutional factors. On the other hand, some household members denied responses to certain questions related to income due to privacy and confidentiality concerns.

Concerning methodology, the study utilized a cross-sectional data collection method, gathering data at a single point in time, which limited the evaluation of climate-smart agriculture (CSA) practices on the income of smallholder agro-pastoral farmers to a shorter period. It focused solely on the impact of CSA practices on annual household income, neglecting factors like food security and livelihoods. Future research could address these gaps for a more comprehensive understanding of CSA challenges in agro-pastoral contexts. To mitigate limitations, strategies such as clearly explaining the study's purpose to households and ensuring confidentiality were employed to gather accurate income information. The propensity score matching (PSM) technique was also utilized to address estimation issues, in the absence of baseline data.

1.6. Significance of the study

The study's findings were particularly beneficial to farmers, local governments, and development participants. This helps them better understand the state of climate-smart agriculture practices in the selected area, which is advantageous for them. Furthermore, the results and insights gained from this study are beneficial to future researchers, who wish to look into this topic further in other Woredas. Consequently, this study's findings also contribute to the assessment of the impact of climate-smart agriculture techniques on agro-pastoral livelihoods.

1.7. Definition of key Terms

Agriculture: Agriculture is defined as an activity that involves farming, cultivation, animal rearing, and fish harvesting or is the art and science of cultivating the soil, growing crops, and raising livestock. It includes the preparation of plant and animal products for people to use and their distribution to markets (Harris & Fuller, 2014)

Agro Pastoral livelihoods: Agro-pastoral livelihood refers to a subsistence strategy that integrates both crop cultivation and livestock management. This approach allows communities to diversify their sources of food and income, particularly in semi-arid and arid regions. By combining agriculture and animal husbandry, agro-pastoralists can enhance food security and resilience to environmental challenges, especially in the context of climate change (Ng'ang'a et al., 2020).

Climate: Climate in a narrow sense is the measurement of the mean and variability of related extents of certain variables (such as temperature, precipitation, wind, and others) over a period ranging from months to thousands or millions of years. The classical period for averaging these variables is 30 years (WMO, 2019).

Climate change: Climate change refers to an alteration in the climate's state that persists for a long time, usually decades or longer, and can be detected by variations in the mean and/or variability of its properties. It also refers to any long-term change in climate, whether brought on by internal natural processes or external factors like variations in the sun's cycle, volcanic eruptions, and human-caused modifications to the atmosphere's composition (IPCC, 2014).

Climate Variability: "Variations in the mean state and other statistics such as standard deviations and statistics of extremes of the climate on all temporal and spatial scales beyond that of individual weather event (Wamalwa, 2017).

Climate smart agriculture (CSA): is an approach to agriculture that sustainably increases productivity, enhances adaptation, and mitigates emissions of greenhouse gases (GHG). The concept was proposed in 2009 and reorganized through inputs and interactions among multiple stakeholders involved in developing and implementing the idea (Lipper and Zilberman, 2018). According to IFAD (2019), CSA is defined by the Food and Agriculture Organization of the United Nations (FAO) as consisting of three pillars: I) sustainably increasing agricultural productivity and incomes (food security); ii) adapting to climate change and fostering resilience; and iii) reducing and/or removing greenhouse gas emissions (mitigation), where possible. Climate Smart Agriculture (CSA) is a fundamental approach to addressing the interlinked challenges of climate related risks, ecological sustainability, and food security (Lipper and Zilberman, 2018).

Climate smart agriculture practices: Climate smart agriculture refers to methods that increase agricultural productivity and profitability while assisting farmers in mitigating the negative effects of climate change and adjusting to them. These include, for instance, crop residue management, conservation of agriculture, integrated soil fertility management, and integrated water shed management (Hussein, 2024).

1.8. Organization of the Thesis

There were five chapters in the thesis. It started with the introduction, which includes the background, statement of the problem, objectives, significance, scope, and limitations of the study. The second chapter reviews literature that deals with past studies and information relevant to the study. The third chapter describes research methodology, including a description of the study area, data type, sources and methods of data collection, sampling procedures and sample size determination, and methods of data analysis. In the fourth chapter, the main findings of the study are presented and discussed. Finally, a summary, conclusions, and recommendations are provided in Chapter five.

2. LITERATURE REVIEW

2.1. Concept of Climate Smart Agriculture

The term climate-smart agriculture (CSA) has developed to represent a set of strategies that can help to meet these challenges by increasing resilience to weather extremes, adapting to climate change and decreasing agriculture's greenhouse gas (GHG) emissions that contribute to global warming (Steenwerth et al., 2014). The CSA concept, developed by the World Bank and FAO, is a crucial tool for addressing climate change in agriculture. It combines political and economic approaches, allowing flexibility to adapt to unique client needs. This approach is vital for addressing global food security challenges (Mereu et al., 2018).

Globally, the climate is changing, and this has implications for livestock. Climate affects livestock growth rates, milk and egg production, reproductive performance, morbidity and mortality, along with feed supply. Simultaneously, livestock is a climate change driver, generating 14.5% of total anthropogenic Greenhouse Gas (GHG) emissions (Lemi, 2019). The agro pastoral system is vital in enhancing the resilience of vulnerable individuals affected by climate change, as it helps mitigate the impacts of changes in livestock systems, water availability, biodiversity, and animal health, thereby ensuring their survival (Silvestri et al., 2012).

Climate change is expected to affect the livelihoods of agro-pastoral communities through diminished crop production and a reduction of livestock numbers due to poor livestock performance and increased mortality (Amari, 2023). The Intergovernmental Panel on Climate Change (IPCC) has highlighted the significant contribution of agriculture to global anthropogenic GHG emissions, with developing nations bearing the majority of these effects. The IPCC concluded that simultaneous mitigation and adaptation efforts are necessary due to slow progress in mainstreaming climate change in the agriculture sector (Chandra et al., 2018).

The CSA aims to promote sustainable use of agricultural systems for food and nutrition security, integrating adaptation and mitigation at local and global levels, with three defined objectives for achieving this goal.

- Sustainably increasing agricultural productivity to support equitable increases in incomes, food security and development.
- Adapting and building resilience to climate change from the farm to national levels; and

- Identifying possibilities to lower agricultural GHG-Emissions relative to historical trends.

Although CSA seeks to achieve all three goals, this does not mean that every practise should produce "triple wins" in every situation. CSA requires consideration of all three objectives, from the local to the global scales and over short and long time horizons, to derive locally acceptable solutions (Mereu et al., 2018).

2.1.1. Climate smart agriculture production

Climate smart agriculture (CSA) is a sustainable approach to agriculture that focuses on improving crop production, rural livelihood systems, and community adaptation to climate change. It involves implementing practices, developing policies, and mobilizing funds, CSA production emphasizes ecosystem services for productivity, adaptation, and mitigation, building on sustainable development knowledge, Examples include improved crop, livestock, aquaculture, agroforestry systems, pest, water and nutrient management (Mereu et al., 2018)
Climate change impacts the agricultural sector, either positively (expanding production zones) or negatively (more frequent natural disasters). Climate-smart agriculture (CSA) aims for higher productivity, resilience, and GHG emission reduction. Small-scale farms, particularly in developing nations, play a crucial role in the industry, and CSA practices aim to sustainably increase and stabilize income by participating in climate change initiatives (Mizik, 2021)

In the Ethiopian context, climate change is significantly impacting crop production, causing a decline in yield due to reliance on rain-fed agriculture. Despite the lack of adaptive strategies, the increasing frequency of extreme weather events and difficulty in predicting growing seasons pose a significant threat to food security (Birhan, 2017).

The primary initiatives being supported are crop rotation, intercropping, composting, training, and promotion of proper fertiliser application, with a concentrate on improving agro pastoral livelihoods and crop yield (Weniga Anuga et al., 2019).

Agro-forestry: This method was carried out by reforesting farmland with trees and shrubs. Basically, Ethiopian farmers have. This is precise in Ethiopia, where the moringa tree is customarily planted alongside crops and orghum in the Konso, Omo, Burji, Sena, and Mele Woreda regions of the SNNP regional state. A tradition and experience of planting and caring for a variety of trees and shrubs.

Researchers believe this practise has many benefits, based on the agro-forestry. Agriculture has the ability to preserve physical characteristics through the preservation of organic matter and soil material. Tree roots regulate runoff and soil erosion, reducing water losses and nutrient losses. This reduces nitrogen inputs in the agroforestry system, promoting a diverse farm economy and improving rural economies, resulting in more stable farms and communities.

Crop rotation and intercropping: The aim of this approach also serves as a means of maintaining soil fertility. The use of Crop Rotation is a crucial method for improving soil management by enhancing its physical and chemical properties. It optimizes nutrient cycling within the field system and minimizes losses in the short and long term. The right crop species for rotation and their arrangement in the right order are essential, as each species has unique traits like shallow or deep roots and crop residue quality (Ouda et al., 2018).

Ethiopia has implemented various climate smart agricultural practices, including Derashe traditional conservation agriculture, Konso cultural landscape, and traditional agroforestry in various zones, Hararghe highland traditional soil and water conservation, Hararghe cattle fattening, Hararghe small-scale traditional irrigation in East Ethiopia, and Ankober manure management in the northern parts of the country (Jirata et al., 2016).

2.1.2. Climate change impacts on agro-livelihoods: pastoral a global perspective

Climate change poses a global threat to food and nutritional security, with increasing greenhouse gas emissions and temperatures. The average global temperature is predicted to rise by 2°C until 2100, causing economic losses. CO_2 concentrations increase, leading to increased growth and plant productivity, but also increased crop respiration and pest infestation. That poses significant challenges to agro-pastoral livelihoods worldwide, affecting crop yields, livestock health, and land productivity. This leads to food insecurity, poverty, and malnutrition. To combat this, sustainable farming practices, improved water management, and climate-resilient technologies are essential (Malhi et al., 2021).

Agro-pastoral communities and smallholder farmers in sub-Saharan Africa (SSA) are largely dependent on livestock and mixed crop-livestock production systems for their livelihood. These production systems are mainly characterized by arid and semi-arid climates with low and erratic rainfall (Menghistu et al., 2020).

Climate change projections show that poor countries, particularly Sub-Saharan African countries like Ethiopia, are vulnerable to its negative impacts, due to their weak adaptive capacity. This vulnerability is particularly evident in rural smallholder farmers, who rely on their indigenous knowledge to sustain their livelihoods in drought-prone regions, despite the recurrent decline in crop yields and livelihood opportunities (Mihiretu et al., 2021).

2.2. Institutional and Policy Frameworks for Climate-Smart Agriculture in Rural Settings

Climate change is posing significant challenges to food security, necessitating the development of Climate Smart Agriculture (CSA) to achieve sustainable agricultural growth. This approach aims to balance objectives such as higher incomes, stable incomes, and lower emissions. However, climate change impacts can lead to trade-offs, such as increased extreme weather events, compromising agricultural productivity. Low-emission growth strategies require clear understanding and external financing to avoid burdening smallholders in developing countries. (Mereu et al., 2018).

Government strategies for managing agricultural risks at the household or community level have taken different forms in different countries, but are generally classified in three groups:

- Mitigation/adaptation activities designed to reduce the likelihood of an adverse event or reduce the severity of actual losses. Risk mitigation options are numerous and varied (e.g., irrigation, use of resistant seeds, improved early warning systems, and adoption of better agronomic practices);
- risk transfer, such as commercial insurance and hedging; and
- Resilience-improving mechanisms to withstand and cope with events ex ante.

Examples of these government strategies include social safety net programmes, buffer funds, savings, strategic reserves, contingent financing, insurance etc. There are many definitions of resilience in the literature, but the common thread in all definitions is the notion that resiliency reflects an ability to successfully manage or withstand a shock or stress (Alinovi et al., 2010).

The Ethiopian government has put in place a number of policies, strategies and institutions that are designed to support climate change adaptation and mitigation and sustainable development as a whole. Policies, laws and strategies relevant to climate change in Ethiopia include the Climate Resilient Green Economy Strategy (2011), National Adaptation Program of Action (NAPA), Ethiopian Programme of Adaptation to Climate Change (EPACC) of 2011, Nationally Appropriate Mitigation Actions (NAMA) of 2010, Rural Development Policy and Strategies (2003), Growth and Transformation Plan (GTP), CAADP Compact and the National Environmental Policy of Ethiopia (1997).

Ethiopia is a signatory to a number of multilateral agreements that have a bearing on the sustainable development efforts of the country. Ethiopia has signed and/or ratified many of the international conventions and protocols related to climate change and land degradation, including the United Nations Framework Convention on Climate Change (1994), the Convention on Biological Diversity (CBD) and the United Nations Convention to Combat Desertification (UNCCD) (Jirata et al., 2016).

2.3. Indigenous Knowledge and Adaptation Strategies in Agro Pastoral Communities

Indigenous knowledge refers to the understandings, skills and philosophies of Indigenous peoples, developed through long and multigenerational histories of interactions with the natural world and adapting to highly variable and changing ecological and social conditions including colonisation and globalisation (Petzold et al., 2020).

Indigenous people and their knowledge have an important role to play in responding to societal challenges. For several millennia, Indigenous people have utilized their long-term knowledge to sustainably explore and adapt to their environment for survival, protecting them from environmental uncertainties. They form unique social and cultural groups with ancestral ties to the landscape and natural resources, which are inextricably linked to their identities, cultures, livelihoods, and physical and spiritual well-being (Nyadzi et al., 2021).

The role of indigenous knowledge to enhance the adaptation of rural communities to climate change cannot be overemphasized. Indigenous knowledge has been earmarked as a good option in climate change adaptation. Therefore, incorporating indigenous knowledge in climate change policies can lead to the development of effective mitigation and adaptation strategies that are cost-effective, participatory, and sustainable (Azibo et al., 2016).

Agro-pastoralists have identified crop diversification, a combination of cropping and livestock operations, as crucial adaptation strategies. They also employ water harvesting technologies and anti-erosive measures. Seasonal, annual, and permanent migration strategies are also employed. Factors such as agro-ecological zone, cultivated surface, ruminant herd size, household size, and education influence farmers' choice of adaptation strategies, which should be considered in climate-change-adaptation programs (Zampaligré et al., 2014).

2.4. Agro pastoral livelihood system and Climate Change

Climate plays a crucial role in determining land suitability for agricultural production in Africa, influencing the transition between grazing and cropping-dominated farming systems. Human activities are likely to significantly impact agro pastoral livelihoods, leading to potential changes in cropping margins. Season-to-season rainfall variability in dry marginal areas poses significant agricultural production risks, which are expected to increase in the future. This results in severe undernutrition of human populations due to low crop yields and limited alternative livelihoods (Nidumolu et al., 2022).

2.4.1 Agro pastoral system in Somali Regional State

Agro pastoralists in the Somali Regional State utilize transhumance to maintain livestock farming, utilizing seasonal migration for water and pasture access and crop cultivation during wet seasons. Their primary sources of food and income are forage, meat, butter, and milk. However, the increasing frequency of drought, desert locust infestation, invasive weeds, and flash floods have threatened their livelihood. Livestock and crop productions have been drastically lowered, risking food security for rural agro-pastoral households. One of the worst droughts in the region occurred in 2016/17, causing widespread crop failure and the death of both livestock and human lives. Climate change has exacerbated these hazards, forcing many agro-pastoral households to diversify their livelihoods (Abdi Hirsi et al., 2021).

2.4.2. Determinants of rural Livelihood of Agro pastoral system

Agro-pastoral communities and smallholder farmers in sub-Saharan Africa (SSA) are largely dependent on livestock and mixed crop-livestock production systems for their livelihood.

Climate change significantly impacts livestock livelihoods in rural areas, particularly in developing countries. These areas rely heavily on agriculture and livestock keeping, with low rainfall and erratic rainfall. Loss of livestock assets could lead to chronic poverty and lasting effects on pastoral and agro-pastoral systems (Menghistu et al., 2020).

Livelihoods are often unpredictable and depend on social, economic, and ecological environments. Climate variability can significantly impact livelihoods, creating opportunities for productivity and positive perception. Rural households often choose livelihoods like education and migration, but climate variability can quickly change these livelihoods. People must develop adaptability skills to exploit new opportunities, as they may be more prevalent in the face of climate change (Biggs et al., 2015).

2.4.3. Sustainable Livelihoods Framework

A livelihood comprises the capabilities, assets (stores, resources, claims and access) and activities required for a means of living: a living is sustainable which can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, and provide sustainable livelihood opportunities for the next generation; and which contributes net benefits to other livelihoods at the local and global levels and in the short and long term (Natarajan et al., 2022).

Livelihood contexts refer to the social, economic and political contexts in which livelihood are developed. Institutions, processes and policies, such as markets, social norms, and land ownership policies, and more importantly climate change affect our ability to access and use assets for achieving our objectives. When these contexts change, they develop new livelihood problems or opportunities (Mihiretu et al., 2019).

Hence, Ethiopian agriculture production is rain feed system, hence, variability in rainfall patterns and drought have disrupted crop productions and exacerbated instability of agro pastoral livelihood system in many part of the country. The trend in number of agro pastoral livelihood insecurities, agro pastoral people are insecure due to climate related calamities is increasing, and reached at a peak of 13 million 2002/2003 (Nin-Pratt et al., 2011)

2.5. Relationships between the Agro Pastoral Livelihood System and CSA

Despite the years of concentration on agricultural development and agro pastoral livelihood systems based on agriculture, the world's population still numbers almost 800 million undernourished people and one billion malnourished people. At the same time, one third of all crops produced are wasted, and over 1.4 billion adults are overweight. The population of the world is predicted to reach well over 9.7 billion by the year 2050. (FDRE, 2015/162019/20).The Intergovernmental Panel on Climate Change (IPCC) has highlighted the dual nature of agriculture systems and climate change. Agriculture systems are a major contributor to global anthropogenic GHG emissions and are vulnerable to climate change shocks and stresses. By 2007, evidence of the dual relationship between agriculture and climate change became apparent through scientific assessments and policy reviews of development agencies. The IPCC concluded that GHG emissions from agricultural lands were increasing, and there are inter-actions between mitigation and adaptation in the agricultural sector. Given the limited progress made on mainstreaming climate change in the agriculture sector, the potential for integrated actions became imperative, leading to the transition to climate-resilient agricultural development (Chandra et al., 2018).

Climate smart agriculture can help to improve agro pastoral livelihood for 80% of the world poor, who live in agro pastoral areas and mainly in farming and rearing livestock communities. Certainly, it is estimated that about 75% of the world's poor lives in agro pastoral areas, with agriculture being their most important livelihood source. Agricultural growth is often the most effective and equitable strategy for improving the agro pastoral livelihoods (Mohammed et al., 2021).

However, climate variability poses a threat to agriculture in SSA. The agro pastoral livelihood system is supported by scientific evidence that, in light of the new climate change realities, climate smart agriculture is its main strength (Emmanuel A. Ojoko, James A. Akinwunmi, 2016).

Climate smart agriculture is a promising solution to climate change, supporting economic growth and agricultural development in Ethiopia. Farmers are adopting new technologies and practices in crop and livestock production systems, promoting organic fertilizer use and precise application, and using improved cereal varieties and crop rotations. This approach ensures stable agro pastoral livelihoods and supports economic growth (Emmanuel A. Ojoko, James A. Akinwunmi, 2016).

Scholars generally agree that CSA plays a significant role in improving productivity and enhancing the agro pastoral livelihood system. In the broader context of urbanisation and the development of an off-farm sector, raising agricultural productivity and quality of life in the mall holder production sector is essential for achieving stable agro pastoral livelihood. It is also a crucial element and driver of economic transformation and growth (Mohammed et al., 2021).

Enhancing soil quality can generate production of the long-term implementation of integrated CSA interventions on crop yield, soil fertility, and carbon sequestration. It is hypothesized that CSA practices increase crop yield, improve soil fertility, and mitigate greenhouse gas (GHG) emissions through soil carbon sequestration, thereby ensuring adaptation and resilience of smallholder farmers to climate variability (Tadesse et al., 2021).

Generally, Climate-smart agriculture builds on previous efforts to achieve sustainable agriculture intensification, such as sustainable crop production intensification. CSA will sustainably intensify production to achieve productivity increases, supporting the achievement of stable and development goals, increase the resilience of the production system and rural livelihood (Adaptation), and reduce greenhouse gas emissions from agriculture, including through increased production efficiency and increased carbon sequestration (mitigation) (Weniga Anuga et al., 2019).

2.6. Understanding Factors Influencing Climate Smart Agriculture Uptake

Adoptions of climate smart agricultural practices are affected by various barriers such as farming factors, technology inaccessibility, environmental factors, policy design and social expertise, negative attitudes and motivations of farmers, farmers' socio-demographic factors, and farmers' socioeconomic factors, To address these barriers, it is crucial to understand the factors that influence farmers' decision-making processes. To reverse the situations, preparation of targeted Climate smart agricultural practices to areas that are likely to provide the greatest GHG reduction potential and demonstration of these practices to other areas should be encouraged so that other farmers will learn for similar agro-ecologies (Shiferaw, 2021).

The adoption of CSA technologies can improve crop yields, increase input use efficiency, increase net income and reduce GHG emissions. Despite the various benefits of CSA technologies, the current rate of adoption by farmers is fairly low, there are many factors that influence extent of adoption of CSA technologies such as socio-economic characteristics of farmers, bio-physical environment of a particular location, and the attributes of new technologies (Kuehne et al., 2017).

2.7. Theoretical Review

Why, how and at what rate new agricultural practices can be adopted by agro pastoral Household's farmers, explained by the following theories, economic constraints, technology Characteristics user's context and the innovation diffusion theory.

2.7.1. The economy of microscopic contradictions

According to Vernon W. Ruttan, (1971) model, the model suggests that market prices, determined by policy and institutional interventions, represent the scarcity of elements, implying the necessity of well-functioning markets and the significant role of price policies. It also suggests that the distribution of resources among potential users influences the adoption of innovative technologies.

2.7.2. The Innovation -diffusion theory

According to this theory, Innovation diffusion theory examines the spread of innovative ideas and technologies within a social system, focusing on the rate and spread of ideas from one society to another or from a focus or institution within a society to other parts (Wani & Ali, 2015). This theory assumed that the technology is appropriate for us e unless hindered by the lack of effective communication. This study is mainly depending on this theory.

2.7.3. The technology characteristics -user's context theory

The technology characteristics user's context theory integrates Theories on technology's relationship with society explore modernity's specificity, knowledge substitution, and meaninglessness, often overlooking technology itself in these concerns. (Grimes & Feenberg, 2013). The importance of policies and strategies that facilitate the participation of farmers and other development actors in the technology development process is indicates in this model.

2.8. Empirical Review

Various literatures showed the most important key determinants of Community-Based Agriculture (CCA) for pastoralists include household income, access to information, extension services, government support, and market access. For agro-pastoralists, access to information, household income, age, and land/livestock ownership were major determinants. Smallholder farmers also rely on household income, land ownership, information access, farm size, and extension services (Menghistu et al., 2020)

Another studies, which was done by Mekonnen & Zerfu, (2013) the study analysed agro pastoral communities in Somali and Oromia regions of Ethiopia, focusing on food availability. The results showed that educational level, farm land size, livestock availability, and peace and security are the most significant factors affecting household food security. The study suggests providing these amenities and resources to reduce food insecurity in these communities.

Recent studies suggest that land has a significant positive impact on production Bahta et al., (2020); discovered The Manica land province of Zimbabwe's factors influencing them, and their consequences for crop production and income, showed that the technical inefficiency of cotton production increased with farm size and the education level of the household head, but decreased with family size and age.

In Ethiopia also Pender & Gebremedhin, (2004) found that several factors commonly hypothesized to have a major impact on land management and agricultural production including population pressure, small landholdings, access to roads and irrigation, and extension and credit programs are found to have limited direct impact on crop production and income, though most affect the intensity of production.

Similarly, Mihiretu et al., (2019) Empirical analysis reveals that higher education levels in rural Ethiopia lead to better knowledge about climate change and its adaptation choices, resulting in literate farmers making the best adaptations to address the challenges of climate change. This study suggests that farmers with better education influence positive adaptation choice decisions.

According to Haji, (2008) Improving crop production leads to several benefits, including increased resource flow, lower food prices, improved consumer welfare, and improved competitiveness in a country's agricultural sector. This leads to economic growth, lower food prices, and a better overall competitive position.

Zampaligré & Fuchs, (2019) Burkina Faso's sudano-sahelian households have adopted adaptation practices to improve food security and livelihoods, influenced by government assistance, farm experience, credit, and farmland ownership. Access to climate and agronomic information and location within a specific pastoral zone also enhances uptake of these practices.

Empirical studies those done at abroad and locally have identified common variables that affect the probability that smallholder farmers will adopt CSA. According to Weniga Anuga et al., (2019) Determinant of CSA adoption among smallholder crop farmers; Economic, environmental, Socio-cultural, personal and institutional factors are identified. Adoption rate is predicted using various factors such as economics, risk, environmental outcomes, farmer networks, farm characteristics, and ease and convenience of the new practice (Kuehne et al., 2017).

CSA plays a crucial role in Ethiopia's agro pastoral livelihood, enhancing productivity and reducing poverty in cereal production. By incorporating larger CSA packages, farmers can alleviate low productivity among smallholder farmers, thereby enhancing their livelihood and reducing poverty. Encouraging farmers to incorporate CSA packages in all four categories can significantly influence the rural household livelihood system (Jirata et al., 2016).

To contribute for local research need, this study aims to identify adoption impact of CSAP on rural livelihood and poverty status of maize and wheat and to identify factor s affect the adoption of CSA at the study area, this research contributes in some way to fill the gap

2.9. Conceptual Framework

According to Mugabe, (2020) suggest that when identifying the key inputs required for successful climate-smart agriculture in agro-pastoral systems, factors such as availability and access to resources (e.g. land, labour, and financial capital), potential benefits compared to other practices, farmers' skills and information, ability to cope with challenges, and compatibility with local social and cultural practices should be taken into consideration, Also emphasizes that in addition to knowledge, technology, financial resources, and community engagement, these factors play a crucial role in facilitating the adoption of climate smart agricultural practices in agro pastoral systems.

Understanding the socioeconomic factors and financial, natural, physical, and social capital required for CSA-technological adoption is crucial. This knowledge shapes the development and Diffusion strategies of CSA practices, ensuring they are tailored to agro pastoral communities 'pressing needs and easily accessible. This understanding is essential for tailoring CSA practices to meet agro pastoral needs and promoting their adoption (Waaswa et al., 2022).

In the regard of climate change challenge and damage, climate adaptation and mitigation are crucial, though to manage, also the impact of the combination of two strategies is very important. In the agriculture sector, there is high potential of synergies between climate change adaptation and sustainable developments (Elshirbiny, 2018); also Elshirbiny highlights the economic benefits of climate-smart agriculture practices (CSAP) in addressing climate change. These benefits include increased agricultural production, higher household income, enhanced environmental services and asset protection, and reduced vulnerability to extreme weather events. Adopting effective adaptation practices and sound policies strengthens farming capacity and maintains stable agro-pastoral livelihoods, especially those dependent on cereal production. Thus, CSA is crucial for socioeconomic development.

Climate-smart agriculture adaptation practices must be introduced to help smallholder farmers overcome these issues. However, farmers' perceptions of climate change, as well as the accompanying uncertainties, impacts, and hazards, are critical, since understanding of these issues in relation to agricultural systems is the first step toward adaptation (Arslan et al., 2014).

Furthermore, discussing and comparing local experience among community members might aid in the identification of recurring trends and individual strategies. Many stakeholders must be involved in adaptation, including policy makers, extension agents, non-governmental organisations, researchers, communities and farmers (Senyolo et al., 2018).

Climate smart agriculture practices are typically adopted in specific locations and socioeconomic settings. However, adoption is influenced by demographic, socio-economic, and institutional factors. Demographic characteristics like age, family size, education, and assets, as well as institutional factors like infrastructure availability, access to information, and participation in social and formal institutions, affect farmers' decisions to adopt climate-smart agricultural practices.

Climate-smart agricultural practices involve adopting specific farming techniques, community participation, capacity-building, adaptation strategies, and policy and institutional support. These practices include conservation agriculture and water-efficient irrigation systems, fostering ownership and cooperation. Capacity-building programs enhance farmers' knowledge and skills, while adaptation strategies address climate vulnerabilities. Policy and institutional support ensure sustainability.

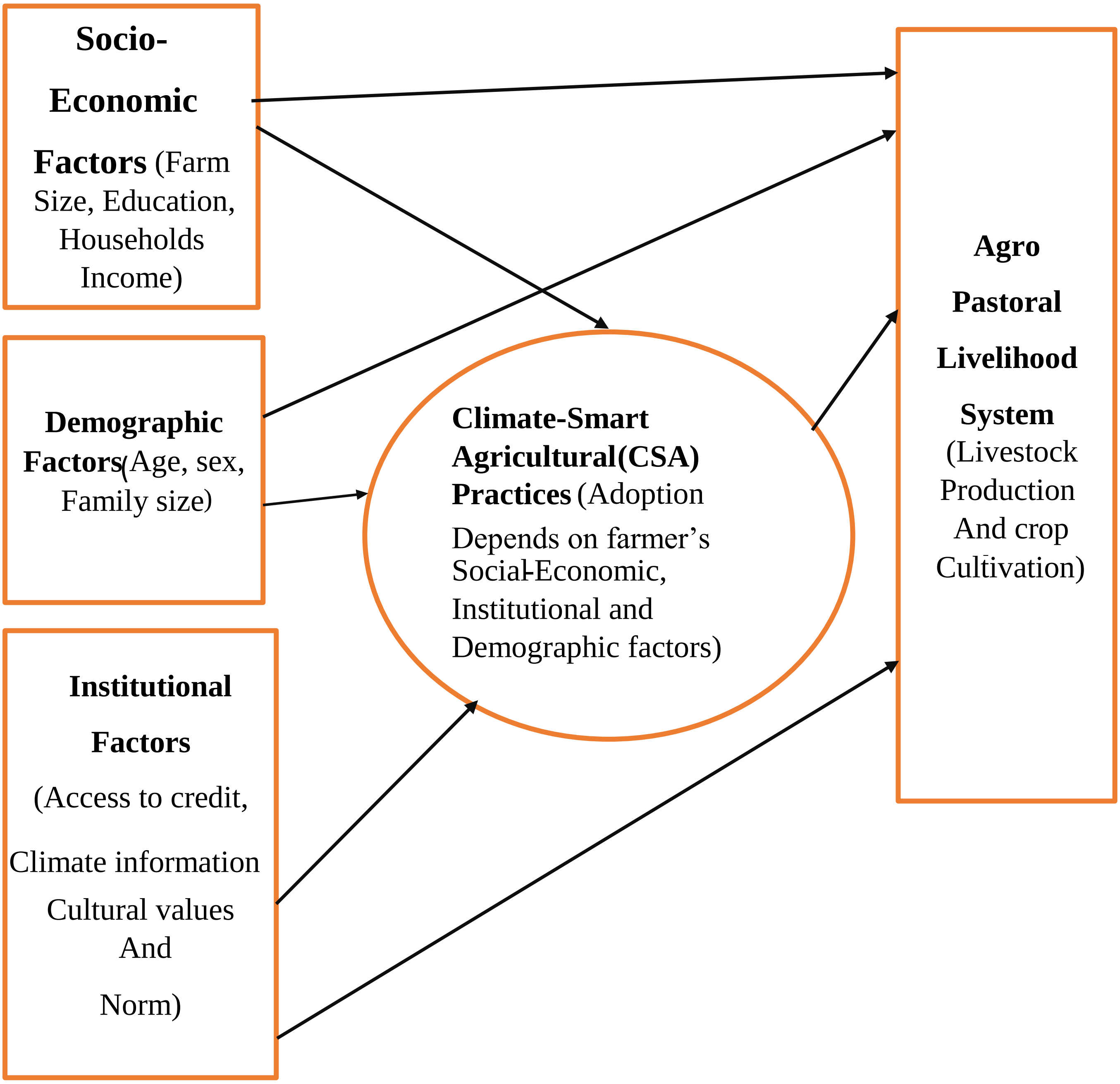


Figure 1: Conceptual Framework of the Study.

Source: (Own-Constructed, 2024)

3. RESEARCH METHODOLOGY

3.1. Description of the Study Area

3.1.1 Physical Characteristics of the Study Area:

This study was conducted in Harshin Woreda, a Somali regional state of Ethiopia, and Harshin is one of the woreda in the Faafan zone of the Somali regional state. Located approximately 150 km east of Jigjiga, the capital city of the Somali regional state, it is 729.2 km away from the capital city of Ethiopia, Addis Ababa, and 20 km west of the border with Somaliland. The district covers a total area of 5120.12 km². The district shares borders with the Degehabur Zone to the south, Kebribeyah to the west, and Somaliland to the northeast. The major town in Harshin is Harshin. Administratively, it comprises 19 Kebeles Development Centres. Geographically, the district is located at, stretching from latitude 9° 13' 0''N to 9.1712° N and longitude 43° 35' 16E to 44° 10' 0E .and 1558.92 m above sea level.

The climate in Harshin Woreda is generally hot and dry, which presents several challenges and impacts on the local environment and communities, such as drought, food security, and limited agricultural productivity. The mean annual temperature ranges from 28 °C to 36 °C. The region experiences limited and unreliable rainfall, with an annual precipitation ranging from 300 mm to 400 mm. The two peak precipitation periods are known as GU (April–May) and Deyr (October–December). The GU rains, occurring in April and May, are particularly important for pastoralists and agro-pastoralists in the area.

Harshin Woreda is characterised by a diverse vegetation landscape, consisting of a mix of shrubs and grasslands that have adapted to the local environment. The specific types of grasses and plants found in the area are influenced by factors such as rainfall, temperature, and soil composition. In the flat areas of Harshin Woreda, the soil is typically a combination of clay and loam, indicating a mixture of fine and medium-textured soil. This soil composition can impact drainage, nutrient availability, and water retention. The relationship between the vegetation and soil in Harshin Woreda plays a significant role in shaping the local ecosystem and determining its suitability for various land uses (Harshin. A. Bureau, 2023).

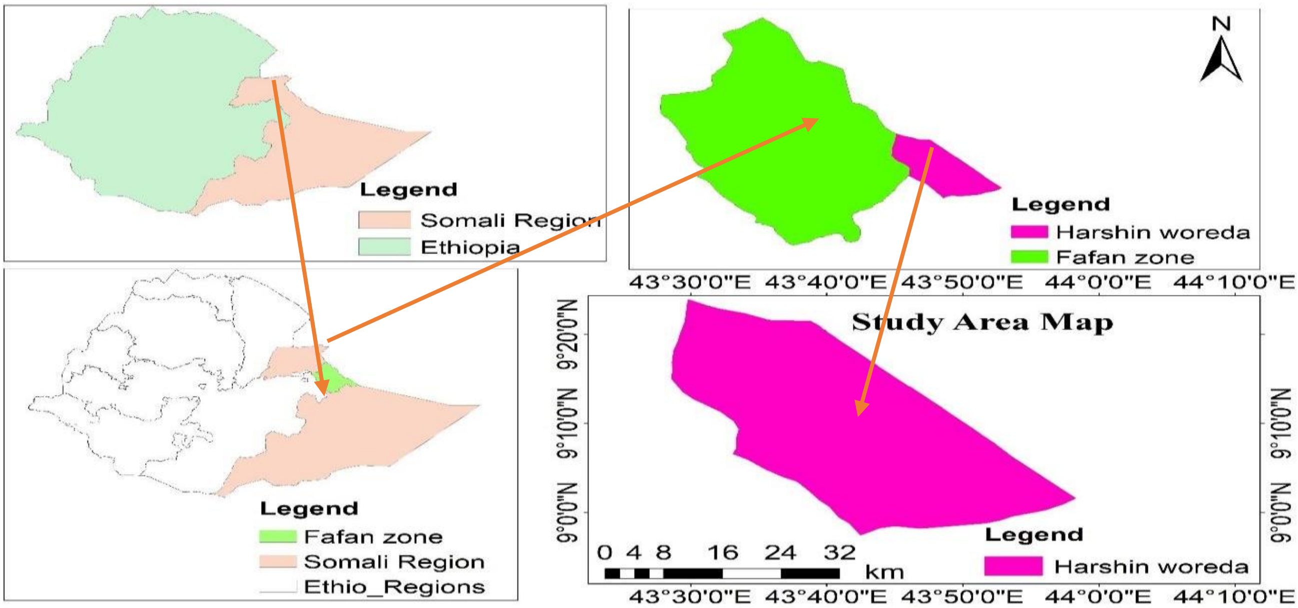


Figure 2: Location Map of the Study Area.

Source: Own constructed using ArcGIS 10.3 (Ethio-GIS)

3.1.2 Socioeconomic Characteristics of the Study Area

The total population of Harshin Woreda, according to the Central Statistics Authority (2023), is 119,866, with 57,558 females and 62,308 males. The people living in this Woreda have diverse livelihood sources, due to its proximity to the international border between Somaliland and Ethiopia. Some individuals rely on selling Khat (a stimulant plant), while others engage in small enterprises like shops. The majority of the population in the Woreda depends on agriculture as their primary livelihood. Crop production is a significant livelihood activity in the area. Livestock rearing, including sheep, camels, and cattle, is another significant livelihood activity in the area that plays a role in the livelihoods and economy of the Woreda's population. Harshin Woreda has a challenging agro ecology, characterized by a semi-arid to arid climate with limited and unpredictable rainfall. The primary agricultural practices in the area are pastoralism and agro-pastoralism, with communities relying on the rearing of livestock and cultivation of crops suited to arid conditions. Main crops include sorghum, maize, millet, and sesame. The study can potentially provide a deeper understanding of the characteristics, strategies, and outcomes associated with agro-pastoralism in the region.

The social infrastructure in Harshin Woreda includes facilities such as education, health, and energy. The Woreda has schools and educational institutions to cater to the educational needs of the population. Health services are provided through health cent and clinics. In terms of energy, the area likely has access to electricity (Harshin A. Bureau, 2023).

3.2. Research Design

The study employed a cross-sectional design, which allowed for data collection at a single point in time, making it particularly suitable for assessing the challenges and practices of agro-pastoral communities in the Harshin district. This approach captured a snapshot of the current conditions and factors affecting these communities, focusing on understanding the complexities of climate-smart agriculture practices within a specific context and facilitating targeted insights into the issues faced by the population.

To enhance the depth and breadth of the findings, mixed research methods were utilized, integrating both qualitative and quantitative approaches. Qualitative data was gathered through interviews and focus group discussions, providing in-depth insights into the experiences and perceptions of community members. In parallel, quantitative data was collected via structured surveys, allowing for statistical analysis that offered a broader understanding of the research context. This combination of methods effectively addressed the study's objectives, informing potential interventions and strategies for promoting climate-smart agriculture in the region.

3.3. Types and Sources of Data collection

The data that was applied in this study included both primary and secondary data, which was collected by using questionnaires and assessments of various relevant documents, respectively. According to the source of the primary data, farmers was the major sources of primary data. In order to ensure the reliability and validity of the data collected, the primary data include the background of the study area, demographic and socio-economic activity in the study area, climate patterns and trends, impacts of climate change on agro pastoral livelihood, factors affecting the adoption of CSA-practices, challenges, opportunities, and institutional services for the practices. Also, information was collected through structured questionnaires, focused group discussions, and key informant interviews with the respondents. The respondents' secondary data comprised various documents regarding climate-smart agricultural practices that was accessed online or from various publications, including books, magazines, published and unpublished literature from previous studies, and documents in libraries or through internet accessibility.

3.4. Techniques for Sampling and Sampling Design

The study utilized a multi-stage sampling approach. Harshin Woreda was selected, purposefully due to its emerging agro-pastoral systems and the prevalence of such practices in several kebeles within the woreda. By focusing on this context, the study aims to gain insights into the challenges and opportunities associated with agro pastoralism in an area where it is relatively new. This targeted investigation can provide a deeper understanding of the characteristics and outcomes of agro-pastoral practices.

A total of 21 kebeles are existed and 12 of them are agro pastoral and the rest 9 are pastoral. The listing of kebeles as per their livelihood diversification is prepared by woreda agriculture or livelihood experts. Accordingly, kebeles were stratified as agro pastoralist and pastoralist. Since the researcher target group was agro pastoral household's faraxliban, qudhaca, and dabeylweyn kebeles was chosen using simple random sampling technique.

After kebeles are sampled, the sample household participants were selected from the three kebeles using simple random sampling method. Finally, the sample households will be distributed to each kebeles proportional to their population size. The three sample kebeles faraxliban, qudhaca, and dabeylweyn, hosts 425, 275, and 300 households' heads, respectively.

Appropriate sample size depends on various factors relating to the subject under investigations cost aspect and the degree of accuracy. Accordingly, the total households of the three kebeles were 9,450. In this study the sample size was Employing a simplified technique from (Yamane, 2007), the required adequate size were determined at a 95% confidence level, with a degree of variability of 0.5 and a precision level of 5% (0.05). The researcher decided this precision level because of limited resources and time.

Where n=the required sample size.

N=Population size (1000) e= is

the level of precision (0.05)

By using of these Formula

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

N =1000/1+1000(0.05^2)

N=1000/1+2.5

N =285.714257 =286

N=286, the researcher were select **286** Households from three Kebeles.

From the above equation, using total house hold Heads number of 1,000 a confidence level of 95% and a precision of 5%, the sample size of 286 household heads were selected. Table was used to show sample size for each kebele household head.

Table 1: Sample size of household selected for questionnaire

Name of Kebeles	No. of HHHs	Sampled HHHs Proportion	Percentage
Faraxliban	425	425*286/1,000= 121	42.30
qudhaca	275	275*286/1,000= 79	27.62
Dabeylweyn	300	300*286/1,000= 86	30.06
Total	**1000**	**286**	

Source: own constructed

3.5. Methods of Data Collection

As previously noted in the research design, the primary tools utilized to gather data for the study were interviews, focused group discussions, and questionnaires. With the use of these tools, the researcher was able to collect data from a variety of sources in order to enhance its reliability and accuracy. By employing a diverse set of instruments, the investigator were make sure that data collection takes a multifaceted approach, encompassing a wide range of viewpoints, The research topic was deeply investigated with the strategic use of a variety of methodologies, enabling an improved comprehension of the wide range of perspectives that was sought through surveys, focused group discussions, and interviews.

3.5.1. Questionnaires

Questionnaires are structured, standardised tools used to collect quantitative data from a larger sample, ensuring consistency, statistical analysis, and establishing patterns for reliable conclusions, so the questionnaire helps in the collection of both quantitative and qualitative data at the household level. A researcher-administered, closed-ended, and open-ended questionnaire has been generated in Somali and given to the respondents.

The questionnaire were divided into five primary sections. The first section focused on the demographic characteristics of households; the second section addressed the socioeconomic conditions of households; the third section examined the agro-pastoral livelihood system; the fourth section discussed households' access to institutions; and the fifth section examined the variables influencing climate-smart agriculture practices.

3.5.2. Interviews

Interviews can be a useful tool for gathering data for agro pastoral producers. Researchers can directly collect data regarding agricultural and pastoral practises from farmers by conducting semi-structured or formal interviews. A wide range of subjects, including resource management, animal management, agricultural production, and difficulties encountered, may be covered by questions.

The goal of the semi-structured interview was to gather information pertinent to this study from important informants and officers operating in this field. The interviews was targeted and concentrated specifically on the difficulties and methods that CSA poses for agro-pastoral livelihoods. Eight informants were specifically chosen for an interview. Three interviews was from the local administration, one was from the agriculture bureau, two were from non-governmental organisations and two were community leaders. Purposive sampling was used to choose these interview subjects, individuals was selected for their special knowledge and previous experience with the subject of the investigation. In an effort to reduce communication barriers, the interview questions was asked in Somali.

3.5.3. Focused group discussions

Focus group discussions are essential to generate data on group dynamics and allows small group respondents to be guided by a skilled moderator, to focus on the key issues of the research topic. The study only used one focus group-discussion in the study area, because the dayable weyn Kebele is the only Kebele that used the climate-smart agricultural technique. Focus groups with the local populations, who was primarily involved in farming and animal husbandry, was held. Dayable Weyn Kebele is the only Kebele in which the Methodology of Focus Groups was used in the Study Region. The reason that the study employed one focus group discussion in the study area was that the dayable weyn kebele is the only kebele in which the approach of climate smart agriculture was used.

Purposive sampling was used to choose respondents for the focus-group discussion. Community leaders in this Kebele participated in the focus-group-discussion and discussed about the goals of the study. For this study, eight community leaders in this Kebele were taken into account. Eight dayable weyn Kebele Community leaders participated in this FGD.

Data was collected through Focus-Group-Discussions: challenges and practises of climate smart agriculture, farming practises, resilience to crop choices, the role of the agro-pastoral livelihood, water management strategies, and the integration of traditional knowledge in the context of climate change.

3.5.4. Document analysis

Documents are the main sources of secondary data that was used in this study. Both published and different report documents like governmental and nongovernmental reports regarding this study was used as a secondary data.

3.6. Methods of Data Analysis

To achieve the specific objectives of this study, a combination of quantitative and qualitative research methods were employed. Combining quantitative surveys with qualitative methods like key informant interviews, focus group discussions, and field observations to thoroughly understand climate-smart agriculture (CSA) practices in Harshin Woreda.

3.6.1. Mann-kendall trend analysis

The Mann-Kendall monotonic trend analysis was employed to assess existing climate patterns and trends in Harshin Woreda. This non-parametric statistical test was used to identify statistically significant trends in climate variables, such as temperature and precipitation, over time. By analysing historical climate data, the study aimed to determine whether these variables exhibited increasing or decreasing trends, which are critical for understanding the broader impacts of climate change on agro-pastoral livelihoods.

3.6.2. Descriptive statistics

Descriptive statistics were utilized to summarize the data collected from surveys in Harshin Woreda. Key measures, including means, frequencies, and percentages, were calculated using SPSS software to provide an overview of respondents' characteristics and experiences related to climate-smart agriculture. This analysis revealed common concerns and practices among the community, with frequency distributions highlighting prevalent responses. Percentages illustrated the proportion of respondents engaged in climate-smart agricultural practices. The results were presented in tables and charts, facilitating a clear understanding of the impacts of climate-smart agriculture on agro-pastoral livelihoods.

3.6.3. Econometric model

In this study, the practices and challenges of adopting climate-smart agriculture (CSA) in agro-pastoral livelihoods were analyzed using a **multivariate probit (MVP)** model. In agro-pastoral systems, decision-making regarding CSA adoption often involves selecting combinations of practices that maximize resilience and utility under resource and climate constraints. As noted by Mwungu et al. (2018), adoption decisions are inherently **multivariate**, and the application of univariate models risks excluding significant interdependencies and simultaneous adoption patterns.

To address these complexities, the MVP econometric technique was used to identify the determinants of key CSA practices while accounting for correlations between unobserved factors influencing different adoption decisions and the potential relationships among these practices.

According to Young et al. (2009), "when the outcomes are correlated, the multinomial logit model produces substantially different predictions relative to the true predictions; and second, through a simulation analysis, we find that even in ideal conditions under which the outcomes are independent, the multinomial logit is still a poor approximation to the true underlying outcome probabilities relative to the multivariate probit model."

Agro-pastoral households are likely to adopt a mix of CSA practices to manage the challenges of climate variability and resource scarcity, resulting in the possibility of multiple simultaneous adoption decisions.

The MVP econometric approach applied in this context is defined by a set of binary dependent variables$Y_{h,j}$, where:

$$Y^*_{h,j} = X'_h \beta_j + \epsilon_{h,j}$$

Here:

- $j = 1,2, \ldots, m$ Represents the CSA practices relevant to agro-pastoral systems, such as **soil water conservation**, **crop diversification**, **livestock integration with manure management**, **agroforestry**, and **irrigation practices**.
- X'_h Is a vector of explanatory variables, including household, environmental, and institutional factors that influence CSA adoption.
- β_j Is a vector of parameters to be estimated for the j-th practice.
- $\epsilon_{h,j}$ Are random error terms distributed as a **multivariate normal distribution** with zero means and unit variance?

It is assumed that an agro-pastoral household h has a latent variable$Y^*_{h,j}$, which reflects the unobserved preferences or demand for adopting the j-th CSA practice. This latent variable is modeled as a linear function of observed characteristics (e.g., socioeconomic status, resource availability, institutional support) and unobserved characteristics represented by the error term. The observable binary variable $Y_{h,j}$ is defined as:

$$Y_{h,j} = \begin{cases} 1 & \text{if } Y^*_{h,j} > 0, \text{ indicating adoption of practice } j, \\ 0 & \text{otherwise.} \end{cases}$$

Since agro-pastoral households often adopt multiple practices simultaneously to manage overlapping challenges, the error terms $\epsilon_{h,j}$ are assumed to jointly follow a multivariate normal distribution. The covariance matrix of the error terms captures the unobserved correlations between the stochastic components of adoption decisions for any two practices, j and m.

This specification enables the MVP model to jointly represent decisions about adopting different CSA practices, offering a comprehensive understanding of the factors influencing adoption and the challenges encountered in agro-pastoral livelihoods.

3.6.4. Estimation of propensity scores

The propensity scores for both adopters and non-adopters were estimated using a Logit model. Since the likelihoods are restricted to values between zero and one, using the logit model has an advantage.

3.6.5. Description of variables

Independent Variables: The Independent Variables Are The Factors Influencing The Adoption Of Climate-Smart Agriculture (CSA) Practices and The Challenges Faced By Agro-Pastoralists. These Include: Demographic Factors (Age, Sex, and Education Level of the Household Head). Physical Factors (Farm Size, Farming Experience, and Local Climate Conditions. Institutional Support (Access to Extension Services, Credit Facilities, Market Information, and Training Programs). Economic Factors (Off-Farm Income, Livestock Ownership, and Asset Wealth). Attitudinal Factors (Perceptions of Climate Change, Willingness to Adopt New Practices, And Risk Tolerance).

Dependent Variables: The Dependent Variables Of This Study Will Be The CSA Practices Adopted By Agro-Pastoralists And The Challenges They Encounter. Common Practices and Challenges Include: Adoption of CSA Practices: (Use of Soil Water Conservation Techniques, Crop Diversification, Integration of Livestock and Crops, and Agroforestry). Challenges Faced): Resource Limitations (Access To Seeds And Fertilizers, Climate Variability Impacts, Market Access Difficulties, And Knowledge Gaps Regarding CSA Practices). Non-Adopters: (Farmers Who Have Not Adopted Any Climate-Smart Practices or Strategies in Response to Climate Change Challenges).

Table 2: Description of the variables for the model and their expected signs

Variables		Description of measurement units	Expected signs
Dependent Variable			
No.		Challenges and Practices of CSA (Yi)	Non
Independent variable			
1	Age	Continuous (Age in years)	+/-
2	Sex	Dummy; Male=1, Female=0	+/-
3	Education level	Continuous (Years of schooling completed)	+
4	Family size	Continuous (Man equivalent)	+
5	Income (Inco)	Continuous (in Ethiopian Birr)	+
6	Land size	continuous (hectares)	+
7	Livestock owner ship	Continuous , Tropical Livestock Unit(TLU)	+
8	Off-farm participation	Dummy; 1. Yes 0. No	+
9	Access to training	Dummy 1. Yes 0. No	+
10	Frequency of extension (Extn)	Continuous(Number of visits by extension agent per year)	+
11	Market distance	continuous (hours)/km	-
12	Access to credit	Dummy; 1. Yes 0. No	+
13	Membership of cooperative association	Dummy; 1.Yes (membership) 0. No	+
14	Access to climate information	Dummy; 1. Yes 0. No	+
15	Perception household heads	Continues measured in Likert scale	+

3.7. Reliability and Validity of Data

In the context of proposing climate-smart agriculture for agro-pastoral livelihoods, it is essential to underscore the significance of data reliability and validity. Reliable data-collection methods, including consistent monitoring of climatic conditions and pastoral activities, was enhance the dependability of the information used in the proposal. Validity is crucial to ensure that the data accurately reflects the impact of climate-smart agricultural practices on both crops and livestock, aligning with the specific needs and challenges of agro-pastoral communities. By prioritizing the reliability and validity of data, the proposal can offer a robust foundation for implementing effective and sustainable strategies that address the unique dynamics of agro pastoral livelihoods in the face of climate change. In relation to this study, the content validity is concerned with the degree to which the designed questionnaire items fairly and accurately represent the main variables. The draft questionnaires was distributed experienced researchers from CC-sectors and DA-expertise of Harshin Districts. After the questionnaire was filled and returned, the Reliability and Validity of items was measured by using SPSS

3.8. Ethical Considerations

The research project prioritizes trustworthiness and equity among respondents, ensuring their participation is protected from harm. This is achieved through principles like equity, inclusivity, and privacy protections. Transparent communication, adherence to regulations, and data integrity are also crucial. These factors contribute to the ethical framework, fostering positive impacts on agro-pastoral livelihoods and ensuring the trustworthiness of the respondents. The researcher were informed KII and FGD participants about the research objectives, ensuring their personal identities are not shared. They was capture data based on participant needs and job availability.

4. RESULTS AND DISCUSSIONS

This chapter deals with the general demographic characteristics and socioeconomic factors of the sample households, focuses on gathered household survey data about existing climate patterns and trends, assesses the economic status of household crop and livestock production, examines institutional accessibility and participation, discusses household agro-pastoral livelihood, and addresses factors affecting climate-smart agriculture production practices.

4.1. Demographic Characteristics of the Respondents

The investigator found it important to establish the demographic proportions of the respondents. As presented in Table 3, it reveals the household demographic and socio-economic characteristics within the study area.

Sex of household head: According to the result of the survey, the majority of the respondents were male-headed households, 201 (70.28%), and 85 (29.72%) were female-headed households. This result showed the implication that the majority of the local females in the study area were more involved in home-based activities than operating domestic activities like farming work. This aligns with (Chanie's 2011) observation that the national average for female-headed agricultural households in Ethiopia is approximately 17.6%.

Education level household head (EDULEV): As in indicated on the table, with regard to the educational status of households Head 278(97.2 %), the majority of them were illiterate who could not read and write, the rest of Households heads 8(2.8%) were literate which indicates that they could at least read the local Language.

Marital statuses (MZ): As it can be seen in table 3, marital statuses of the households were that 286(100%) are married which indicate that all of the sampled households have their own family.

farming activities: The type of farming activities that the agro pastoral households Follow 271(94.76%) are both crop and livestock rearing which increases agro pastoral household Livelihoods and increases their production in both crop and livestock production whereas the Remaining 10(3.5) and 5(1.75) of the household respondents responded that they follow crop Production only and livestock rearing respectively.

Age of the household head (AGE): the age of the majority of the agro pastoral households in the study area aged in between 25 to 35 which 165(57.69%) of the households indicate that more than half of the household are in the productive age. whereas the remaining 65(22.73%), 49(17.13%) and 7(2.45%), of the households responded that their age is 36-45, 46-59 and 60-75 respectively, This finding was in agreement with the study conducted by Umunakwe *et al.* (2014), and Faleye and Afolami (2020) confirmed that younger farmers are more likely to adopt climate-smart agricultural practices since they are economically active.

family size (FZ): Regarding the family size of the agro pastoral households in the study area, 201(70.78%) of the households have the family size members of 5-10 which indicates that majority of the households in the study area is in between 5 to 10 household members which has direct effect on household livelihood means whereas the remaining 6(2.1%), and 79(27.62%) of the households responded that they have family size of 1-4 and 10-15 respectively.

Land size (LZ): Regarding to table it indicated that 286(100%) households responded that they have their own land for their agricultural production and livestock production increment. while the average size of land of the household in item 7 is 11.5511 hector with 5.98549 standard deviation which indicates they have enough source of land if they properly implement and utilize smart agriculture, and they can develop their agro pastoral livelihood system which plays significant role in the regional development, and the standard deviation indicates that there is less variation in the household livelihood system.

Farm income (FARINC): Regarding to family size that the average family size of the household in this study area is 6.02 with standard deviation of 1.9 and as the average show the household members which may affect the economic growth and livelihood means of the family where as the standard deviation show less variation between family size of the household respondent finally the average income that household earn from agricultural activity is 39247.1631 with standard deviation of 7529.22248 Thus, the standard deviation shows that there is a large variation between the incomes of household earned from agricultural activity.

Table 3: Demographic and Socioeconomic Characteristics Descriptive Result.

Characteristics	Response	Frequency	Percentage
Sex of household head	Male	201	70.28
	Female	85	29.72
Educational status	Illiterate	278	97.20
	Literate	8	2.80
Marital status	Married	100	100
Which types of farming activity are you following currently	crop only	10	3.5
	Livestock rearing	5	1.75
	Mixed	271	94.7

Age	25-35	165	57.69
	36-45	65	22.73
	46-60	7	2.45
	61-75	49	17.13
Do you have land	Yes	100	100.0
Character	**Measurement**	**Mean**	**STD**
Family size	Number of person	6.0245	1.90735
Farm land size	Hectare	11.5511	5.98549
Family income from farming agricultural activity	In birr	39247.1631	7529.22248

Source: Field survey (2024)

In connection to the socio-economic factors in the study area, attempts were made to generate detail information through interviews and organize FGDs. Accordingly; one of the FGD participants (Community leaders) reflected his views when he states:

> *Only a small percentage of crop and livelihood production depends on irrigation systems. However, the majority of farming and agro-pastoral communities remain heavily reliant on rainfall patterns. During dry seasons, production capital is often poor due to the direct dependence on rainfall. Irregular rainfall patterns can significantly impact the livestock and crop production capital, which serves as the major source of income for agro-pastoral livelihoods. Given this heavy reliance on rainfall, the socio-economic factors related to both livestock and crop production capital appear to be relatively low. NGOs and regional state government bodies could play an important role in promoting strategies like water-efficient irrigation, drought-resistant crops, and diversified cropping systems that may prove beneficial in enhancing the resilience and productivity of agro-pastoral livelihoods*

Participants in the focus group discussions (FGDs) also expressed their views and concerns regarding the socio-economic factors. Accordingly, nearly all the participants stated that the production capital is inadequate. They emphasised that the lack of sufficient water supply is the primary challenge to enhancing local productivity, and this issue has not received the full attention it deserves from the various stakeholders, including non-governmental organisations (NGOs) and agricultural bureaus at both the regional and federal levels.

Similar perspectives and concerns, which are not presented here to avoid repetition, were also reflected in other interviews and FGDs conducted with community leaders and the local NGO, Save Ethiopia.

4.2. Climate Patterns and Trends in Harshin Woreda

The Climate patterns and trends in Harshin Were conducted. Using survey data, interviews, and focus group discussions, and analysing the results obtained by using Mann-Kendall monotonic trends analysis, and obtained historical climate data from the Ethiopian Meteorological Station over a period of 30 years from 1991 to 2021. The Mann-Kendall monotonic trend analysis was utilized to identify monotonic trends in time series data as show below.

Table 4: Existing Climate Patterns and Trends.

Characteristics	Response	Frequency	Percentage
Duration of residency or Time lived in woreda	05-10	22	7.69
	>10	264	92.30
Climate Change observations	Yes	279	97.55
	No	7	2.46
Over all Temperature variations observed	Increasing	275	96.15
	Decreasing	9	3.15
	No Significant change	2	0.69
Overall Rainfall variations observed	Increasing	5	1.74
	Decreasing	278	97.20
	No significant change	3	1.04

Source: Field Survey (2024)

Duration of residency: The duration of residency among respondents indicates that a significant majority (92.30%) have lived in the woreda for over ten years, while only 7.69% have resided there for 5 to 10 years. This suggests that most respondents possess a deep familiarity with local climate patterns, which may enhance the reliability of their observations regarding climate change.

Climate Change observations: In terms of climate change observations, an overwhelming 97.55% of respondents reported having noticed changes, while only 2.46% said they had not. This high percentage of acknowledgment points to a widespread recognition of climate change impacts within the community, reflecting a collective awareness that could drive discussions and actions around climate adaptation and mitigation.

Temperature variations observation: Regarding overall temperature variations, an impressive 96.15% of respondents observed an increase in temperatures, while only 3.15% noted a decrease, and 0.69% reported no significant change. This consensus on rising temperatures aligns with global climate trends, indicating that local perceptions are consistent with broader scientific findings.

Rainfall variations observation: When it comes to rainfall variations, the responses reveal a stark contrast: only 1.74% of respondents observed an increase in rainfall, while a substantial 97.20% reported a decrease. Additionally, 1.04% noted no significant change. This pattern suggests a significant concern about decreasing rainfall, which could have serious implications for agriculture and water resources in the region.

According to one of the interviewees, there has been a significant increase in temperature, leading to the hottest days being felt last year. Additionally, there has been a decrease in rainfall and a shift in the timing of rainfall to different months. These changes are impacting the agro-pastoralist communities in the woreda.

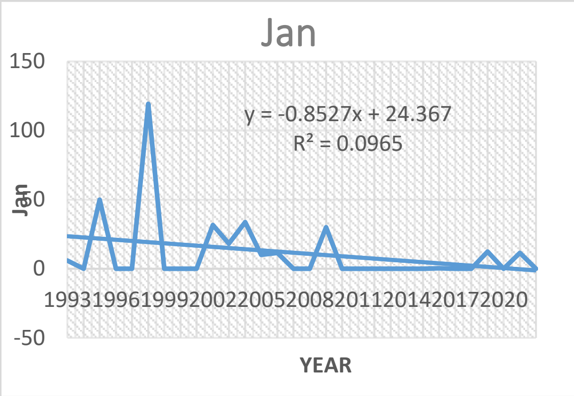
Further investigation into the existing climate trends in rainfall and temperatures, along with analysis of actual data using Mann-Kendall monotonic trend analysis and secondary data obtained from the Ethiopian Meteorological station, would be crucial for understanding the existing climate patterns in the woreda. As shown in the tables below:

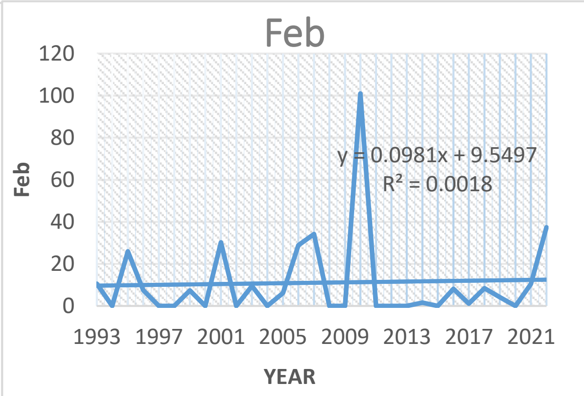
4.2.1. Mann-Kendall Monotomic Trend Analysis

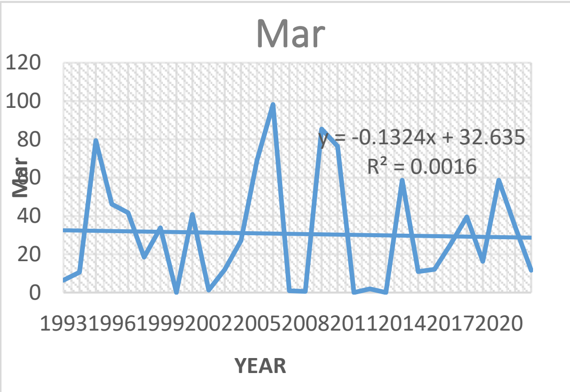
In this study, the Mann-Kendall (MK) test was applied to analyse trends in climate data, focusing on Rainfall, Maximum Temperature (Tmax), and Minimum Temperature (Tmin) over a 30-year period from 1993 to 2022, using data from the Ethiopian Meteorological Station.

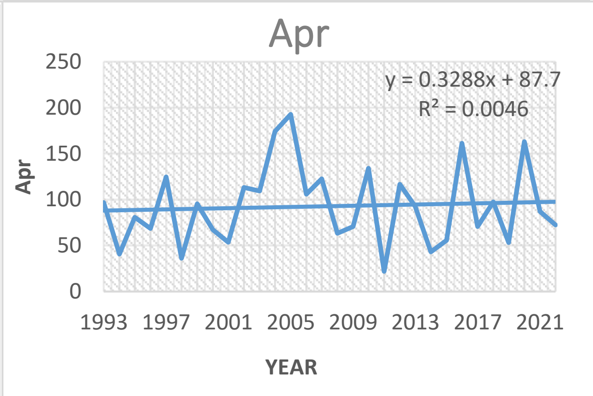
4.2.2. Monthly rainfall trend analysis

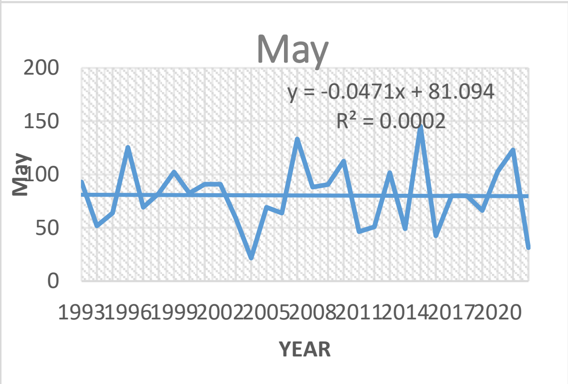
The variation in rainfall data (trend) on monthly basis is calculated individually for each month using Mann-kendall statistically method and magnitude of slope is calculated with Sen's slope estimator as represented in fig. 3. It was analysed that there is significant changes in monthly rainfall data mean some of the months showed increasing (upward) trend and some showed decreasing trends. Five months (Feb, Apr, Sept. Oct, And Nov) give positive values of z– statistics which represent rising trend while other months (Jan, Mar, May, Jun. Jul, Aug, And Dec) represent falling trend as shown the estimated Sen's slope (q) was also calculated for each month separately and the month (Feb, Apr , Sep, Oct And Nov) Give increasing slope magnitude and the month (Jan, Mar, May, Jun, Jul, Aug And Dec) showed a decrease in the slope magnitude, as indicated by their negative Kendall's tau values.

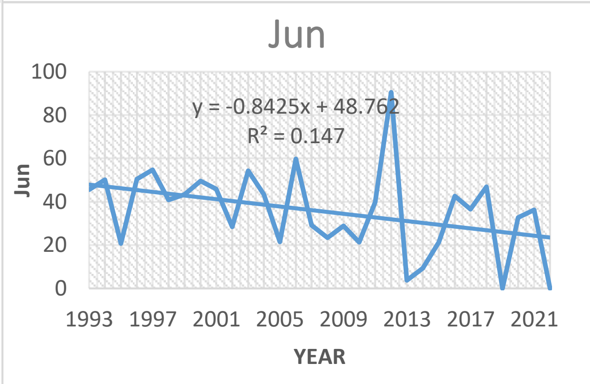

Jan
y = -0.8527x + 24.367
R² = 0.0965
Jan
YEAR
150
100
50
0
-50
1993 1996 1999 2002 2005 2008 2011 2014 2017 2020

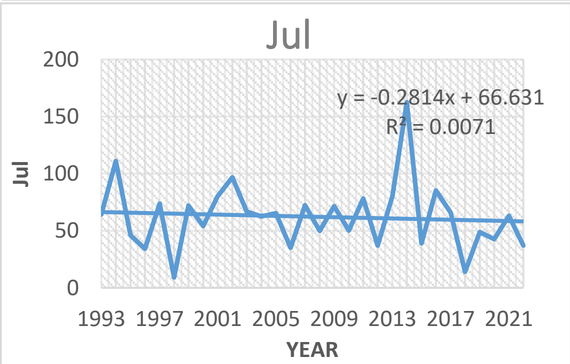

Feb
y = 0.0981x + 9.5497
R² = 0.0018
Feb
YEAR
120
100
80
60
40
20
0
1993 1997 2001 2005 2009 2013 2017 2021

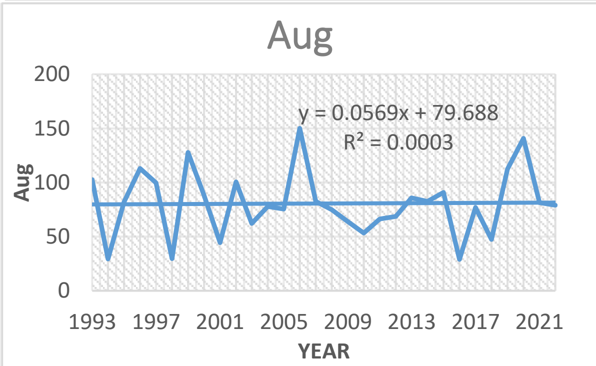

Mar
y = -0.1324x + 32.635
R² = 0.0016
Mar
YEAR
120
100
80
60
40
20
0
1993 1996 1999 2002 2005 2008 2011 2014 2017 2020

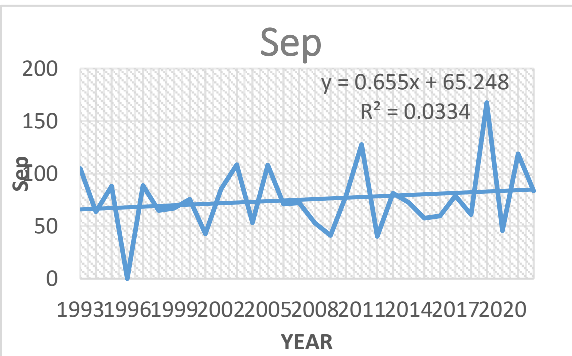

Apr
y = 0.3288x + 87.7
R² = 0.0046
Apr
YEAR
250
200
150
100
50
0
1993 1997 2001 2005 2009 2013 2017 2021

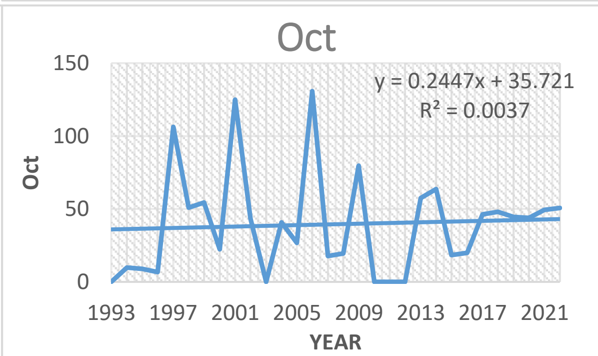

May
y = -0.0471x + 81.094
R² = 0.0002
May
YEAR
200
150
100
50
0
1993 1996 1999 2002 2005 2008 2011 2014 2017 2020


Jun
y = -0.8425x + 48.762
R² = 0.147
Jun
YEAR
100
80
60
40
20
0
1993 1997 2001 2005 2009 2013 2017 2021


Jul
y = -0.2814x + 66.631
R² = 0.0071
Jul
YEAR
200
150
100
50
0
1993 1997 2001 2005 2009 2013 2017 2021


Aug
y = 0.0569x + 79.688
R² = 0.0003
Aug
YEAR
200
150
100
50
0
1993 1997 2001 2005 2009 2013 2017 2021


Sep
y = 0.655x + 65.248
R² = 0.0334
Sep
YEAR
200
150
100
50
0
1993 1996 1999 2002 2005 2008 2011 2014 2017 2020


Oct
y = 0.2447x + 35.721
R² = 0.0037
Oct
YEAR
150
100
50
0
1993 1997 2001 2005 2009 2013 2017 2021

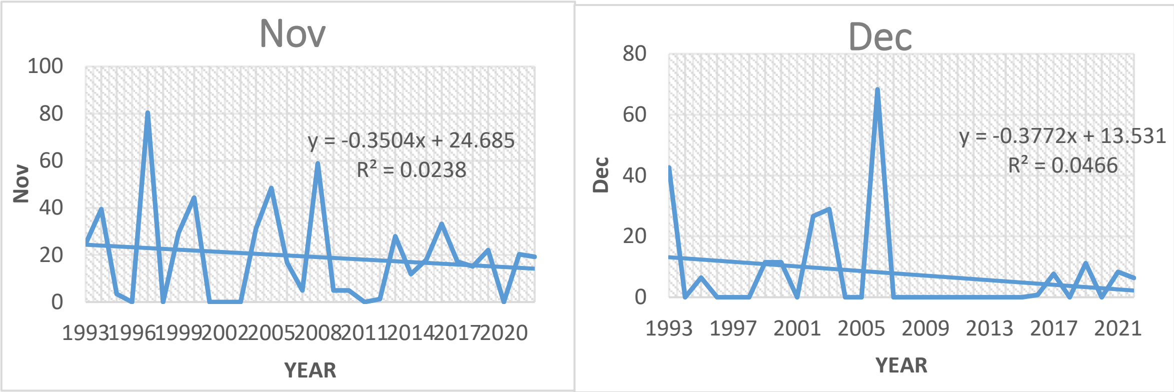


Figure 3: Monthly Rainfall Trend Analysis.

4.2.3. Seasonal rainfall trend analysis

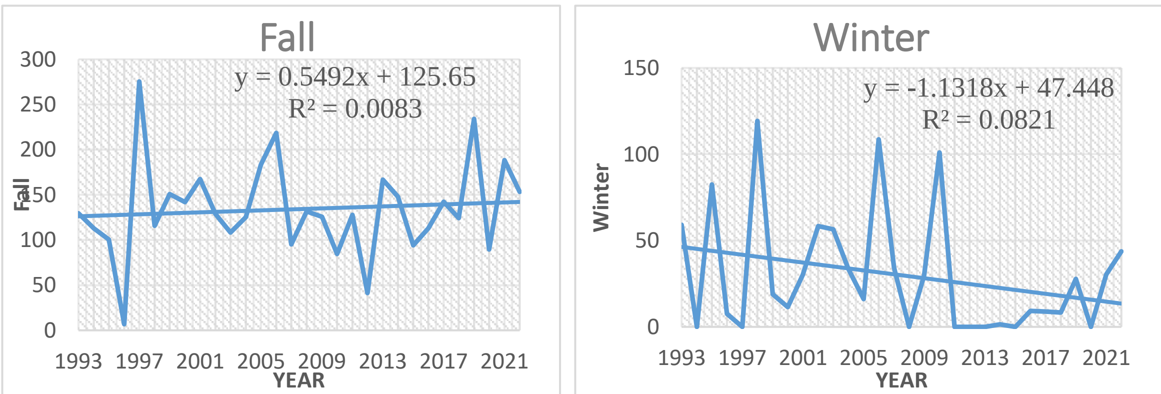
From the 30-year rainfall data, the analysis reveals distinct seasonal variations in precipitation levels. The spring season experienced the overall highest seasonal rainfall, with a maximum of 331.0 mm, indicating a period of significant rainfall beneficial for agro-pastoral livelihoods in the woreda. The overall lowest seasonal rainfall was 0.0 mm, posing a significant challenge for agro-pastoral communities in Harshin Woreda, which occurred multiple times during the winter season, indicating potentially dry winter conditions in some years.

Winter (December-February): The winter season exhibited a slightly negative Z value of approximately **-1.118,** indicating a Moderate decreasing trend in rainfall. Sen's slope estimator revealed downward slope of **-0.407mm** per year during the winter months.

Spring (March-May): The analysis suggests that there is no significant trend in spring rainfall over the observed period, As Sen's slope indicated a slightly decreasing trend of **-0.038 mm** per year in spring rainfall over the 30-year period.

Summer (June-August): The summer season shows decreasing in rainfall trend as indicted the negative slope of trend line which approximately is **-1.64**, However, Sen's slope estimated a downward slope of **-1.371 mm** per year during the summer months.

Fall (September-November): The fall season showed a very slight positive trend of approximately **0.392**, and the Sen's slope **is 0.50mm** per year, indicating a moderate increasing trend in fall rainfall over the analysed time period.



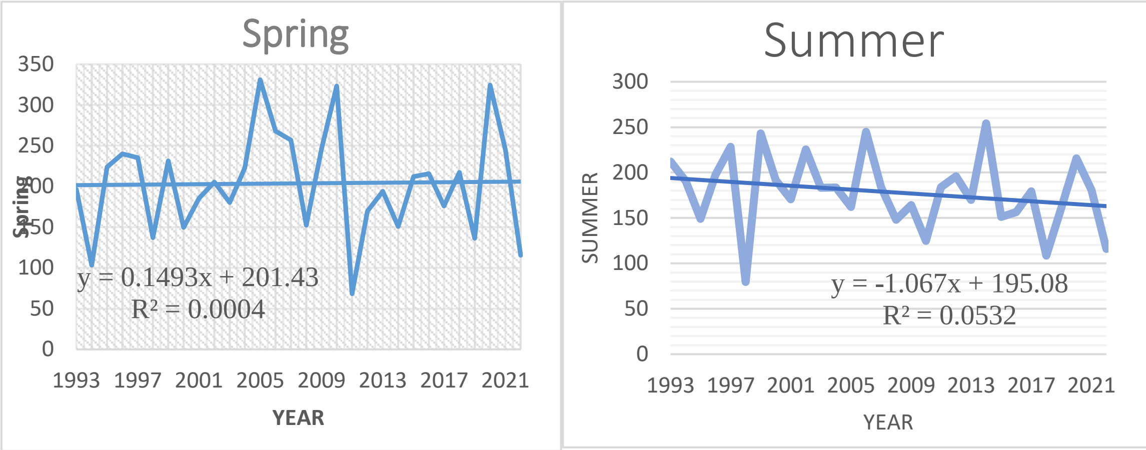


Figure 4: Seasonal Rainfall Trend Analysis.

4.2.4. Annual rainfall trend analysis

The trend of total annual rainfall of 30 years data is represented in Fig 5. Which depicted that the total maximum annual rainfall **839.8 mm** has occurred in the year 2006 while minimum total annual rainfall **380.1mm** has occurred in 2011 of whole reference period. Average annual rainfall of 30 years data is **546.4mm.** The negative value of Z and Q -Statistics showed that there is a falling trend with a downward slope of rainfall on an annual basis.

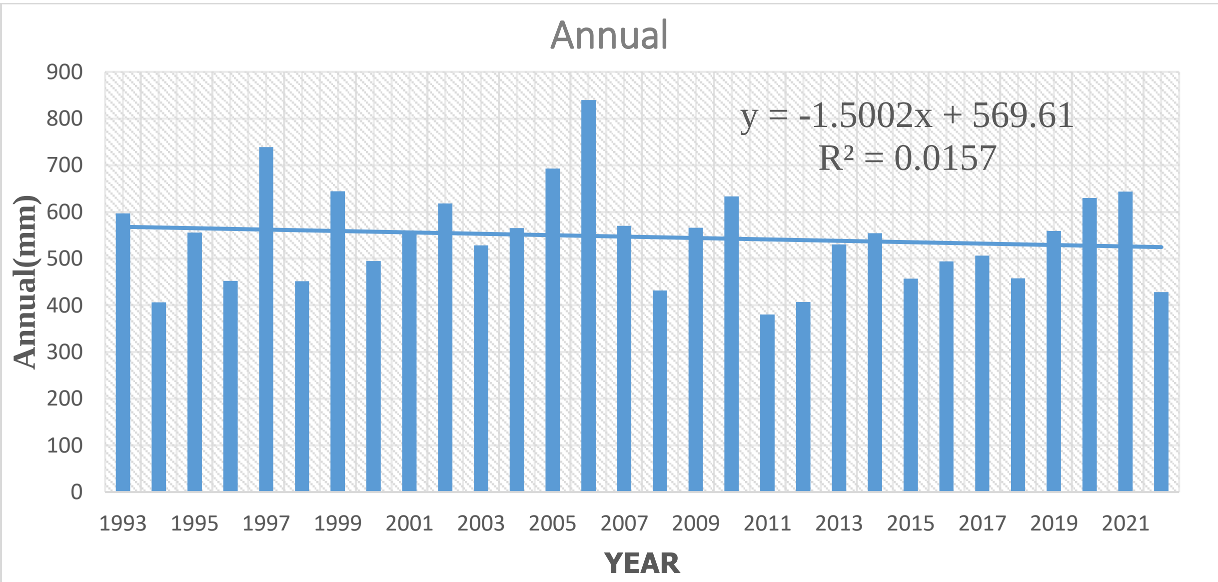


Figure 5: Annual Rainfall Trend Analysis

4.2.5. Temperature trend analysis

Trend Analysis of harshin woreda has been done with 30 years temperature data from 1993-2022. Mann-Kendall and Sen's Slope Estimator has been used to determine the trend. Fig 6. Show the Maximum, Minimum, average temperatures and comparison of the temperatures of the study area for the study period respectively

The Woreda experiences significant temperature fluctuations, with record highs of 29.81°C in 1997 and 28.48°C in 2019, as well as lows of 8.9°C, posing risks to crop productivity. This data reveals that maximum and minimum temperatures do not exhibit a direct relationship within the Woreda. Adopting cold-resistant crop varieties affects these temperature variation challenges for climate-smart, Sustainable agriculture and food security.

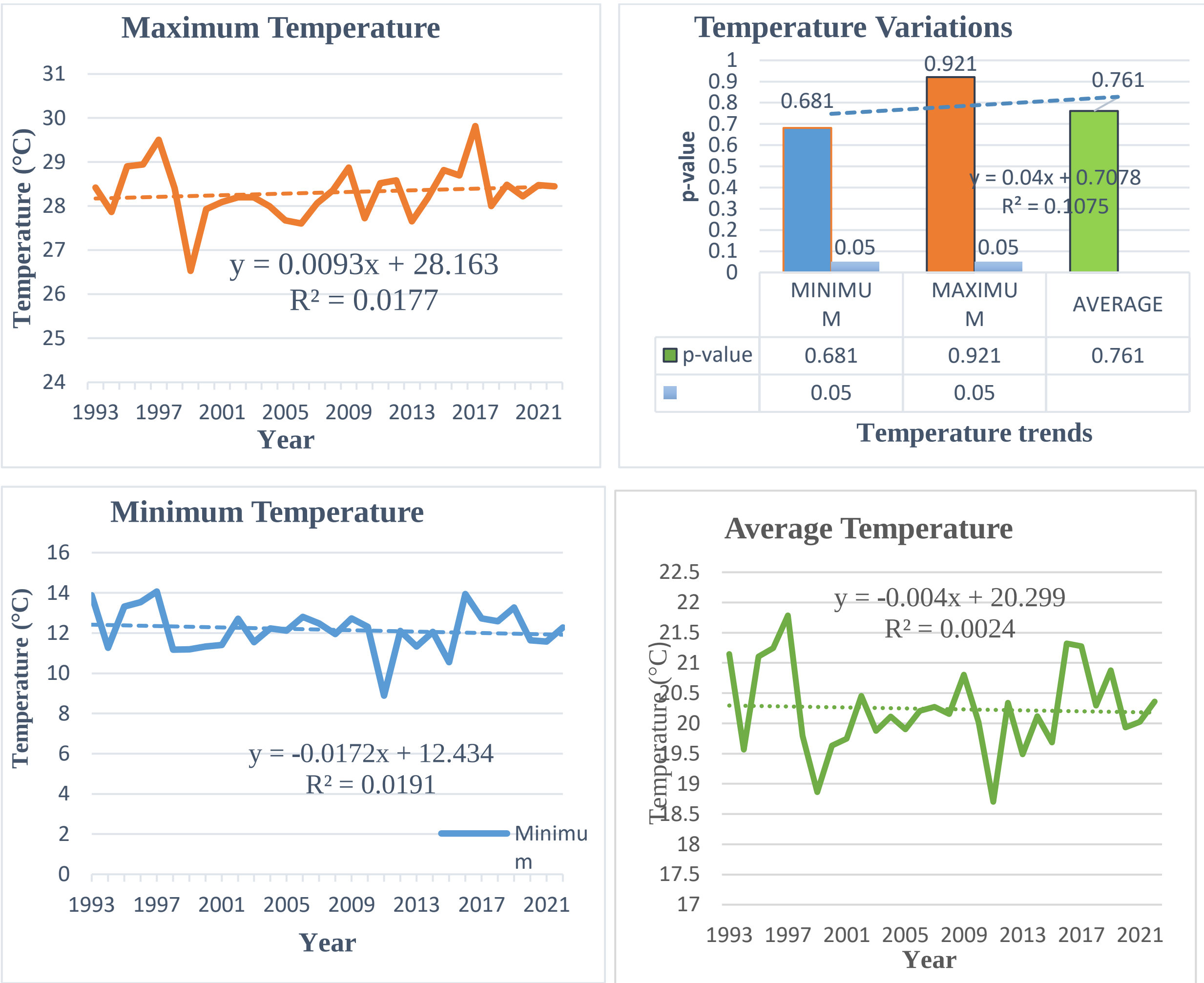


Figure 6: Maximum, Minimum and Average Temperatures for the Study Period.

The analysis of temperature and rainfall trends in Harshin Woreda indicates a significant rise in temperatures along with a decline in rainfall over the past three decades. These trends align with the findings of (Abrham & Mekuyie, 2022) that the significant rise in temperatures and decline in rainfall in Harshin Woreda create serious challenges for agro-pastoral communities. It is essential to address these issues to develop effective adaptation strategies that ensure long-term sustainability.

Table 5: Summary of Climate Patterns and Trends with Z Statistics and Sen's Slope

	Observation	Trend Direction and Magnitude	
		Z-Statistic	Sen's Slope
Monthly Rainfall Trend	Decreasing in Jan, Mar, May, Jun, Jul, Aug, Dec; Increasing in Feb, Apr, Sept, Oct, Nov	Varies	Varies increasing slope magnitude (Feb, Apr , Sep, Oct And Nov) decrease slope magnitude (Jan, Mar, May, Jun, Jul, Aug And Dec)
Seasonal Rainfall Trend	Winter(Dec-Feb): moderate decrease; Spring (Mar-May): low Decline; Summer (Jun-Aug): Steep decline; Fall (Sep-Nov):Slight increase	Negative/ Positive	Winter:-0.407 mm/year Spring: -0.038 mm/year Summer:-1.371mm/year Fall: +0.50 mm/year
Annual Rainfall Trend	Decreasing significantly	-1.371	-0.407 mm/year
Temperature Trend	increasing sharply	Positive	+0.5°C per decade

Source: Analysis from Mann- Kendell Test on Climate Date (2024)

4.3. Overview of Household Crop and Livestock Production

Household crop and livestock production enhances resilience through sustainable practices like crop rotation and diversification, improving yields and soil health. Analyzing these systems reveals that integrating crops and livestock fosters greater adaptability to climate variability. However, limited resources and climate impacts challenge productivity, necessitating targeted support and education for effective adaptation.

Crop Production: As we can understand from the above table 6. indicate that 161(56.29%) of the household respondents responded that their crop production type is maize which is the main source to sustain their agro pastoral household livelihood whereas the remaining 125(43.71%) of the household respondents responded that that their crop production type is wheat which indicate that majority of farmer in this study area produce maize to sustain their agro pastoral livelihood..

Regarding to the average quantities of crop produced and sold by the households is 29.0211 and with standard deviation 4.83673 and 14.3636 with standard deviation 2.97485 respectively which show that majority of the household use their crop production for sell to enhance their household livelihood system in this study area rather than using directly for household consumption finally as indicated in item 16 of table 4.3 the average income that household earn from farming activity is 13759.4386 with standard deviation of 12396.48532. Thus, the standard deviation shows that there is a large variation between the incomes of household earned from farming activity.

On the other hand the average income that the sampled households earn from farming activity is 11671.1712 with standard deviation 5865.20094 which indicate that there is great variability or deviation from mean which indicates that incomes from farming activities of the household have great different level of earning.

Livestock Production: As presented in the table 6, Demonstrates that 135 (47.21%) of the household respondents indicated their livestock type as sheep, while 151 (52.79%) responded that their livestock type is cattle. This indicates that the majority of households are culturing and rearing sheep for their livestock production to sustain their household agro-pastoral livelihood in this study area. Additionally, 98 households (34.26%) reported rearing camels, which are valued for their adaptability to arid environments, providing milk, meat, and transportation, further supporting the livelihoods of these households.

Livelihood sustainability: As shown in the table 6, reveals the sustainability of this livelihood type. The majority of the sampled households 277(96.85%) responded that their livelihood is sustainable whereas the remaining 9(3.5%) of the sampled households responded that their livelihood is not sustaining in this study area.

Income earned: Regarding to table 4, shows the amount of income earned from livestock production is in average 30550.2308 Birr with 1460.20728 standard deviation of whereas the average number of livestock sold by the household is 1.8951 with standard deviation of 0.71292. Thus, the study result shows that the average number of livestock possessed by the household is 23.0105 with standard deviation of 4.62752. Therefore standard deviation indicates that most of the time the sampled agro pastoral households don’t sell their livestock rather they possess for their own direct household consumption in this study area.

Table 6: Overview of Household Crop and Livestock Production

Characteristics	Response	Frequency	Percentage
Type of crops	Wheat	125	43.71
	Maize	161	56.29
Characteristics	**Unit**	**Mean**	**STD**
Quantity of crops Produced in year 2015 E.C	Quintal	29.0211	4.83673
Quantity of crops consumed for household of livelihood in year 2015 E.C	Quintal	14.3636	2.97485
Quantity of crops sold in year 2015 E.C	Quintal	14.6632	5.47583
Income earned from farming activity in year 2015 E.C	Birr	13,759.4386	12,396.485
Types of livestock	Cattle	98	34.26
	Camels	80	27.97
	Sheep	108	37.76
Livelihood source sustainability	Yes	277	96.85
	No	9	3.15
Characteristics	**Unit**	**Mean**	**STD**
Income from livestock	Birr	30550.2308	1460.20728
Size (quantity) possessed by the household	Number	23.0105	4.62752
Number of livestock sold	Number	1.8951	.71292

Source: Analysis from own survey data (2024)

4.4. Impact of climate change on agro-Pastoral Livelihoods

Climate change has severely disrupted agro-pastoral livelihoods in the study area, leading to reduced crop yields, livestock losses, and increased socioeconomic challenges. Key impacts include increased frequency of droughts, crop pests, and irregular rainfall patterns, all contributing to the vulnerability of these communities. Here are the results detailing these impacts. In these sections, we analysed the impact of CC on agro-pastoral livelihoods.

Impact of Climate change: Climate change has significantly affected agro-pastoral livelihoods in the study area, with 45.10% of households reporting decreased agricultural productivity, 30.76% experiencing livestock losses, and 24.12% facing socioeconomic issues like income instability and food insecurity.

These findings highlight the multifaceted challenges that climate change poses for agro-pastoral livelihoods in the study area. The data indicates that climate change is negatively impacting both crop production and livestock rearing, leading to broader socioeconomic consequences for households.

Climate threats: The majority of the household respondents 219(76.57%) responded that their cereal and livestock production remains low for the reason that they do not have an early warning system during potential hazard, The remaining respondents attributed their low production to either a lack of application of climate-smart agricultural practices (16.43%) or directly to climate variability such as drought (6.99%).

These findings correlate with (Michael, 2017), indicating that climate change severely threatens pastoralists' livelihoods by causing resource scarcity, altering weather patterns, and increasing vulnerability. Such impacts disrupt traditional practices and necessitate innovative adaptation strategies to enhance resilience in affected communities.

Climate practices: The majority of the households 199(69.58%) responded that they properly use smart agricultural practise whereas the remaining 14(4.89%) and 73(25.52%) of the households responded that their cereal and livestock production is high for reason that having access of weather information and access to agricultural extension service respectively.

Factor affecting agro pastoral: Shows that 185(64.68%) of the household respondents responded that shortage of water or rainfall is the main factor that affects agro pastoral livelihood of households in this study area Additionally, 59(20.62%) of the respondents indicated that the lack of proper utilization of climate-smart agriculture practices is another key factor. The data also shows that shortage of food/poor cereal production 12(4.19%) respondents and lack of access to weather information 30(10.48%) respondents are contributing to the challenges faced by the agro-pastoral community in this region. Therefore, the findings suggest that the shortage of water/rainfall is the predominant issue impacting agro-pastoral livelihoods in the study area.

Natural hazards: The main natural hazards that disrupt the normal flow of production in the study area are drought, crop insects, and high temperatures. Specifically, drought is reported as the primary natural hazard, with 217 respondents (75.87%) citing it as a disrupting factor. Crop insects are the second most significant hazard, mentioned by 49 respondents (17.13%). High temperatures are also noted as a disruptive factor, reported by 20 respondents (6.99%). Therefore, the data suggests that drought, crop insects, and high temperatures are the predominant natural hazards impacting the normal production flow and agro-pastoral livelihoods in the study area.

Off farm income: The result shows that 286(100%) of the household respondents responded that they have off-farm which help them to sustain their livelihood means at the times natural hazard such as prolonged droughts.

Table 7: Impact of Climate Change on Agro-Pastoral Livelihoods.

Characteristics	Response	Frequency	Percentage
How climate change influenced agro-pastoral livelihoods	Low Agriculture Productivity	88	30.76%
	Livestock Losses	129	45.10%
	The socio-economic implications	69	24.12%
What are the Climate impacts reason why your cereal and livestock production remain low in your kabele	lack of earn warning of potential hazards	219	76.57
	lack of the application of climate smart agricultural production practices	47	16.43
	due to climate variability such as drought	20	6.99
What are the Climate impacts reason why your cereal and livestock production higher in your kabele	proper utilization of climate smart agriculture	199	69.58
	Having access to weather information	14	4.89
	access to agricultural extension service	73	25.52
What are the main factor affecting agro pastoral livelihood in your kabele	shortage of water/rainfall	185	64.68
	lack of proper utilization of CSA practices	59	20.62
	Shortage of food/ poor cereal production	12	4.19
	Lack of access to weather information	30	10.48
What are the climate impacts or Natural hazard disrupt normal flow of production	Drought	217	75.87
	crop insect	49	17.13
	flood	0	0.00
	Others (high temperature)	20	6.99
During climatic problems, Do you have any source of off farm income to sustain household livelihood	Yes	286	100.0
	No	0	0.000

Source: Field Survey (2024)

In the interviews held with Kebele administrators, community leaders, and the Agricultural Bureau of the woreda, the participants provided insights into the devastating impact of climate change on the agro-pastoral livelihoods in the study area.

> *The Kebele administrator stated, "The prolonged droughts we have experienced have been devastating. We have lost the majority of our livestock due to the lack of water and grazing resources. This has forced us to migrate to other areas in search of sustenance for our remaining livestock. The declining water supply and degradation of our grazing lands have made it incredibly difficult to maintain our traditional way of life."*

In connection to this, one of the interviewed community leader declared:

> *The community leader further explained, "The low agricultural productivity has also been a major challenge. We have seen a significant drop in our crop yields due to the changing rainfall patterns and increased frequency of droughts. This, combined with the livestock losses, has severely undermined our food security and economic well-being."*

In the FGDs held with the community leader, similar reflections were made like those of the above interviewees were made. However, what was unique was that participants in the FGDs stressed that what we want to be improved is that there should be an investment to increase the local and cropping productivity to enhance the local agro pastoral livelihood in the sampled study area.

4.5. Climate-Smart Agricultural Practices Adopted by Agro-Pastoralists

The study revealed that a significant majority of agro-pastoral households (89.86%) adopted climate-smart agricultural practices, utilizing technologies, skilled labour, and training from agricultural extension workers. Conservation Agriculture, especially crop rotation, was the most common practice (71.32%), followed by Integrated Soil Fertility Management (24%) and Crop Diversification (6.99%). All respondents acknowledged the positive impact of these practices on their livelihoods, with 77.97% reporting improvements in both crop and livestock productivity. Additionally, 82.69% found climate-resilient practices more productive than traditional methods. Notably, 73.3% believed that crop production was more vital for sustaining their livelihoods than livestock production.

Table 8: Major Climate Smart Agricultural Practices Adopted in the Study Area.

Characteristics	Response	Frequency	Percentage
employment of any Practice of climate smart agriculture	Yes	257	89.86
	No	29	10.13
Types of Climate smart agricultural practice employed ,	Conservation Agriculture	205	71.67
	Integrated soil fertility management	60	21.32
	Crop diversification	20	6.99
Duration of practice of adoption	< 5 years	27	9.44
	5 -10 years	44	15.38
	>10 years	215	75.17
Do you think that climate smart agriculture has positive for the CC?	yes	286	100.00
If your answer for the above question is yes in which way it helps you	Both cropping and livestock productivity	223	77.97
	livestock productivity	39	13.63
	cropping productivity	27	9.44
Comparing traditional agricultural practices to climate resilient agricultural practices, do you think climate resilient agricultural practices are more productive	Yes	237	82.86
	No	49	17.13
Do you think crop production sustains household livelihood than livestock production	Yes	204	71.32
	No	89	28.67

Source: Analysis from own survey data (2024)

CSA practice; These table, highlights that the majority of the households 257(89.86%) responded that they employed climate smart agricultural practice which indicates that they get chance to develop their farming activities and livestock production a well through using technology material like tractor, skilled labour, and different training assistances from agricultural extension worker, and this result also reveals that 29(10.13%) of the households didn't employ in any climate smart agriculture practices in this study area.

CSA Methods: The table indicates that the majority of respondents, 204 (71.32%), responded that they employ conservation agriculture (crop rotation), while 61 (24%) and 20 (6.99%) of households indicated they used integrated soil fertility management and crop diversification, respectively. Therefore, we conclude that most agro-pastoral households reported using conservation agriculture (crop rotation) as the climate-smart agriculture practice in this study area.

Duration of climate-smart agriculture: The duration of climate-smart agriculture practice adoption among agro-pastoralists shows that 215 out of 286 households have been using these practices for more than 10 years, 44 households for 5-10 years, and 27 households for less than 5 years. This suggests that agro-pastoralists in this community have had enough time to become familiar with and effectively implement these practices. The long duration of practice adoption indicates that these climate-smart approaches have become well-integrated into their farming and livestock management systems.

Positive impact of CSA: all of the households respondent 286(100.0%) responded that smart agricultural practise have positive effect on their household agro pastoral livelihood in the study area. The majority of the sampled household respondents (77.97%) stated that the use of climate-smart agricultural practices helps them increase both their crop and livestock productivity. Additionally, 13.63% of the household respondents indicated that climate-smart agriculture specifically helps improve their livestock productivity, while 9.44% said it benefits their cropping productivity. Therefore, we can conclude that the majority of the sampled agro-pastoral households responded that the application of climate-smart agricultural practices is used to enhance both their crop and livestock productivity in this study area.

Agricultural Practices Comparison; Comparing the productivity of traditional agricultural practices to climate resilient agricultural practices, 239(82.69%) of the sampled household respondents responded that climate resilient agricultural practices are more productive than traditional agricultural practices whereas 49(16.95) of the household respondents responded that traditional agricultural practices are more productive. Thus, the majority of the sampled agro pastoral household responded that climate smart agricultural practices are more productive than traditional agricultural practices.

Regarding to comparison of crop production and livestock production in enhancing the sustainability of livelihood of the agro pastoral households, 237(73.3%) of the sampled household respondents responded that crop production sustains the household agro pastoral livelihood than livestock production whereas 49(26.7%) of the household respondents responded that livestock production sustains the household agro pastoral livelihood than crop production which indicates that the majority of the households believe crop production sustains the household agro pastoral livelihood than livestock production in this study area.

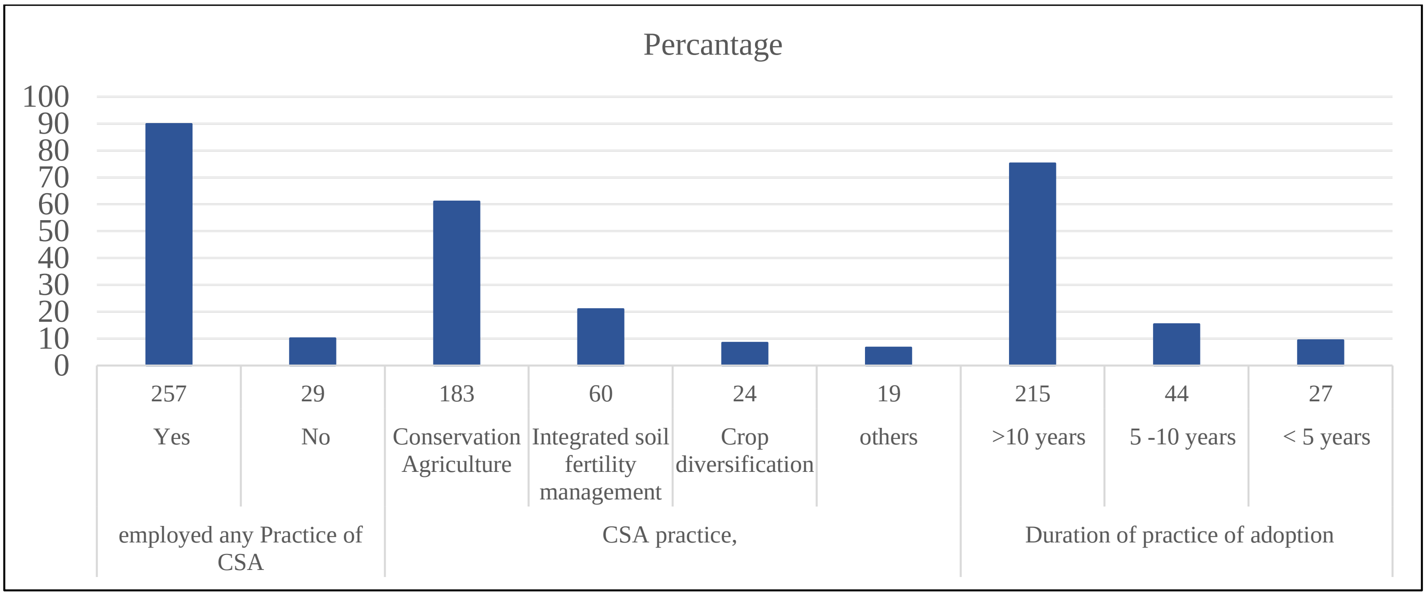


Figure 7: Distribution of CSA Practices by Percentage.
Source: Own survey data (2024)

These findings support the conclusion Takele, (2019) that implementing climate-smart agricultural practices such as adaptive grazing management, community-based resource management, reforestation, and crop diversification can enhance ecological resilience. Additionally, these strategies, along with efficient water management and capacity building, promote sustainable land use and improve livelihoods amid significant land use changes

Table 9: Institutional Characteristics and Status of Participation

Characteristics	Response	Frequency	Percentage
Do you have contact to agricultural Service	yes	286	100.0
are you member of formal or/and informal institution in your village	yes	206	72.03
	no	80	27..97
Access of weather information	yes	182	63.63
	no	104	36.36
Access of market information	yes	196	68.53
	no	90	31.46
Characteristics	**Unit**	**Mean**	**STD**
Average visit of agricultural extension worker in a production season	Number of visiting per production season	1.0691	.25395
Distance to market place	In km	24.2912	2.42698

Source: Analysis from own survey data (2024)

Agricultural Contact: Revealing that all households have contact with agricultural extension services, reflecting strong engagement with support systems.

Institutions Membership: A majority (72.03%) are members of formal or informal institutions, enabling experience sharing,

Access of weather and market information; While 63.63% have access to weather information and 68.53% have access to market information, both critical for informed decision-making.

Agricultural Extension Visits and Market Distance: The average number of visits by agricultural extension workers per season is just over one, and the average distance to the marketplace is about 24.2912 km, though this varies significantly. These insights underscore the role of institutional support and information access in shaping agricultural practices and livelihoods in the region.

In connection to the institutional or organizational role to improve the agro pastoral livelihood in the study area, attempts were made to generate detail information through interviews and organize FGDs. Accordingly; one of the FGD participants (community leader) reflected his views when he states:

> *"There is a lack of formal institutional or organizational interventions to improve the agro-pastoral livelihoods in the kebele. Therefore, we need adequate formal sectoral interventions to enhance the quality and sustainability of the agro-pastoral livelihood system in this area."*

Participants in the FGDs also spoke out their views regarding the informal institutional role which has been in significant position to improve the agro pastoral livelihood, and they took Tabantaabo as an informal institution which is Rotating Savings and Credit Associations and, is based on pre-established social ties. They stated that this informal institution consists of homogenous groups; people from the same work place, the same language based, trade, schooling or neighbourhood.

The capital contributions vary according to the purpose of the Tabantaabo and economic status of members. The participants noted that the Tabantaabo is no longer working as effectively compared to when it was first established in previous years. In the face of the rapid growth, they mentioned that modern financial sector does not reduce the acceptance of Tabantaabo, rather it grows in a parallel way

Similar views and concerns [which are not presented here to avoid replication] were reflected on other interviews and FGDs held with the community leaders, kebele administrators, and the local NGO such as SEE about the institutional role to improve the agro pastoral livelihood security and economic status of the household and crop production

4.6. Challenges of Climate Smart Agriculture on Agro Pastoral Livelihood

These Table highlights several key challenges that agro-pastoral households in Harshin Woreda face when implementing climate-smart agricultural practices. Each item in the table reflects a significant factor or barrier impacting the effectiveness and sustainability of these practices.

Table 10: Challenges of Climate Smart Agriculture on Agro Pastoral Livelihood.

Characteristics	Response	Frequency	Percentage
Factor affecting smart agriculture practice in your kebele	CSA Technology	176	61.53
	Skilled Human Labour	15	5.24
	Other	95	33.21
Poor irrigation highly affect practice	Yes	286	100.0
Irregular rainfall pattern affects CSA	Yes	286	100.0
Inadequate agricultural extension programs and assistance	Yes	207	72.37
	No	79	27.62
Lack of practical understanding of climate-smart approaches	Yes	286	100.0
Inadequate coordinated supportive and enabling policy frameworks	Yes	286	100.0
Lack of adequate financing mechanisms and effective risk-sharing schemes	Yes	286	100.0

Source: Analysis from own survey data (2024)

Availability and Accessibility of CSA Technology: The primary challenge identified by 61.53% of households is the availability and accessibility of climate-smart agriculture technology, while 33.21% also cite other factors such as seed quality and soil fertility, and 5.24% mention the lack of skilled labour.

Irrigation and Rainfall Challenges: All respondents (100%) agreed that poor irrigation systems and irregular rainfall patterns severely hinder agricultural productivity.

Lack of Agricultural Support and Understanding of CSA Approaches: were recognized as a significant barrier by 72.37% of households, and the universal acknowledgment of a lack of practical understanding of climate-smart approaches (100% of respondents) underscores the need for more comprehensive education and training initiatives.

Policy and Financial Gaps: The table also highlights a critical gap in governance, with all respondents agreeing that there is a lack of coordinated supportive policy frameworks and adequate financing mechanisms. This combination of technological, educational, infrastructural, and policy-related challenges emphasizes the need for a more integrated and well-supported approach to effectively implement climate-smart agriculture in the Woreda.

As mentioned, Tessema et al., (2015) said that conservation agriculture (CA) has been widely advocated by international organizations such as the Food and Agriculture Organization (FAO). CA has been promoted as it can improve long-term crop productivity, yield stability, and ecosystem services.

Furthermore, attempts have been made to explore detail information through interviews and FGDs about the impacts of climate smart agriculture practices on agro pastoral livelihood in the study area. Accordingly, one of the interviewed informants from agriculture bureau reflected his views when he states:

> *Inadequate agriculture extension programmes and assistances have been the major gap that has not motivated to speed up the implementation climate smart agriculture. To me, I believe agriculture extension programmes are the main conduits of addressing the rural poverty to enhance the livelihood security and productive level through the means of transformation of technology, supportive agro pastoral adult learning, and assistance of farmers in problem-solving and getting farmers and actively involved in the agriculture knowledge and information system.*

Similarly, in the FGDs held with community leaders reflected their feelings about the impacts of climate smart agriculture practices on agro pastoral livelihood and they stressed that Changing in climate is hitting local production and the livelihood means hard. Some of the problems we face are; for example, lack of practical understanding of the approach, inadequate coordinated, supportive and enabling policy frameworks, and lack of adequate and financing mechanisms and effective risk-sharing schemes. Thus these are the major problems we face in order to implement climate smart agriculture.

5: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

In this chapter, the summary of the major findings, the conclusions reached at and the recommendations forwarded on the basis of findings are presented.

5.1. Summary

The primary purpose of this study was to explore the challenges and practices of climate smart agriculture on the agro pastoral livelihood system in the case harshin Woreda. A sample of 286 respondents were selected and their views were assessed through questionnaire, interviews and FGDs and the collected information were analysed through quantitative and qualitative approaches. To achieve the purpose of the study, the following basic research questions were set as:

1. What are the existing climate patterns and trends in study area?
2. How does climate change impact agro-Pastoral Livelihoods?
3. What are the climate-smart agricultural practices in the study area?
4. What are the challenges climate-smart agriculture practices?

Based on the analysis and interpretation of the data, the study identified several key findings:

The analysis of climate data revealed a significant trend of increasing temperatures and decreasing rainfall over the past three decades in Harshin Woreda. Seasonal rainfall patterns have become more erratic, with reduced rainfall during critical growing seasons, leading to prolonged droughts and negatively impacting agricultural productivity. These climatic changes have heightened the vulnerability of agro-pastoral households, making them more susceptible to food insecurity and threatening their livelihoods.

The impact of climate change on agro-pastoral livelihoods is profound in Harshin woreda, as evidenced by the decline in crop yields and the reduced availability of grazing land for livestock. As a result, many households have experienced a decline in income and food security. The study also found that the increased frequency and severity of droughts have forced some households to diversify their livelihoods, often by reducing their reliance on livestock and turning to alternative income sources, but these efforts have had limited success

Despite these challenges, some agro-pastoral households in Harshin Woreda have adopted climate-smart agricultural practices. The most commonly implemented practices include conservation agriculture, such as crop rotation and minimal tillage, integrated soil fertility management, and water-efficient irrigation techniques. However, the overall adoption rate remains low, hindered by barriers such as limited access to appropriate technology, inadequate training and extension services, and insufficient financial resources.

Several challenges further complicate the adoption of climate-smart agriculture in the region. Technological limitations, including the lack of suitable tools and machinery, and infrastructural challenges, particularly poor irrigation systems, pose significant barriers. Additionally, institutional support is often inadequate, with many households lacking access to essential information, such as weather forecasts and market data. Cultural resistance to adopting new practices also remains a challenge, compounded by the absence of robust policy frameworks to support and incentivize CSA adoption.

The results suggest that while CSA practices have the potential to significantly enhance the resilience of agro-pastoral livelihoods in Harshin Woreda, overcoming the barriers to their adoption is crucial. The study emphasizes the importance of targeted interventions, such as improving access to CSA technologies, strengthening agricultural extension services, and developing supportive policy frameworks that are responsive to the specific needs of agro-pastoral communities. These measures are essential for building a more resilient agricultural system in the region.

The significance of this study lies in its contribution to understanding the challenges and opportunities associated with CSA in agro-pastoral communities. It provides valuable insights that can inform policymakers, development practitioners, and local governments about critical areas where intervention is needed. Moreover, the findings have broader implications for other similar regions facing climate-related challenges, offering a foundation for future research and policy development aimed at enhancing the resilience of agro-pastoral livelihoods.

5.2. Conclusions

This study aimed to explore the challenges and practices of climate-smart agriculture (CSA) among agro-pastoral households in a region particularly vulnerable to the effects of climate change. The research highlighted significant climatic trends, such as increasing temperatures and decreasing rainfall, which have exacerbated the vulnerabilities of agro-pastoral livelihoods. These changes have led to declining crop yields, reduced availability of grazing lands, and increased food insecurity, making it increasingly difficult for households to sustain their livelihoods.

The study found that while some agro-pastoral households have adopted CSA practices—such as conservation agriculture, integrated soil fertility management, and water-efficient irrigation—the overall adoption rate remains low. This is primarily due to barriers such as limited access to appropriate technologies, inadequate extension services, insufficient financial resources, and cultural resistance to new agricultural practices. Addressing these barriers is critical for building a more resilient agricultural system in vulnerable regions.

The study has important implications for local governments, development professionals, and policymakers. Addressing obstacles to CSA adoption in Harshin Woreda requires more agricultural extension services, better access to CSA technology, and regulatory frameworks. These actions promote sustainable agricultural growth in climate-sensitive regions and can provide insight into successful interventions in other areas dealing with similar climate-related issues. The study's findings can help create more resilient agricultural systems.

While the study provides valuable insights into the challenges and practices of CSA, it is important to acknowledge that the research was geographically specific, which may limit the generalizability of the findings to other regions with different environmental, cultural, or socio-economic contexts. Additionally, the reliance on self-reported data introduces the possibility of biases, such as recall bias or social desirability bias. Future research should consider expanding the geographic scope and utilizing more diverse data sources to gain a broader understanding of CSA adoption and its challenges.

Building on the findings of this study, future research could explore the long-term impacts of CSA practices on agro-pastoral livelihoods in various regions, considering differing environmental and socio-economic conditions. Additionally, further studies could investigate the effectiveness of specific interventions aimed at overcoming the identified barriers to CSA adoption, providing evidence-based recommendations for policymakers and development practitioners. Exploring the role of community involvement and local knowledge in the successful implementation of CSA practices could also offer valuable insights into how these strategies can be scaled up and adapted to different contexts.

5.3. Recommendations

Based on the findings and analysis presented in this research study on exploring the practices and challenges of climate-smart agriculture in agro-pastoral livelihoods in Harshin woreda, Somali Regional State, Ethiopia, the following recommendations are proposed:

- ✓ Adaptation of Agricultural Practices: Encourage farmers to adapt their crops and livestock to enhance resilience to climate change impacts such as changing temperatures and rainfall patterns. Promoting crop varieties that are more adaptable to drought can help mitigate the risks associated with unpredictable weather conditions.

- ✓ Climate-Resilient Infrastructure: Invest in climate-resilient infrastructure such as improved storage facilities, weather-resistant shelters for livestock, and sustainable energy sources to withstand the impacts of climate change. Building resilient infrastructure can help agro-pastoral communities adapt to changing environmental conditions and minimize losses.

- ✓ Early Warning Systems: Establish and strengthen early warning systems for extreme weather events to help farmers prepare and respond effectively to climate-related disasters. Timely information on impending risks can enable farmers to take preventive measures to protect their crops, livestock, and livelihoods.

- ✓ Capacity Building on CSA Practices: It is recommended to invest in training programs focused on climate-smart agriculture (CSA) practices tailored to the specific needs of agro-pastoral communities in Harshin woreda. Providing hands-on training sessions and demonstrations can enhance the adoption of sustainable agricultural techniques.

- ✓ Different type of climate smart agriculture practices are implemented by farmers, so these effective practices which are suited to the agro-ecology characteristics of area should be applied comprehensively. For effective implementation of practices, necessary capacity building, technical support and financial support must be provided from every stakeholder.

- ✓ There is less formal institutional or organizational interventions to improve the agro pastoral livelihood means in the kebele. So it should be taken into account to develop and enhance adequate formal sectoral interventions to improve the quality of the agro pastoral livelihood.

- ✓ Having frequent contact with extension service provider positively affect the adoption level of farmers, and implies to increase the awareness of farmers‟ strong extension service is important. Building capacity of extension service provider (development agent) regarding CSA practices can help to easily disseminate the required knowledge to reach mass farmers‟
- ✓ Establishing cooperative farmers at nearest place to provide easily agricultural input for the sake of saving production time as well to get inputs timely, although distance between homestead and market where buy input negatively affect household adoption level of practices.

By implementing these targeted recommendations, stakeholders can work towards addressing the specific challenges and opportunities related to climate-smart agriculture in agro-pastoral livelihoods in Harshin woreda, Somali Regional State, Ethiopia. These recommendations aim to support the sustainable transformation of agricultural practices and contribute to the resilience of communities facing the impacts of climate change.

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Appendix I: Questionnaire

Exploring the practices and challenges of climate-smart agriculture in agro pastoral livelihoods: A Case Study of Harshin woreda in Somali Regional State, Ethiopia

The objective of this questionnaire is to collect data for individuals or households involved in agro-pastoral livelihoods. This MA research conducted for the purpose of education and all information provided was used solely for education purposes and was remain confidential. Your full support and willingness to respond to the questions is very essential for the success of the study. Therefore, you are kindly requested to answer all questions and provide clear and reliable information on the issues. Please feel free to convey the required information honestly.

Thank you in advance for your cooperation.

Sincerely,

Kalid Mohamoud Tahir

Postgraduate Program Directorate at Haramaya University

Department: Climate Change and Disaster Risk Management

Telephone no: +251913473337

Email: Qaloonbi.55@gmail.com

Date of Interview: ______________

Section A. Household Demographic factor related questions

1. Sex of Household head: ________________
2. Age (Years):_ ____________
3. Level of Education: A. Literate B = Illiterate
4. Marital status: A= Married; B=Single; C=Divorced; D=Widowed; E=other (specify)
5. Family size:

Number of family members		
Age	Male	Female
<15		
15 – 64		
>64		

Section B: Socio – Economic Factor Related Questions

6. Do you own land?

A=yes B=No

7. If yes, how many hectares of land do you have? ___________________________

8. Which farming activities are you following currently?

A= only crop production B= livestock rearing

C= mixed farming (crop production and livestock rearing)

9. How much income did you generate from your farming activities to secure your agro pastoral livelihood during last production? Year (i.e. 2014/2015)? Specify in birr

From Crop Production

Type of crops	Quantity produced	Quantity consumed for households livelihood	Quantity sold	Income earned from farming activity

From Livestock production

Type of livestock	Size (quantity possessed by the household	No of livestock sold	Income earned	Livelihood source sustainability	
				Yes	No

Section C: Climate Patterns and Trends Related Questions

10. How long have you lived in Harshin Woreda?

A. Less Than 1 Year

B. 1-5 Years

C. 5-10 Years

D. More Than 10 Years

11. Have you observed any changes in the climate patterns in Woreda over the past decade?

A. Yes B. No

12. If you answered "Yes" to the previous question, please mention the observed changes in Climate patterns.

A. _____________ B. _____________ C. _____________

13. How would you rate the overall temperature trends in Harshin Woreda over the past decade?

A. Increasing B. Decreasing C. No Significant Change

14. How would you rate the overall rainfall trends in Harshin Woreda over the past decade?

A. Increasing B. Decreasing C. No Significant Change

15. Have you experienced any extreme weather events in Harshin Woreda in the past few years (e.g., droughts, floods, and heatwaves)?

A. Yes B. No

A. _______________ _______________

B._______________ _______________

C._______________ _______________

Then the existing climate patterns and trends are analysed using the date obtained from the Ethiopian Methodology and Mann-Kendall monotonic trends analysing.

Section D: Questions climate change impacts on agro pastoral livelihoods:

17. How climate change influenced agro-pastoral livelihoods

A. Low Agriculture Productivity B. Livestock Losses C. The socio-economic implications

18. Which of the following reasons do you think climate change impacts your cereal and livestock production to remain low in your Kebele in the year 2015 E.C?

A. lack of early warnings of potential hazards

B. lack the application of climate smart agriculture activities to sufficiently produce

C, due to climate variability such as drought

D. other reasons (could you specify)

19. Which one of the following reasons do you think climate change impacts cereal and livestock production to remain high or more in your Kebele in the year 2015 E.C?

A. Proper utilization of climate smart agriculture B. Having access to weather information

C. Access to agricultural extension services

20. Do you think CSA has positive contribution on your livelihood? A. Yes B. No

21. If your answer to question 18 is “Yes,” in what way does it helps you?

A. Improving Cropping productivity B. Improving Livestock Productivity

C. Both cropping and livestock productivity

22. What are the main factors affecting agro pastoral livelihood in your kebele?

A. Shortage of water/ rainfall B. Lack of proper utilization of CSA practices

C. Shortage of food/ poor cereal production D. Lack of access to weather information

23. Which one of the following natural hazards most often disrupts the normal flow of production capabilities, more often in your area?

A. drought B. Flood C. Crop insects D. others (please specify)

24. Comparing to traditional agricultural practices, do you think climate smart agriculture practices are more productive? A. Yes B. No

25. Do you think that crop production sustains your household agro pastoral livelihood more than livestock production? A. Yes B. No

26. In times of difficulties such as drought, floods and other climatic problems, do you have any sources of off-farm income to sustain agro pastoral household livelihood? A. Yes B. No

Section E: Question Related with Access of Institutions

27. Do you have contact with agricultural extensions services? A=Yes B= No

28. If your answer to question 25 is "yes," how many times on average does an extension worker visit you in a production season?

A. One time per seasonal production B. More than one time per seasonal production

29. Are you a member of any formal/informal institutions in your village? A. Yes B. No

30. How long does it take to reach market centre where you **buy** your agricultural inputs?

Distance in KM; _____________ Time in minutes: _______________

31. How long does it take to reach market centre where you **sell** your agricultural production?

Distance in KM; _____________ Time in minutes: _______________

32. Do you have regular access to whether information? A=Yes B= No

33. Do you have regular access to market information? A=Yes B= No

Section F: Question on factors affecting climate and smart **production practices**

34 .Which of the following factors affects climate smart agriculture practices in your kebele?

A. Climate smart agriculture technology. (E.g. tractor)

B. Skilled human labour

C. Other factors (please specify) __________________

35. Do you think that Poor irrigation highly affects climate smart production practices? In your area?

A) Yes B) No

36. Do you also think that irregular rainfall patterns affect climate smart production practices in your kebele

A) Yes B) No

37. Are inadequate agricultural extension programs and assistance a barrier to agricultural development in your kebele?

A) Yes B) No

38. Is there a lack of practical understanding of climate-smart approaches among farmers in your kebele?

A) Yes B) No

39. Are coordinated supportive and enabling policy frameworks insufficient for agricultural progress in your kebele?

A) Yes B) No

40. Is there a lack of adequate financing mechanisms and effective risk-sharing schemes in agriculture within your kebele?

41. Have you employed any of the following climate smart production practices in the (2014/15) E.C production season?

A) Yes B) No

CSA Practice	**Components**	**Yes /No**
Conservation agriculture	Reducing tillage	
	Crop residue management – mulching, intercropping	
	Crop rotation/intercropping with cereals and legumes	
Integrated soil fertility Management	Compost and manure management, including green manuring	
	Efficient fertilizer application techniques (time, method and amount)	
Small – scale irrigation	Year round cropping	
	Efficient water utilization	

Agro forestry	☐ Tree based conservation agriculture (planting and managing trees)	
	☐ Practiced both traditionally and as improved practice	
	☐ Farmer – managed natural regeneration	
Crop diversification	☐ Popularization of new crops	
	☐ Popularization of crop varieties	
	☐ Pest resistance	
	☐ high yielding	
	☐ tolerant to drought	
	☐ short season	

Appendix II: Focus Group Discussion (FGD) Guidelines for Community leaders

Dear FGD participants,

The purpose of this FGD is to collect data for M.B thesis entitled "**Exploring the Practices and Challenges of Climate-Smart Agriculture in Agro-Pastoral Livelihoods: A Case Study of Harshin Woreda in Somali Regional State, Ethiopia".** Your opinions are vital for the success of the study. Therefore, you are kindly requested to provide the best information for the questions below. Your views and opinions were used solely for the research purposes.

Thank you in advance for your cooperation

ll) Please respond to the Following questions concisely and precisely:

1. What are the major problems you face in implementing the Climate smart agricultural practices?
2. What is your primary source of agro pastoral livelihood during the dry season?
3. What do you think about your production capital?
4. What is your perception towards the CSA practices in your agricultural output?
5. What are your future plans for your livelihood?
6. Are the Formal or informal sectors are easily accessible to support your agro pastoral Livelihood?

Appendix III: Interview guides for Kebele administrators, agriculture bureau, NGO

Dear interviewees,

The purpose of this interview is to gather data for M.B thesis entitled **Exploring the Practices and Challenges of Climate-Smart Agriculture in Agro-Pastoral Livelihoods: A Case Study of Harshin Woreda in Somali Regional State, Ethiopia".** Your opinions and suggestions are crucial for the success of the study. Therefore, please provide your views in response to the following questions. Please note that your views and suggestions was only be used for research purposes, and the information you provide was kept confidential.

Thank you in advance for your cooperation

III). Give your response to the following questions in short and precise.

1. What are your responsibilities in the agriculture bureau?

2. What roles has your organization or office played in rural livelihoods?

3. Do you provide any training or seminars or other agricultural assistance to improve the skill of farmers?

4, Did you monitored or evaluated the practices of climate smart agriculture (CSA)?

5. What is your role on the national, legal and policy environment in Ethiopia?

6. What improvements would you like to see in agro pastoral livelihood based agriculture

Appendix IV

Precipitation of harshin district (1993-2022)

Parameter	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation	**1993**	6	10.5	6.5	96.7	93	45.6	64.1	102.6	104.8	0	24.8	42.6
Precipitation	**1994**	0	0	10.7	40.6	51.8	50.2	111	29.4	63.7	9.9	39.4	0
Precipitation	**1995**	50	25.9	79.4	80.7	63.8	20.8	46.1	82	88.1	9	3.5	6.5
Precipitation	**1996**	0	7.5	46.2	68.4	125.5	50.5	34.1	113	0	6.8	0	0
Precipitation	**1997**	0	0	41.6	124.6	69.2	54.7	73.7	99.8	88.8	106.2	80.4	0
Precipitation	**1998**	119.3	0	18.4	36.2	82.3	40.9	9.1	29.5	65	50.9	0	0
Precipitation	**1999**	0	7.3	33.8	95.3	102.4	43.3	72.1	127.8	67.1	54.4	29.2	11.55
Precipitation	**2000**	0	0	0	67.3	82.4	49.6	54	88.2	75.5	22.3	44.3	11.5
Precipitation	**2001**	0	30.2	40.8	53.5	91	45.8	80.2	44.4	42.5	125	0	0
Precipitation	**2002**	31.7	0	1.2	113.1	91	28.4	96.7	100.5	85.4	43.5	0	26.6
Precipitation	**2003**	18.1	9.5	11.9	109.2	59.1	54.3	66.8	62	108.4	0	0	29
Precipitation	**2004**	33.8	0	27.1	174	21.6	43.4	62.6	77.7	53.4	40.8	31.1	0
Precipitation	**2005**	10	6.2	69	192.7	69.3	21.4	65.3	75.5	108.1	26.8	48.4	0
Precipitation	**2006**	11.5	28.8	98.2	105.8	63.8	59.7	35.1	150	71	130.8	16.8	68.3
Precipitation	**2007**	0	34.2	0.9	122.5	133.4	29.2	72.4	82.5	72.3	17.7	5	0
Precipitation	**2008**	0	0	0.6	63.5	88.2	23.4	49.8	74.9	53.1	19.5	58.9	0
Precipitation	**2009**	29.9	0	85.3	70.5	90.7	28.8	71.4	63.9	41	79.8	4.9	0
Precipitation	**2010**	0	101	76.3	134.2	112.7	21.3	50.2	53.4	79.5	0	4.9	0
Precipitation	**2011**	0	0	0	21.9	46.4	39.8	78.1	66.2	127.7	0	0	0
Precipitation	**2012**	0	0	2	116.6	50.9	90.5	36.9	68.5	40.3	0	1.2	0
Precipitation	**2013**	0	0	0	92.6	101.6	3.8	80.2	85.7	81.2	57.6	27.9	0
Precipitation	**2014**	0	1.5	58.7	43	49.2	9.3	162.5	82.4	72.5	63.6	11.9	0
Precipitation	**2015**	0	0	11	55.8	145.4	21.3	39	90.9	57.6	18.4	18	0
Precipitation	**2016**	0.3	8.1	12.1	161.2	42.4	42.6	85.1	28.9	59.8	19.9	33.2	0.8
Precipitation	**2017**	0	1.1	25.2	70.7	80.2	36.6	66	76.8	78.8	46.3	17.2	7.7

Precipitation	**2018**	0	8.4	39.5	97.4	80.2	46.9	14.1	47.4	61	48	15.1	0
Precipitation	**2019**	12.4	4.1	16.3	53.4	66.4	0	48.9	112.4	167.6	44.5	22	11.2
Precipitation	**2020**	0	0	58.7	163	102.6	32.7	42.5	140.6	45.6	43.8	0	0
Precipitation	**2021**	11.5	10.4	34.4	87	123.1	36.3	63.1	81.2	118.7	49.3	20.3	8.4
Precipitation	**2022**	0	37.4	11.7	72.5	31.3	0	37	79	83.5	50.6	19.2	6.4

Appendix V

Monthly Minimum Average Temperature for Harshin (1993-2022)

parameter	**Year**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Tmin	**1993**	15.3	7.2	7.4	14.1	14.4	16.8	15.7	15.7	16.0	14.3	14.4	15.3
Tmin	**1994**	14.8	8.4	8.2	8.7	9.1	10.1	10.4	11.2	12.7	12.7	14.4	14.4
Tmin	**1995**	16.0	18.6	17.8	14.2	13.3	12.9	11.2	11.7	11.5	11.3	10.8	10.5
Tmin	**1996**	11.2	11.9	13.4	12.3	13.5	15.5	15.4	15.2	14.1	13.5	13.4	13.1
Tmin	**1997**	12.1	13.2	13.3	13.4	13.4	14.9	14.9	15.9	15.0	13.5	14.9	14.4
Tmin	**1998**	11.4	10.5	11.7	9.8	9.5	8.0	16.7	16.9	15.7	12.0	6.5	5.4
Tmin	**1999**	6.5	6.4	7.0	9.0	13.5	13.5	15.7	15.5	14.9	11.9	10.7	9.7
Tmin	**2000**	4.9	6.2	8.3	12.1	16.2	15.8	15.6	15.8	16.1	10.5	8.3	6.3
Tmin	**2001**	6.6	7.1	11.9	12.1	12.3	14.7	15.0	15.6	15.0	11.9	7.2	7.5
Tmin	**2002**	9.9	7.5	12.7	14.6	16.6	16.6	16.5	16.3	14.1	8.4	8.6	10.7
Tmin	**2003**	8.6	8.4	10.5	12.4	14.0	14.8	15.2	13.9	14.3	9.5	8.6	8.4
Tmin	**2004**	8.7	6.5	9.8	15.5	13.4	15.8	16.0	16.5	15.0	11.3	9.4	8.7
Tmin	**2005**	8.2	7.6	14.0	13.6	16.0	16.3	16.2	16.2	16.0	9.9	6.6	4.9
Tmin	**2006**	7.2	9.5	11.6	12.5	14.8	16.9	16.6	16.5	15.5	13.6	8.6	10.5
Tmin	**2007**	9.1	9.9	11.1	14.4	15.6	16.9	17.0	17.0	15.7	9.0	8.0	6.0
Tmin	**2008**	6.4	7.3	7.4	13.3	16.6	16.8	16.3	16.1	16.2	11.9	9.3	6.0
Tmin	**2009**	8.9	8.7	11.9	14.1	14.2	17.2	16.8	17.1	15.8	12.5	6.4	9.2
Tmin	**2010**	6.3	12.4	14.9	15.8	15.5	16.8	15.0	15.9	14.4	8.6	7.6	4.5
Tmin	**2011**	5.7	6.7	7.7	9.8	11.8	10.7	9.0	10.7	9.0	9.7	8.6	7.3

Tmin	**2012**	8.6	7.4	9.2	14.4	14.0	15.9	16.3	16.9	16.0	9.7	7.8	9.1
Tmin	**2013**	10.0	8.1	9.7	15.0	11.1	15.4	14.1	15.2	14.4	10.2	8.4	4.4
Tmin	**2014**	4.4	9.2	10.6	12.1	13.4	15.0	16.7	16.5	15.8	10.8	9.1	11.3
Tmin	**2015**	14.2	10.7	7.7	8.8	12.1	13.5	13.7	14.1	13.4	8.9	5.4	4.1
Tmin	**2016**	9.8	8.2	13.6	19.2	18.9	19.3	16.8	16.8	16.6	10.7	9.3	8.2
Tmin	**2017**	5.0	12.3	16.0	16.3	16.0	15.6	15.6	12.1	12.1	12.0	10.7	9.0
Tmin	**2018**	8.5	10.3	10.2	14.1	14.9	16.5	16.5	14.5	14.7	12.2	10.3	8.3
Tmin	**2019**	9.1	10.2	11.8	14.6	15.6	14.9	16.6	16.2	15.8	14.1	10.3	8.5
Tmin	**2020**	9.6	9.6	12.7	14.2	14.2	15.9	15.0	14.6	10.7	9.0	7.2	7.1
Tmin	**2021**	12.4	14.6	12.7	14.9	14.8	15.6	10.7	9.0	7.2	7.4	10.7	9.0
Tmin	**2022**	10.2	9.6	16.3	15.9	14.7	14.6	15.7	10.7	9.0	14.4	8.6	7.6

Appendix VI

Monthly Maximum Average Temperature for Harshin (1993-2022)

Parameter	**Year**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Tmax	**1993**	26.7	27.9	30.4	28.2	28.2	27.2	27.3	27.5	29.5	29.8	28.1	28.4
Tmax	**1994**	26.8	26.6	26.4	26.7	29.8	28.3	27.3	25.6	26.3	26.4	26.6	27.3
Tmax	**1995**	29.4	29.4	28.5	27.6	28.4	29.2	29.4	29.2	29.5	29.5	29.4	29.3
Tmax	**1996**	30.0	30.9	30.6	30.3	29.3	28.0	26.0	27.9	28.4	28.7	28.8	28.3
Tmax	**1997**	29.1	28.7	30.4	29.4	31.1	29.1	29.0	28.9	29.5	29.1	30.2	29.4
Tmax	**1998**	29.6	29.7	30.2	30.1	29.4	29.3	26.7	27.0	27.5	27.2	27.2	26.9
Tmax	**1999**	26.4	26.3	26.3	25.9	26.4	26.3	25.6	26.2	27.5	26.2	25.4	26.2
Tmax	**2000**	27.9	29.0	29.9	30.0	27.9	27.4	26.9	26.1	27.3	28.2	27.2	27.3
Tmax	**2001**	25.9	29.3	29.2	30.2	28.9	28.4	26.7	26.5	28.1	28.3	27.6	28.0
Tmax	**2002**	26.1	29.2	30.1	28.7	29.1	28.5	27.7	27.3	27.4	28.4	28.4	27.6
Tmax	**2003**	27.2	29.9	30.8	29.4	30.1	27.1	26.5	26.8	26.9	28.9	28.3	26.6
Tmax	**2004**	27.7	28.5	29.5	27.9	29.6	28.4	27.5	27.6	27.7	27.4	27.5	26.8
Tmax	**2005**	27.5	30.4	29.6	28.9	27.3	26.7	25.9	26.9	27.3	27.9	27.1	26.7

Tmax	**2006**	27.4	29.0	29.2	27.5	28.6	28.6	27.6	26.5	26.6	27.7	26.9	25.6
Tmax	**2007**	26.7	29.3	30.5	29.1	28.6	27.3	27.4	27.5	27.4	28.6	27.4	27.0
Tmax	**2008**	28.5	27.9	30.6	30.5	29.3	28.0	27.2	27.5	28.7	28.4	26.7	27.1
Tmax	**2009**	27.1	29.1	30.1	28.9	30.0	29.7	28.3	29.0	29.5	28.0	28.6	28.2
Tmax	**2010**	28.0	28.0	28.1	28.4	28.6	28.1	25.1	26.5	27.5	29.7	27.7	27.1
Tmax	**2011**	28.0	29.4	30.6	31.2	29.2	28.4	27.8	27.2	27.3	28.5	28.1	26.4
Tmax	**2012**	27.5	28.6	30.4	29.4	30.0	28.5	26.5	28.1	28.0	29.0	28.8	28.2
Tmax	**2013**	27.5	29.8	28.8	28.6	28.4	28.2	26.4	26.2	27.7	27.1	27.0	26.0
Tmax	**2014**	28.0	28.9	29.2	29.3	29.7	29.8	28.7	27.0	26.6	27.0	27.6	26.4
Tmax	**2015**	26.6	29.8	30.3	30.2	28.6	28.8	29.1	28.4	28.7	29.5	28.7	27.3
Tmax	**2016**	27.8	28.2	31.8	29.1	28.9	28.3	28.1	28.4	29.0	29.6	28.4	26.8
Tmax	**2017**	27.9	29.4	31.0	30.1	29.4	30.1	30.2	29.9	29.9	30.1	30.0	29.9
Tmax	**2018**	26.6	29.7	29.7	28.4	29.7	26.7	26.7	26.9	28.7	29.1	27.9	28.0
Tmax	**2019**	25.2	30.5	31.3	31.2	30.4	27.8	28.4	27.1	27.1	Na	27.0	26.2
Tmax	**2020**	27.7	30.2	Na	29.5	29.1	28.3	26.5	26.8	24.2	26.4	25.6	26.4
Tmax	**2021**	25.3	27.4	28.4	30.1	27.0	28.6	28.5	28.6	28.7	28.7	28.7	28.7
Tmax	**2022**	27.4	30.3	30.5	28.0	32.1	25.6	26.8	27.2	28.7	28.7	27.5	28.7

APPROVAL SHEET

HARAMAYA UNIVERISTY POSTGRADUATE DIRECTORATE PROGRAM

Exploring the practices and challenges of climate-smart agriculture in agro-pastoral livelihoods: A Case Study of Harshin woreda in Somali Regional State, Ethiopia.

Submitted by:

______________________	______________	______________
Name of the Student	Signature	Date

Approved by:

1. ______________________	______________	______________
Major Advisor	Signature	Date
2. ______________________	______________	______________
Co-Advisor	Signature	Date
3. ______________________	______________	______________
Research Thematic Area Leader	Signature	Date
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Chairman, DGC/SGC	Signature	Date
5. ______________________	______________	______________
Dean, PGDP	Signature	Date