



**COLLEGE OF AGRICULTURE AND
NATURAL RESOURCES
DEPARTMENT OF NATURAL RESOURCE
MANAGEMENT**

**FARMERS' PERCEPTIONS ON SOIL EROSION AND ADOPTION
OF PHYSICAL SOIL AND WATER CONSERVATION PRACTICE
IN THE CASE OF ARBEGONA WOREDA ETHIOPIA**

**BY
ESHETU LOGITA**

ID ; 002/22

JUNE, 2026

DILLA, ETHIOPIA

**FARMERS' PERCEPTION OF SOIL EROSION AND THE
ADOPTION OF PHYSICAL SOIL AND WATER CONSERVATION
PRACTICE IN THE THE CASE OF ARBEGONA WOREDA**

MSC THESIS

BYESHETU LOGITA

ID;002/22

ADVISOR: HABTAMU TEMESGEN (PhD)

**A THESIS SUBMITTED TO COLLEGE OF AGRICULTURE AND
NATURAL RESOURCES, DEPARTMENT OF NATURAL
RESOURCES MANAGEMENT IN PARTIAL FULFILMENT OF THE
REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE
IN NATURAL RESOURCE MANAGEMENT SPECIALIZATION ON
WATERSHED AND ECO-HYDROLOGY**

JUNE , 2026

DILLA, ETHIOPIA

DILLA UNIVERSITY
SCHOOL OF GRADUATE STUDIES

EXAMINERS' APPROVAL SHEET

This is to certify that the M.Sc. Thesis entitled 'Farmers Perception on Soil Erosion and the Adoption of Physical Soil and water Conservation practice in the Case of Arbegona Woreda' submitted in partial fulfilment of the requirements for the Degree of Master of Sciences in Natural Resource Management Specialization with Watershed and Eco-Hydrology, the Graduate Program of the Department of Natural Resource Management, and has been carried out by Eshetu Logita, under my supervision. Therefore, I recommend that the candidate has fulfilled the requirements and hence can submit the thesis to the department.

Name of Advisor

Signature

Date

Name of Co Advisor

Signature

Date

Internal Examiner

Signature

Date

External Examiner

Signature

Date

Name of Chair Person

Signature

Date

Name of School Head

Signature

Date

DECLARATION

I hereby declare that this MSc Thesis entitled ‘Farmers Perception of Soil Erosion and the Adoption of Physical Soil and water Conservation practices in the Case of Arbegona Woreda’ is in my original work, and all sources of materials used for this thesis have been duly acknowledged. This thesis work has not been submitted earlier for the award of any degree.

<u>Eshetu Logita</u>	_____	_____
Name of Designate	Signature	Date

ACKNOWLEDGEMENTS

First and foremost, I would like to thank the *Almighty God* for His providence and faithful guidance, without whom nothing would have come to this end. He protected me, and for this, I will always honor my God and all praise and glory to him for granting me the ability and strength to accomplish this research paper all the way through.

And also, I would like to extend my deepest gratitude and greatest respect to my thesis Advisor, Habtamu Temesgen (PhD), for his tremendous academic support, valuable suggestions, and constructive guidance in writing this thesis with wisdom and patience; without his genuine advice, this research would not have been possible. I really appreciate his invaluable guidance and advice from the conception of my thesis to its realization in a statement.

I am also very grateful to my girlfriend, Mrs .Elfinesh Woshashe,for her countless pieces of advice, continuous prayers, and moral encouragement.

My great sincere thanks and my deepest appreciation goes to all participants and respondents of the study, and to all my relatives and friends, especially Tumicha Tunsisa, Bura Buchacha for his unreserved encouragement during the whole period of the research work.

Last but not least, it is a great pleasure to extend my appreciation to the respondents who participated in providing the necessary data for this study.

TABLE OF CONTENTS

Contents	Page
ADVISOR'S APPROVAL SHEET	i
DECLARATION	ii
ACKNOWLEDGEMENTS	iii
TABLE OF CONTENTS	iv
LIST OF TABLES	vii
LIST OF FIGURES.....	viii
ABBREVIATIONS AND ACRONYMS.....	ix
ABSTRACT	x
1.1 Background of the Study	1
1.2 Statement of the Problem	3
1.3 Objectives of the Study	5
1.3.1 General Objective of the Study.....	5
1.3.2 Specific Objectives of the Study.....	5
1.4. Research Questions	5
1.5 Significance of the Study.....	5
1.6 Delimitation of the Study	6
1.7 Limitations of the Study	6
1.8 Definitions of Key Terms	6
REVIEW OF RELATED LITERATURES	8
2.1 Soil Erosion in the Global Context	8
2.2 Soil Erosion in Ethiopia.....	9
2.2.1 Extents of Soil Erosion/meten	10
2.2.2 Causes of Soil Erosion.....	10
2.2.3 Consequences of Soil Erosion	12
2.2.4 Farmers' Perception on Soil Erosion.....	13
2.3 Farmers' Perception towards Soil Conservation Measures	14
2.4 Adoption of the Soil Conservation Measures in Ethiopia	14
2.5 Effectiveness and sustainability of adopted physical SCMs.....	15
2.6. Soil Conservation Activities in Sidama Region	16

2.7. Theoretical Perspectives on Soil Erosion and Conservation.....	17
2.7.1 The Planned Behavior Theory (PBT)	18
2.7.2 The Diffusion of Innovations Theory	18
2.7.3 Environmental Kuznets Curve (EKC) Theory	19
2.7.4 Socio cultural Theory.....	20
2.8 Conceptual Framework of the Study	21
3. MATERIAL AND METHODS.....	23
3.1 Description of the Study Area	23
3.2 Research Design.....	24
3.3 Sources of the Data.....	25
3.3.1 Primary Sources of the Data	25
3.3.2 Secondary Sources of the Data	25
3.4 Population ,Sample Size ,Determination and Sampling Techniques	25
3.5 Methods for Data Collection.....	27
3.5.1 Survey Questionnaire.....	27
3.5.2 Key Informant Interviews (KIIs).....	27
3.5.3 Focus Group Discussions (FGD).....	28
3.5.4 Field Observations	28
3.6 Methods of Data Analysis	28
3.7 Ethical Considerations.....	29
4. RESULTS AND DISCUSSIONS.....	30
4.1 Introduction to the Data Presentation.....	30
4.2 Demographic and Socio economic Characteristics of Household the Respondents	30
4.3 Farmers Perception about the Causes and Consequences of Soil Erosion	34
4.3.1 Farmers' Awareness and Recognition of Soil Erosion	34
4.3.2 Farmers' Perceptions of Causes of Soil Erosion on Their Farmlands	36
4.3.3 Farmers' Perceptions of Consequences of Soil Erosion	37
4.3.4 Variation in Perceptions Across Farmer Categories	39
4.4 Factors Influencing the Adoption of Physical Soil Conservation Measures	40

4.4.1 Types and Extent of Physical Soil and Water Conservation Practices Adopted	41
4.4.2 Factors Influencing Adoption: Bivariate Analysis	42
4.4.3 Factors Influencing Adoption: Binary Logistic Regression Analysis	45
4.4.4 Farmers' Reasons for Non-Adoption	47
4.5 Effectiveness and Sustainability of Physical Soil Conservation Measures	48
4.5.1 Farmers' Perceptions of Conservation Effectiveness	48
4.5.2 Factors Limiting Soil and Water Conservation Effectiveness	50
4.5.3 Current Condition of Soil and Water Conservation Structures	51
4.5.4 Factors Affecting Sustainability of Conservation Measures	52
4.5.5 Farmers' Recommendations for Improving Conservation Effectiveness	53
5.1 Conclusions	55
5.2 Recommendations	56
References	57
APPENDICES	66

LIST OF TABLES

Tables	Page
Table 3.1: Distribution of sample size across agro-ecological zones of selected kebeles...	27
Table 4.1: Demographic and Socio-Economic Characteristics of Respondents (n=148) ...	31
Table 4.2: Farmers' Awareness and Recognition of Soil Erosion (n=148).....	34
Table 4.3: Farmers' Perceptions of Causes of Soil Erosion (n=148).....	36
Table 4.4: Farmers' Perceptions of Consequences of Soil Erosion (n=148)	37
Table 4.5: Relationship Between Farmer Characteristics and Perception of Soil Erosion Severity	39
Table 4.6: Adoption of Physical Soil Conservation Measures (n=148)	41
Table 4.7: Level of Adoption of Soil Conservation Measures (n=148)	42
Table 4.8: Bivariate Analysis of Factors Associated with Adoption.....	43
Table 4.9: Binary Logistic Regression Results for Factors Influencing Adoption of Soil Conservation Measures.....	45
Table 4.10: Farmers' Reasons for Non-Adoption of Soil Conservation Measures (n=36)..	47
Table 4.11: Farmers' Perceptions of Effectiveness of Conservation Measures (n=112)	49
Table 4.12: Perceived Benefits of Conservation Measures (Multiple Responses, n=112) .	49
Table 4.13: Reasons for Limited Effectiveness of Conservation Measures (n=52)	50
Table 4.14: Condition of Conservation Structures Observed in Field (n=112 farms).....	51
Table 4.15: Maintenance Practices for Conservation Structures (n=112)	52
Table 4.16: Reasons for Lack of Maintenance (n=32).....	52
Table 4.17: Farmers' Recommendations for Improving Conservation Effectiveness (Multiple Responses, n=148).....	53

LIST OF FIGURES

Figures	Page
Figure 1. Conceptual Framework Constructed by Researcher (2025).....	22
Figure 2.Location Map of the study area.	24
Figure 3.Observation to ongoing work done to observe damaged farmland (Source: Field Survey, 2025).....	35
Figure 4.Discussions on the effect of erosion and soil fertility with FGDs (Source: Field Survey, 2025).....	38

ABBREVIATIONS AND ACRONYMS

AWPDO:	Arbegona Woreda Planning & Development Office
CSZ:	Central Sidama Zone
EKC:	Environmental Kuznets Curve
FGDs:	Focus Group Discussions
KIIs:	Key Informant Interviews
NGOs:	Non- Governmental Organizations
OR:	Odds Ratio
PBT:	Planned Behavior Theory
SLM:	Sustainable Land Management
SLMP:	Sustainable Land Management Program
SPSS:	Statistical Package for Social Science
TLU:	Tropical Livestock Units

ABSTRACT

Land degradation through soil erosion poses a critical threat to agricultural productivity and food security in the highland area of the country.. soil erosion has reached alarming levels, severely impacting smallholder farmers who depend on the land for their subsistence. The Arbegona woreda, known for its hilly terrain and unpredictable rainfall, faces considerable soil degradation issues, exacerbated by the traditional farming practices that often neglect soil conservation techniques This problem leads to the depletion of fertile soil, reduced agricultural yields, and increased vulnerability to climate change Physical measures such as terraces, bunds, and check dams, have been widely promoted as solutions to reduce soil erosion and improve soil fertility. However, the uptake of these practices among farmers remains inconsistent, largely due to their perceptions of the effectiveness and feasibility of these methods Additionally, many farmers in the this Woreda are deterred from adopting physical conservation measures due to the perceived high costs, labor intensiveness, and the lack of immediate, visible benefits.

This study assessed farmers' perceptions of soil erosion and the adoption of physical soil conservation measures in Arbegona Woreda, . A mixed-methods approach was employed, combining a survey of 148 randomly selected farmers with key informant interviews, focus group discussions, and field observations. A survey results revealed that majority (86.5%) of farmers perceived soil erosion as a severe or moderate problem, accurately identifying heavy rainfall (91.9%), steep slopes (83.8%), and deforestation (75.7%) as primary causes of soil erosion. Likewise, adoption of physical soil conservation measures was moderate, with soil bunds (43.2%) and stone bunds (39.2%) most common, while about 10.8% of farmers were high adopters. A survey finding reveals that, overall, 24.3% of farmers were non-adopters, 39.2% were low adopters, 25.7% were medium adopters, and only 10.8% were high adopters of physical soil conservation measures. Binary logistic regression model identified that access to extension services, training, landholding size, and perception of erosion severity as the strongest predictors of adoption. However, only 53.6% of adopters rated measures as effective, and field observations revealed only 21.4% of structures in good condition. Maintenance was inadequate, with 28.6% of farmers performing no maintenance due to labor shortages (75%) and dependency mindsets (43.8%). The study concludes that while farmers possess strong awareness of soil erosion, adoption is constrained by institutional, economic, and labor factors, and sustainability is compromised by poor maintenance and lack of ownership. Therefore, the study recommends that strengthening extension services, providing practical training, promoting participatory approaches, and shifting policy focus from adoption targets to ensuring long-term functionality and maintenance of soil conservation structures.

Keywords: Adoption, Farmers' perception, Soil conservation, Soil erosion, Physical conservation measures, Sustainability,

CHAPTER ONE

1.1 Background of the Study

Soil erosion remains one of the most severe forms of land degradation worldwide, significantly threatening agricultural productivity, food security, and environmental sustainability. Globally, an estimated 24 billion tons of fertile soil are lost annually due to erosion, with serious consequences for rural livelihoods, especially in regions heavily dependent on subsistence agriculture (Molla 2025). The impact is particularly pronounced in developing countries where agriculture is the backbone of the economy, and resources to mitigate land degradation are limited (EEA, 2023).

In Sub-Saharan Africa, soil erosion is accelerated by inappropriate land use practices, deforestation, steep slopes, and erratic rainfall patterns intensified by climate change (Wolka , 2018). This ongoing degradation reduces the soil's capacity to retain nutrients and water, undermining the productivity of smallholder farms and exacerbating poverty and food insecurity. To counter this, many countries have promoted soil and water conservation (SWC) measures, including both biological and physical methods such as terraces, soil bunds, and check dams (Molla 2025). However, the success of these measures largely depends on the perceptions, willingness, and sustained participation of farmers.

In Ethiopia, soil erosion is a long-standing environmental issue, especially in the highland areas where steep terrain and intensive land cultivation dominate (Dilnesa & Kelemu 2023). The government, in collaboration with NGOs, has invested significantly in the promotion of soil conservation technologies since the 1980s through programs like the Sustainable Land Management (SLM) initiative (Dinav, 2017). Despite these efforts, adoption rates vary across regions, and many interventions fail to produce lasting impact due to socio-economic, institutional, and perception-based barriers (Muluken , Eric . & Eliso , 2020). Several researches show those farmers' perceptions of the causes, severity, and consequences of soil erosion influence their decisions to implement or reject conservation practices (Samuel, 2018)

In the Southern Ethiopian context, farmers have identified several primary causes of soil erosion, including overgrazing, deforestation, and improper land tillage methods, all of which contribute to the degradation of soil quality and loss of arable land (Dilnesa & Kelemu 2023). The region's agricultural sector, heavily dependent on traditional farming systems, faces the dual challenge of declining soil fertility and increasing vulnerability to climate change, (Abera & Firehiwot 2024). These challenges undermine food security and threaten the livelihoods of farmers. In this context, physical soil conservation measures, such as terraces, stone bunds, check dams, and contour plough, have been introduced as solutions to mitigate soil erosion and enhance agricultural sustainability (Samuel, 2018). Despite these efforts, the adoption rates of such conservation measures remain low. According to (Feyisa & Chala, 2024), the farmers' perceptions on soil erosion and conservation are influenced by a variety of factors, including their education level, exposure to extension services, and past experiences with soil conservation projects. The same studies indicate that farmers' awareness of the consequences of soil erosion varies widely, with some viewing it as a natural phenomenon beyond human control, while others recognize it as a preventable problem (Bayata, 2024).

The Sidama Region, located in the southern part of the country, is characterized by its mountainous terrain, erratic rainfall patterns, intensive agricultural practices and dense population, all of which contribute to severe soil erosion (SOER, 2024). While physical soil conservation measures such as soil bunds and stone terraces have been introduced in the area, adoption remains inconsistent and poorly documented at the kebele level. Moreover, the importance of soil conservation in maintaining soil fertility, enhancing water retention, and ensuring long-term agricultural viability cannot be overstated, especially in areas where agriculture the backbone of the region's economy (EEA, 2023).

Arbegona District, in the Sidama Region, which is characterized by its highland topography and varying rainfall patterns, has witnessed significant soil loss, which has reduced the productivity of agricultural lands and exacerbated rural poverty. As soil fertility declines, many farmers are forced to increase their input use, often relying on external chemical fertilizers, which are not sustainable solutions in the long term. Farmers in study area are faced with multiple barriers, including limited financial resources, lack of technical knowledge, and labor constraints, all of which hinder the adoption of recommended conservation measures (Molla et al 2025). Despite the challenges, there is a

growing recognition of the importance of understanding local perceptions and context-specific factors that influence the adoption of soil conservation practices. Previous research has shown that farmers are more likely to adopt conservation measures when they perceive them as beneficial to their livelihoods and when they are actively involved in the design and implementation of such practices (Marcus 2017). Hence, understanding how farmers perceive soil erosion and the factors influencing their adoption of physical conservation measures is crucial for tailoring effective, sustainable interventions. Therefore, this study aims to assess farmers' perceptions of soil erosion and their adoption of physical soil conservation measures in selected kebeles of Arbegona District, Sidama Region. By identifying the socio-economic, institutional, and environmental drivers affecting adoption, the findings will inform local policy makers, extension agents, and development practitioners to design better-aligned and farmer-centric land management strategies.

1.2 Statement of the Problem

In Ethiopia, particularly in the Sidama Region, soil erosion has reached alarming levels, severely impacting smallholder farmers who depend on the land for their subsistence. The Region, known for its hilly terrain and unpredictable rainfall, faces considerable soil degradation issues, exacerbated by the traditional farming practices that often neglect soil conservation techniques (SOER, 2024). Soil erosion, driven by both natural and anthropogenic factors, leads to the depletion of fertile soil, reduced agricultural yields, and increased vulnerability to climate change. Despite the critical importance of addressing soil erosion for agricultural sustainability, the adoption of soil conservation practices in the region has remained relatively low, with many farmers continuing to face significant challenges in mitigating the effects of soil erosion. This problem is particularly evident in the Arbegona District of Sidama, where the combination of steep slopes, intensive agricultural activities, and limited access to resources has made soil erosion a persistent threat to both the environment and local communities (Chala & Elsabet, 2022).

Physical measures such as terraces, bunds, check dams, and agro forestry have been widely promoted as solutions to reduce soil erosion and improve soil fertility. However, the uptake of these practices among farmers remains inconsistent, largely due to their perceptions of the effectiveness and feasibility of these methods. While some farmers recognize the 70% of soil erosion and its negative impacts on their livelihoods, others view

it as a natural and unavoidable process that does not require intervention (Abera & Firehiwot 2024). Additionally, many farmers in the region are deterred from adopting physical conservation measures due to the perceived high costs, labor intensiveness, and the lack of immediate, visible benefits. The installation and maintenance of soil conservation structures are time-consuming and require substantial financial investment, which is often beyond the reach of smallholder farmers (Molla , 2025). Furthermore, inadequate access to technical support, extension services, and suitable inputs further complicates the adoption process, as farmers may lack the necessary knowledge and skills to implement these measures effectively (Marcus , 2017). Consequently, the gap between the availability of soil conservation technologies and their actual adoption suggests that farmers' perceptions, attitudes, and the socio-economic context play a crucial role in shaping conservation outcomes.

Understanding farmers' perceptions of soil erosion and their willingness to adopt soil conservation practices is essential for the design and implementation of effective interventions that are contextually appropriate and widely accepted. Previous studies have highlighted the importance of incorporating farmers' views and local knowledge into the design of conservation programs, as this can significantly influence their adoption decisions (Feyisa & Chala , 2024). In the case of Arbegona District, however, there has been limited research that specifically investigates how farmers perceive soil erosion and the physical conservation measures promoted by external agencies. Existing studies often generalize findings from broader regional or national studies, without fully accounting for the unique environmental, socio-economic, and cultural factors that shape farmers' attitudes toward soil erosion and conservation practices (Derege , 2014).

Therefore, there is a pressing need for a comprehensive understanding of the factors that influence farmers' perceptions and interventions that can effectively address soil erosion and promote the widespread adoption of physical soil conservation measures in Arbegona. This research aims to bridge this gap by exploring farmers' perceptions of soil erosion in the Arbegona District, identifying the factors that affect their adoption of soil conservation practices, and assessing the effectiveness of current interventions.

1.3 Objectives of the Study

1.3.1 General Objective of the Study

The main objective of this study is to assess the farmers' perceptions of soil erosion and the adoption of physical soil and water conservation practices in the Arbegona Woreda, Ethiopia.

1.3.2 Specific Objectives of the Study

- 1) To assess farmers' perception about the causes and consequences of soil erosion in the study area.
- 2) To identify the major factors influencing farmers' level of adoption of physical soil and water conservation practices in the study area.
- 3) To evaluate the effectiveness and sustainability of adopted physical soil and conservation Practices in controlling soil erosion in the study area.

1.4. Research Questions

The study addresses the following major research questions:

- 1) How do farmers in Arbegona Woreda perceive soil erosion, and what are their views on its causes and consequences?
- 2) What are the major factors influencing farmers' decisions to adopt physical soil and water conservation practices in the study area?
- 3) Which physical soil and water conservation practices have been adopted by farmers, and how effective and sustainable are these practices in controlling soil erosion?

1.5 Significance of the Study

The findings of this study are expected to benefit different stakeholders and policymakers. For policymakers and development practitioners, the research provides evidence-based insights into the socio-economic, institutional, and perceptual factors that influence farmers' adoption of soil conservation measures in Arbegona Woreda. This information can guide the design of more targeted and effective interventions.

For researchers and academicians, the study contributes empirical data on farmer perceptions and adoption behavior in the highland areas of the region, filling a local-level knowledge gap. For farmers and local communities, the study outcomes can lead to

improved agricultural extension services and support systems, ultimately enhancing their capacity to sustainably manage their land and soil, improve agricultural productivity, and secure their livelihoods against the threats of land degradation.

1.6 Delimitation of the Study

This study was delimited geographically to three purposively selected *Kebeles* (Hure, Kalalcho, and Mayu) within Arbegona Woreda, Sidama National Regional State. Thematically, it focused exclusively on physical soil conservation measures, assessing farmers' perceptions of soil erosion, factors influencing the adoption of these measures, and their effectiveness and sustainability. The study did not extensively cover biological conservation practices nor conduct biophysical measurements of soil loss. The component of analysis was the smallholder farming household, and data collection was cross-sectional. Besides, this study was conducted between October 2025 and May 2026. This period was chosen according to the academic schedule.

1.7 Limitations of the Study

Several limitations were encountered during this study. First, reliance on self-reported data may introduce recall or social desirability bias. Second, the cross-sectional design precludes establishing causal relationships. Third, the remote terrain of the study area posed logistical challenges, limiting field observations. Finally, while the sample size of 148 households is statistically adequate, it may not capture the full diversity of farming conditions across the entire *Woreda*. Some of them who have enough time were also unwilling to fill in and return the questionnaire within the required time. To overcome those limitations, the researcher attempted to create a smooth relationship with the respondents. Nevertheless, the limitations would not have a significant impact on the results of the study.

1.8 Definitions of Key Terms

Definitions of key terms are given more by the meanings they hold in this study, and some of them are operational zed.

Adoption: The implementation of at least one physical soil conservation measure by a farmer, measured by the number and type of measures adopted.

Farmers' Perception: Farmers' understanding, interpretation, and evaluation of soil

erosion and conservation practices are shaped by observation, experience, and socio-cultural context.

Physical Soil and Water Conservation Measures: Structural interventions such as soil bunds, stone bunds, *Fanya juu* terraces, and check dams are constructed to control runoff and soil loss.

Soil Erosion: The detachment and transport of topsoil by water, which is the dominant form of land degradation in the study area.

Sustainability: The continued functionality and proper maintenance of a conservation structure, ensuring it delivers long-term benefits beyond its initial construction.

2. REVIEW OF RELATED LITERATURES

2.1 Soil Erosion in the Global Context

Soil erosion is a critical environmental challenge that threatens agricultural productivity and food security worldwide (OSS, 2024). Farmers' perceptions of soil erosion play a fundamental role in their willingness to adopt physical soil conservation measures. Research suggests that farmers often recognize soil erosion through visible signs such as reduced crop yields, gully formation, and topsoil loss (FAO, 2015). However, their responses to these challenges vary depending on socio-economic conditions, land tenure security, access to extension services, and perceived effectiveness of conservation practices (Mamush , 2021). In many developing regions, smallholder farmers face barriers such as labor shortages, financial constraints, and inadequate technical knowledge, which hinder their adoption of physical conservation measures like terraces, stone bunds, and contour plowing (Getahun , & Abiyot 2021).

Studies from Sub-Saharan Africa and South Asia reveal that while some farmers actively implement soil conservation practices, others remain hesitant due to short-term economic priorities and uncertain long-term benefits (Katherine , 2015). The role of institutional support, such as government incentives, training, and community-based conservation initiatives, is crucial in enhancing farmers' participation in soil conservation programs (Kedir, 2024). Additionally, research highlights that integrating traditional knowledge with modern conservation techniques can improve adoption rates, as seen in Ethiopia and Brazil, where indigenous soil conservation practices have been effectively combined with scientific approaches (Thais Palumbo Silva, 2023).

Despite global efforts to promote sustainable land management, the success of physical soil conservation measures ultimately depends on farmers' perceptions and their socio-economic realities. Therefore, policymakers and development agencies must prioritize participatory approaches that align conservation strategies with farmers' needs, ensuring that soil conservation efforts are both effective and widely adopted (Dilnesa & Kelemu , 2023) . Future research should focus on long-term impact assessments of conservation interventions and explore how climate change influences farmers' perceptions and adaptation strategies toward soil erosion control.

2.2 Soil Erosion in Ethiopia

Soil erosion is a significant environmental and agricultural challenge in Ethiopia, particularly in the highland regions, where steep slopes, high rainfall variability, and unsustainable land-use practices accelerate land degradation (Adugna, 2024). Farmers' perceptions of soil erosion play a crucial role in shaping their willingness to adopt physical soil conservation measures such as terracing, stone bunds, and soil bunds. Studies indicate that farmers who perceive soil erosion as a severe threat to their productivity are more likely to adopt conservation strategies (Feyisa 2024). However, adoption rates remain low due to socio-economic, institutional, and technical barriers, including limited access to extension services, land tenure insecurity, and labor shortages (MoA, 2018).

The decision-making process for adopting soil conservation measures is influenced by multiple factors, including land tenure security, farm size, access to credit, and perceived effectiveness of the techniques (Molla , 2025). Farmers with secure land tenure are more likely to invest in long-term conservation measures, as they anticipate future benefits from improved soil fertility and reduced erosion. Moreover, participation in extension programs significantly enhances farmers' knowledge and technical capacity, leading to increased adoption rates (Dilnesa & Kelemu , 2023). Nonetheless, the effectiveness of physical soil conservation measures depends on proper implementation, maintenance, and integration with biological conservation practices, such as agro-forestry and cover cropping (Abyiot , 2024).

Despite government efforts to promote soil conservation, the sustainability of these practices is often challenged by the top-down approach of policy implementation. Farmers' willingness to adopt and maintain conservation structures is higher when they actively participate in the decision-making process (Assefa et al., 2024). Therefore, strengthening community-based approaches, enhancing access to financial and technical support, and integrating indigenous knowledge with modern conservation practices are essential for improving soil conservation outcomes in Ethiopia. Addressing these challenges will require coordinated efforts among farmers, policymakers, researchers, and development organizations to ensure sustainable land management and food security in the country.

2.2.1 Extents of Soil Erosion

Soil erosion is a severe environmental challenge in Ethiopia, significantly threatening agricultural productivity, food security, and sustainable land management. Ethiopia's highland areas, which constitute approximately 43% of the country's landmass and support over 80% of its population, experience the highest rates of soil erosion due to a combination of steep topography, intensive agriculture, and deforestation (Woldemichael ,& Pål 2023). Studies indicate that annual soil loss rates in Ethiopia range from 16 to 300 tons per hectare per year, with the Ethiopian highlands experiencing an average loss of 42 tons per hectare per year (Bayata, 2024). Such rates of erosion contribute to land degradation, declining soil fertility, and sedimentation in reservoirs and waterways, which further exacerbate hydrological and agricultural challenges (Abera & Firehiwot 2024).

The primary drivers of soil erosion in Ethiopia include deforestation, unsustainable farming practices, overgrazing, and climate variability (Bichaye 2022). Population pressure has led to the conversion of forested lands and grasslands into cultivated fields, reducing vegetative cover and exposing topsoil to erosive forces. Additionally, erratic rainfall patterns, particularly intense short-duration storms, accelerate the detachment and transport of soil particles, increasing sediment loads in river systems (Derege , 2014). Without effective soil conservation strategies, erosion continues to degrade land productivity and undermine rural livelihoods. In response, the Ethiopian government and development partners have implemented soil and water conservation measures, such as terracing, reforestation, and watershed management programs, which have shown promising results in reducing soil loss and restoring degraded landscapes (Aschalew 2024). However, widespread adoption and sustained implementation remain critical to addressing soil erosion and ensuring long-term agricultural sustainability in Ethiopia.

2.2.2 Causes of Soil Erosion

Soil erosion is a significant environmental challenge in Ethiopia, primarily driven by a combination of natural and anthropogenic factors. One of the leading causes is deforestation, which has intensified due to population pressure and the increasing demand for agricultural land, fuel-wood, and construction materials (Amanuel Tadesse & Worku Hailu, 2024). Studies indicate that the removal of vegetation cover reduces soil stability,

making it more vulnerable to erosion by wind and water (Woldemichael ,& Pål 2023;). In the Ethiopian highlands, deforestation has been particularly severe, leading to the loss of fertile topsoil and declining agricultural productivity (Abera & Firehiwot 2024).

Another critical factor is intensive and unsustainable agricultural practices. Traditional farming methods, such as plowing along the slope rather than contour plowing, expose soil to runoff and accelerate erosion. Overgrazing by livestock further depletes vegetative cover, leading to soil compaction and reduced water infiltration, which in turn increases surface runoff and soil displacement (Adugna, 2024). In many areas, repeated cultivation without proper soil conservation measures has led to the depletion of organic matter, making the soil more prone to erosion (Abera & Firehiwot , 2024).

Climate variability and extreme weather events also contribute significantly to soil erosion. Ethiopia experiences highly variable rainfall patterns, with intense and erratic precipitation leading to flash floods that wash away topsoil (SOER, 2024). The effects of climate change have further exacerbated the situation, increasing the frequency and intensity of heavy rains, particularly in the highlands (Bayata, 2024). The interplay between climate-induced soil erosion and poor land management practices has accelerated land degradation across different agro-ecological zones.

Moreover, topographical factors play a crucial role in soil erosion in Ethiopia. The country's rugged terrain, characterized by steep slopes and high altitudes, naturally predisposes land to erosion, especially in regions where protective vegetation has been removed (MoA, 2018). The Ethiopian highlands, which constitute a significant portion of the country's agricultural land, suffer from high rates of soil loss due to the combined effects of steep slopes and unsustainable land-use practices (Amanuel & Worku 2024).

Lastly, policy and institutional challenges have contributed to the worsening soil erosion problem. Although various soil conservation programs have been implemented, the lacks of sustained community participation and inadequate institutional support have limited their effectiveness (Aschalew &. Tebeje, 2024). The short-term focus on agricultural expansion without integrating sustainable land management practices has led to widespread land degradation, threatening long-term food security and rural livelihoods (Bekele, , & Kissi, 2017)

2.2.3 Consequences of Soil Erosion

Soil erosion is a critical environmental challenge in Ethiopia, significantly affecting agricultural productivity, food security, and ecosystem stability (Amanuel & Worku 2024). The country's rugged topography, erratic rainfall, and unsustainable land-use practices have exacerbated soil erosion, leading to severe consequences for both rural livelihoods and national economic growth (Woldemichael ,& Pål 2023). The loss of fertile topsoil due to erosion reduces land productivity, making it difficult for farmers to sustain crop yields, thereby increasing the risk of food insecurity (SOER, 2024). In Ethiopia, where over 80% of the population relies on agriculture, soil degradation has direct implications for household incomes and overall economic stability (MoA, 2018).

Erosion also leads to significant downstream effects, such as sedimentation in water bodies and reservoirs, reducing hydroelectric power generation and water availability for irrigation (Mekonnen, 2021). Studies indicate that Ethiopia loses over 1.5 billion tons of soil annually, resulting in nutrient depletion and declining soil organic matter, which further exacerbate land degradation and desertification (Feyessa, 2023). Moreover, soil erosion contributes to increased carbon emissions, as degraded soils release stored carbon into the atmosphere, thereby accelerating climate change impacts ((Rattan 2015). The socio-economic consequences of soil erosion include displacement of rural communities, increased vulnerability to droughts, and the escalation of poverty levels in already fragile areas (Anand, 2003).

Addressing soil erosion requires integrated soil and water conservation strategies, including agroforestry, terracing, and conservation agriculture, which have shown promising results in mitigating land degradation in Ethiopia (Wolka , 2018). Government and community-led initiatives, such as the Sustainable Land Management Program (SLMP), have played a key role in rehabilitating degraded lands and improving soil fertility (Misgina ,& Biadgilgn , 2024). However, to ensure long-term sustainability, these efforts need to be reinforced with policy interventions, farmer capacity-building, and investment in climate-resilient agricultural practices (Tesfaye, 2023).

2.2.4 Farmers' Perception on Soil Erosion

Soil erosion is a significant challenge in Ethiopia, particularly in the highland areas where steep slopes and intensive agricultural activities exacerbate land degradation (Abera & Firehiwot , 2024). Farmers' perceptions of soil erosion are crucial in shaping their responses and willingness to adopt soil conservation measures. Studies indicate that Ethiopian farmers generally recognize soil erosion as a major problem, identifying factors such as rainfall intensity, deforestation, and poor land management practices as key drivers (SOER, 2024). However, perceptions vary based on socio-economic status, land ownership, and access to extension services (Feyisa , 2024).

Research has shown that while many farmers acknowledge the negative impacts of soil erosion, including declining soil fertility and reduced crop yields, their responses to the problem are influenced by traditional knowledge, economic constraints, and institutional support (Aschalew & Tebeje, 2024). For instance, in the Ethiopian highlands, farmers with land tenure security are more likely to invest in soil conservation practices such as terracing and agro-forestry compared to those with insecure tenure (Bekele,& Kissi, 2017). Additionally, a study by Getahun & Abiyot (2021) highlights that farmers who receive training and government incentives are more proactive in implementing conservation measures. However, challenges such as labor shortages, financial limitations, and competing short-term economic needs often hinder the widespread adoption of sustainable practices (SOER, 2024).

Understanding farmers' perceptions of soil erosion is essential for designing effective soil conservation policies in Ethiopia. Policymakers and development agencies must integrate farmers' local knowledge with scientific approaches to create context-specific interventions. Strengthening extension services, ensuring land tenure security, and promoting community-based conservation strategies can enhance farmers' resilience against soil erosion and improve agricultural sustainability in Ethiopia (Kefyalew & Eyayu , 2024).

2.3 Farmers' Perception towards Soil and Water Conservation Practices

Soil conservation plays a crucial role in maintaining soil fertility and ensuring sustainable agricultural productivity, particularly in the highlands of Sidama, where soil erosion is a major challenge. Farmers' perceptions of soil conservation measures significantly influence their adoption and implementation of sustainable land management practices. Studies have shown that farmers' awareness and attitudes towards soil degradation, as well as their knowledge of conservation techniques, determine their willingness to invest in soil conservation measures (Feyisa 2024). In the Sidama highlands, farmers generally acknowledge the negative impacts of soil erosion on agricultural productivity, leading many to adopt traditional and modern conservation techniques such as terracing, mulching, agro-forestry, and the use of organic manure (Getachew et al., 2024). However, socio-economic constraints, land tenure insecurity, and limited access to extension services hinder the widespread adoption of these practices (Woldemichael & Pål 2023).

Several studies emphasize that farmers' perceptions of soil conservation are shaped by their farming experience, education level, and access to extension services. Research by Molla et.al, (2025) suggests that farmers with greater access to agricultural extension programs and training are more likely to adopt soil conservation strategies. Furthermore, indigenous knowledge systems, which have been passed down through generations, play a significant role in shaping farmers' attitudes toward soil conservation (Megento, 2017). Despite the recognition of conservation benefits, some farmers remain reluctant to implement long-term measures due to labor intensity and short-term economic pressures (Mamush, 2021). Thus, strengthening institutional support, providing incentives, and integrating traditional and scientific knowledge are essential for improving farmers' participation in sustainable soil conservation in the Sidama highlands.

2.4 Adoption of the Soil and Water Conservation Practices in Ethiopia

The adoption of soil conservation measures in the Ethiopian highlands is crucial for mitigating land degradation and enhancing agricultural sustainability. Soil erosion, exacerbated by steep topography, intensive land use, and erratic rainfall, has been a persistent challenge in the region (Woldemichael, & Pål 2023). Farmers in the highlands have implemented various conservation techniques, including physical structures such as

soil bunds, stone terraces, and check dams, as well as biological methods like agro forestry and cover cropping (Kedir, 2024). Despite the availability of these techniques, adoption rates remain variable due to socio-economic, institutional, and biophysical constraints (Wolka 2018).

Key factors influencing adoption include land tenure security, access to extension services, labor availability, and farmers' perceptions of conservation benefits (Feyessa, 2023). Secure land tenure encourages long-term investment in conservation structures, while *well-functioning extension services provide farmers with technical knowledge and incentives* to adopt sustainable practices (.Gebremedhin,& Scott , 2024). Additionally, local community participation and indigenous knowledge systems play a vital role in the success of conservation efforts (Alemu & Aga, 2024). Research indicates that integrating indigenous soil conservation practices with modern scientific approaches enhances sustainability and increases adoption rates (Samuel, 2018).

Policy support and institutional interventions are also essential for scaling up soil conservation efforts in the Ethiopian highlands. Government programs, such as the Sustainable Land Management (SLM) initiative, have contributed to the promotion of conservation technologies; however, their success is contingent on adequate financial resources, farmer participation, and continuous monitoring (Tebeje, 2024). Future strategies should focus on strengthening farmer cooperatives, providing financial incentives, and incorporating climate-smart agricultural **practices** to enhance resilience against land degradation and climate variability (MoA, 2018) .

2.5 Effectiveness and sustainability of adopted physical soil and water CPs

Ethiopia is among the countries in Sub-Saharan Africa most affected by soil erosion and land degradation due to its mountainous topography, erratic rainfall, deforestation, and intensive land use (MoA, 2018). In response, physical soil and water conservation (SWC) structures such as soil bunds, stone bunds, terraces, and check dams have been widely implemented, particularly through government-led initiatives like the Sustainable Land Management Program (SLMP). Numerous studies affirm the erosion control potential of physical SWC practices. For instance, Andualem et.al, (2025) reported that soil and stone bunds reduced soil loss by up to **60%** and runoff by **40–70%**, especially on steep slopes.

Similarly, Molla et.al,(2025) found that treated plots in the Anjeni watershed showed a significant decrease in sediment yield compared to untreated plots. Soil bunds reduced runoff volume by 28–40%, while stone bunds were more effective in sediment retention on steeper terrains (.Gebremedhin,& Scott 2024).

Physical SWC structures also improve soil properties by minimizing nutrient loss and enhancing organic matter retention. In a study by Wolka et al. (2018), conserved plots in the Gumara- Maksegnit watershed recorded: higher soil organic carbon (SOC), increased total nitrogen (TN), and improved cation exchange capacity (CEC). However, physical barriers can reduce the cultivable area, particularly in smallholder farms, leading to mixed impacts on short-term crop yields (Derege , 2014).

Sustainability hinges on maintenance and community ownership. Structures such as bunds either soil or stone require periodic maintenance, which can be labor-intensive. According to Bichaye, (2022) lack of incentives, insecure land tenure, and low awareness often hinder long-term commitment to upkeep. Adoption rates are influenced by: farmers' education level, Perception of soil erosion, Access to extension services and Land tenure security(Woldemichael ,& Pål 2023). Marcus , (2017) highlighted that farmers are more likely to sustain conservation practices when they see tangible benefits and receive technical support. Participatory approaches that involve the community from planning to execution have shown greater long-term success.

While physical SWC measures are effective alone, their sustainability improves when combined with biological measures (e.g., grass strips, agro-forestry) and agronomic practices (e.g., crop rotation, mulching) (Tatek 2024). This integrated approach enhances soil cover, improves biodiversity, and supports microclimates favorable for crop growth (Aschalew K. Tebeje, 2024) (Haregeweyn et al., 2015). A recent study by Kefyalew & Eyayu , (2024) showed that stone-faced soil bunds with *Sesbania* improved soil nutrients significantly, particularly in marginal uplands.

2.6. Soil and Water Conservation Activities in Sidama Region

Soil conservation in the Sidama Highlands of Southern Ethiopia is a critical agricultural and environmental intervention, given the region's rugged terrain, high population density,

and vulnerability to soil erosion. The steep slopes and intensive farming practices, combined with seasonal heavy rainfall, exacerbate land degradation, leading to declining soil fertility and reduced agricultural productivity (Woldemichael ,& Pål , 2023). Traditional soil conservation practices, such as stone bunds, contour plowing, and agro-forestry, have been employed by local farmers to mitigate erosion and maintain soil health (Andualem , 2025). However, due to increasing land fragmentation and climate variability, these methods require integration with modern soil management strategies to enhance their effectiveness.

In response to the challenges of soil degradation, government and non-governmental organizations have promoted sustainable land management (SLM) techniques, including terracing, check dams, and biological conservation measures such as vetiver grass strips and multipurpose tree planting (Abyiot , 2024). Research indicates that the adoption of integrated soil fertility management, which combines organic matter application, crop rotation, and reduced tillage, significantly improves soil structure and moisture retention in the highlands (Molla , 2025). Moreover, indigenous knowledge systems, particularly the enset-based agro-ecosystem, play a crucial role in soil conservation by enhancing organic matter input and preventing erosion through its deep-rooted structure (Assefa et al 2024).

Despite these efforts, challenges such as limited access to extension services, financial constraints, and land tenure insecurity hinder the widespread adoption of soil conservation measures (Andualem , 2025). Studies emphasize the need for community-based participatory approaches that engage farmers in co-designing and implementing soil conservation strategies tailored to local conditions (Bekele, & Kissi, 2017). Policy support, coupled with research-driven interventions, is essential to ensure long-term sustainability in soil management. Strengthening institutional frameworks and promoting climate-smart agricultural practices can further enhance the resilience of farming systems in the Sidama Highlands, securing soil fertility and agricultural productivity for future generations (Assefa et al, & Stephanie 2024;).

2.7. Theoretical Perspectives on Soil Erosion and Conservation

In Sidama region like others Ethiopian regions, where agriculture is heavily reliant on soil quality and agricultural practices are deeply intertwined with local environmental conditions, farmers' perceptions are crucial in determining their willingness to adopt soil

conservation techniques. This section reviews the key theories that explain farmers' behaviors regarding soil erosion and the adoption of soil conservation measures, particularly focusing on the socio-economic and psychological factors that influence these decisions in Arbegona District, Sidama Region.

2.7.1 The Planned Behavior Theory (PBT)

According to Martin & Kyra (2025), this theory individual' intentions to perform a particular behavior (such as adopting soil conservation measures) are influenced by three key factors: attitude towards the behavior, subjective norms, and perceived behavioral control.

Attitude towards Behavior context of soil conservation, farmers' attitudes towards soil erosion and conservation practices are shaped by their experiences, knowledge, and perceived effectiveness of conservation measures. If farmers believe that physical soil conservation measures (such as terraces or bundling) will improve their soil fertility and agricultural output, they are more likely to adopt them (Sirinakorn , 2022).

Subjective Norms (Social pressures or expectations) within farming communities also influence the decision to adopt conservation practices. In areas where soil conservation is promoted by local leaders or farming groups, farmers are more likely to follow suit due to the social influence (Abdullah & Al-Swidi, 2014). In Sidama, the role of local agricultural extension services and peer influence could be significant in shaping the adoption of SCM.

Perceived Behavioral Control refers to the ease or difficulty of performing the behavior, which in this case relates to the perceived feasibility of adopting conservation practices (Rasouli, 2019). Farmers with sufficient access to resources, such as labor, knowledge, and financial support, are more likely to adopt SCM than those who perceive these practices as too difficult or costly (Mekonnen 2021).

2.7.2 The Diffusion of Innovations Theory

This theory was developed by Rogers (2003) provides insights into how new ideas, practices, or technologies are adopted over time within a social system (Sahin, 2006). This

theory can be applied to understand the spread of physical soil conservation practices among farmers in Arbegona District.

According to Rogers, innovations (in this case, soil conservation practices) are adopted based on their perceived relative advantage, compatibility with existing practices, complexity, trialability, and observability (Sahin, 2006). If farmers in Sidama view physical soil conservation measures as advantageous in terms of improved soil fertility, increased yields, or reduced erosion, they are more likely to adopt these practices. Similarly, if the techniques align with traditional farming methods and are easy to implement, adoption rates will be higher (Roger, 2003).

Social System: The social system within Arbegona, including community leaders, extension agents, and peer groups, plays a crucial role in determining how quickly these innovations spread (Sahin, 2006). Farmers are more likely to adopt SCM if they observe neighbors or influential figures successfully implementing these measures (Abdullah & Al-Swidi, 2014). In Sidama, local agricultural extension services and community-based organizations can serve as key agents in the diffusion process.

2.7.3 Environmental Kuznets Curve (EKC) Theory

The Environmental Kuznets Curve (EKC) theory suggests that there is an inverted U-shaped relationship between economic development and environmental degradation, meaning that as a country or region's economy grows, environmental degradation initially increases but eventually decreases after reaching a certain level of economic growth (Aquilas, 2020). This theory has been applied to many environmental issues, including soil erosion, to explain how economic development, agricultural intensification, and technological innovation might affect natural resources and land use practices over time.

The EKC posits that at early stages of development, farmers may prioritize economic growth over environmental sustainability, leading to soil degradation through overuse of land, deforestation, and improper farming techniques. However, as farmers' incomes increase, and with greater access to education, information, and conservation technologies, they may adopt soil conservation measures that enhance environmental sustainability.

In the context of soil erosion in Arbegona District, Sidama Region, and the EKC theory can help explain how the adoption of physical soil conservation measures might evolve over time. Initially, farmers may be less inclined to invest in soil conservation due to their limited economic resources, reliance on traditional farming methods, and lack of awareness of the long-term impacts of soil erosion. However, as income levels rise and farmers achieve greater financial stability, they may be more willing to adopt costly but effective soil conservation practices, such as terracing, bundling, and check dams (Molla , 2025). Moreover, the role of government and non-governmental organizations in promoting soil conservation can also be viewed through the lens of the EKC, as policies aimed at environmental protection tend to become more prominent once a region has reached a certain level of economic development (Wassie, 2020).

2.7.4 Socio cultural Theory

Developed by Lev (1978), emphasizes the role of social and cultural factors in shaping human behavior, including decision-making processes regarding environmental issues such as soil erosion (Chung, 2022). The theory posits that individuals' understanding of the world, including environmental phenomena, is shaped by their social interactions, cultural norms, and collective knowledge.

Farmers' perceptions of soil erosion and their adoption of physical soil conservation measures in the Sidama region, and specifically in Arbegona District, are shaped by a combination of traditional knowledge, community norms, and social networks. For instance, in many Ethiopian farming communities, the practices of soil conservation are passed down through generations, deeply embedded in the local cultural and social fabric; which have long been developed in response to the specific environmental conditions of the region (W, and Fikadu, 2023). However, social pressures and group dynamics can also play a role in influencing individual decisions. Farmers are more likely to adopt soil conservation measures if they observe the success of such practices within their community or if local leaders and peers endorse the importance of protecting the land (Geertje , 2023). In the Sidama region, social networks and community-based agricultural extension services can either facilitate or hinder the diffusion of soil conservation innovations, depending on the community's shared beliefs and experiences.

Furthermore, socio-cultural theory emphasizes the importance of community-based approaches to solving environmental problems. Local knowledge, combined with external interventions such as government policies and non-governmental organizations (NGOs), can shape the effectiveness of soil conservation programs. For example, when farmers in Sidama perceive soil erosion as a collective problem that affects their community's well-being, they may be more inclined to engage in communal conservation practices, such as gully rehabilitation and joint maintenance of terracing systems (Derege 2014). Thus, the EKC theory provides an important framework for understanding how economic development in Sidama could influence both the perceptions of soil erosion and the willingness to adopt physical soil conservation measures.

2.8 Conceptual Framework of the Study

This Section outlines the theoretical and Conceptual frameworks that illustrates the intricate pathway from Farmer decision making to sustainable land management by integrating Scio-economic and cultural context factors specifically age ,income, education , social norms , and local knowledge with Farmers perceptions of soil erosion (knowledge ,attitudes ,beliefs ,and experiences) . Underpinned by theoretical perspectives such as the Diffusion of Innovations (Relative advantage ,Compatibility , Complexity, Trialability, Observability) and Planned Behavior theories (Attitudes ,Subjective norms ,Perceived behavioral control) ,The model Positions. External moderating variables like extension services ,Policy support ,incentives and Local government actions as critical catalysts that influences the Adoption of physical soil conservation measures including Terracing , Check dams ,Contour farming and Agro forestry.

Ultimately, this Comprehensive approach highlights how tailored ,knowledge-driven and supported adoption leads to long-term outcomes of improved soil health ,increased productivity and sustainable agricultural practices .

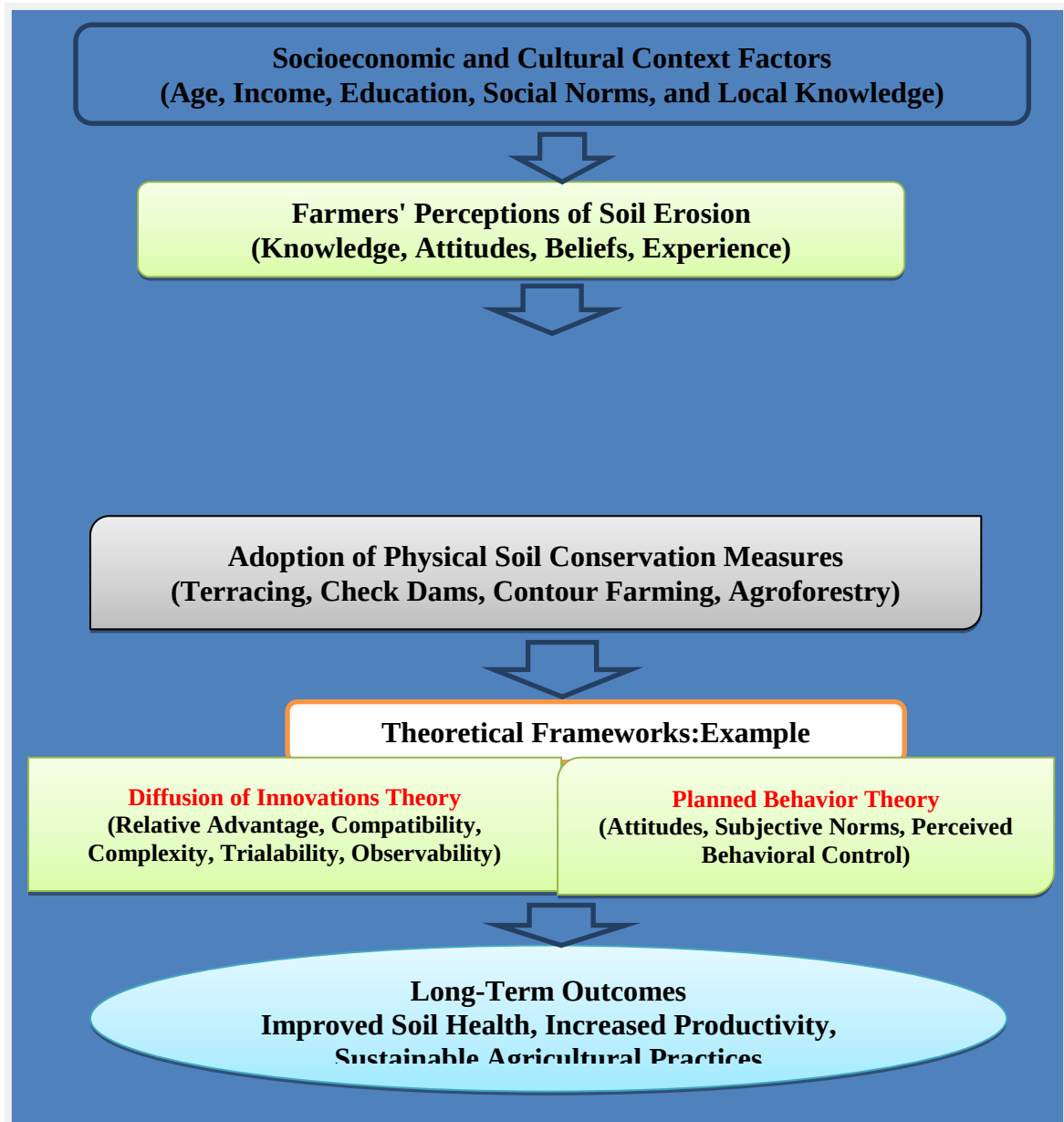


Figure 1. Conceptual Framework Constructed by Researcher (2025)

3. MATERIAL AND METHODS

3.1 Description of the Study Area

This study was conducted at Arbegona District, which is one of the districts of the Central Sidama Zone in the Sidama Region of Ethiopia. Sidama regional state consists of 36 districts with total area coverage of 10,000 km². Arbegona is bordered on the south by Bona Zuria, on the south west by Shafamo, on the north west by Gorche, on the north East by the Oromia Region, and on the east by Bensa. The Woreda is located 6° 49'.21" at the North and 38° 35'.24" at the East. Arbegona woreda is located 74 kilometers from Hawassa City, which is capital city of Sidama regional state. In the 2007 national census, Arbegona's population was 189,625 with about 95% living in rural areas, and a population density of 700.1 people per km² (AWPDO, 2025).

The farming system of the study area is characterized as mixed crop and livestock farming. The economic activities of distinct is mainly agriculture, animals and crop production (AWANRO 2024). The dominant crops in the study districts are maize, wheat, enset, barley, pea and bean (AWANRO 2024). The animals like cows, sheep, goats, horses, donkeys and chickens are reared by small holder farmers.

Climatic characteristics of District has a diverse agro ecology classified as highlands (dega), and midlands (woinadega) covering 60%, and 40% respectively (SRPD, 2024). The woreda receives an average RF ranging from 1800-2400mm and mean maximum and minimum Temperature of 21°C and 14°C respectively. At approximately 2600 m above sea level, Arbegona is wet and cool. The woreda / cropping season duration mid-July to mid-November. The altitude of the woreda ranges between 2000-3336 m.a.s.l (meters above sea level) with a rugged topography, and the altitude of the specific site is 2812 m.a.s.l. (AWANRO 2024)

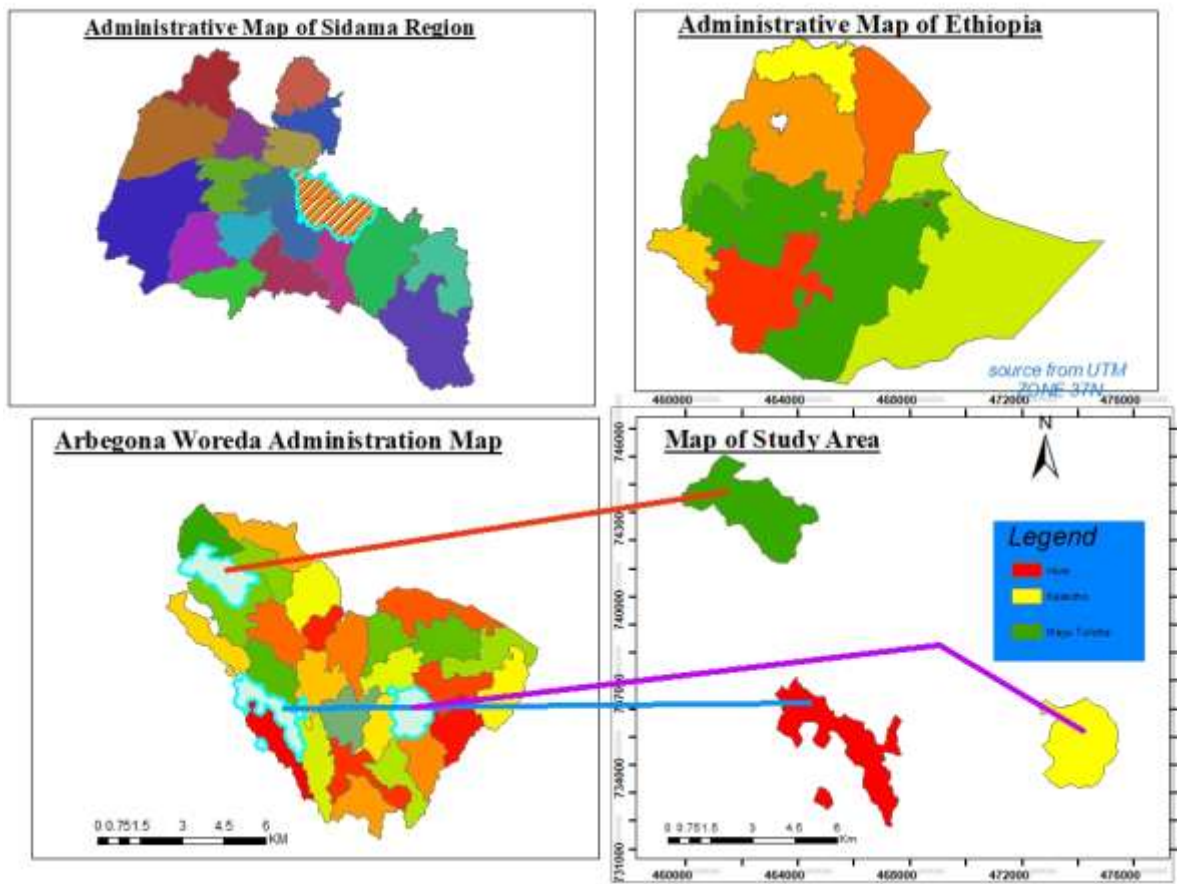


Figure 2. Location Map of the study area.

3.2 Research Design

The study were followed an exploratory descriptive research design, as it aims to explore and describe the perceptions of farmers in the Arbegona District regarding soil erosion and conservation measures (Sreejesh , 2014). The research was primarily be cross-sectional in nature, meaning it was involved the collection of data at one point in time from a sample of farmers in the district to enabling the assessment of factors influencing farmers' perceptions and conservation decisions. The research design was allowed for a broad understanding of the factors influencing the adoption of conservation practices, as well as any potential relationships between socio-economic variables, perceptions of erosion, and the adoption of physical conservation measures.

Given the diverse range of factors influencing farmers' perceptions of soil erosion and the adoption of physical soil conservation measures in Arbegona District, the mixed-methods approach is appropriate as it allows for triangulation, enhancing the reliability and validity

of the findings (John & Creswell, 2018). This methodology is particularly appropriate for capturing the complexity of the problem, including individual and communal perceptions, as well as socio-economic factors and institutional contexts.

3.3 Sources of the Data

Data for this study were captured from two sources: primary and secondary sources.

3.3.1 Primary Sources of the Data

The primary sources of data were farmers. Hence, field observation, focus group discussion, and interviews with selected farmers and key informants were primary data sources. Zonal and district Agricultural experts, kebele administrators, and soil and water conservation supervisors were considered as primary information.

3.3.2 Secondary Sources of the Data

In addition, secondary sources of information used for this study include different reports in the woreda .Secondary data were collected from relevant government documents, reports from local NGOs, and previous studies on soil erosion and conservation in the Central Sidama Zone (CSZ) and Sidama National Regional State Agricultural and Natural Resource Management Bureau. This provided a contextual background and assisted in comparing the findings with regional or national trends.

3.4 Population ,Sample Size ,Determination and Sampling Techniques

The study was conducted in the Arbegona Woreda of the Sidama Region, an area known for its agricultural activities and susceptibility to soil erosion due to its high rainfall, topography, and farming practices (Singh, 2014). The target population consists of farmers within the district, focusing on both smallholder farmers and larger-scale agricultural producers of selected kebeles. This provided a wide range of perspectives on soil erosion and the adoption of soil conservation practices.

Arbegona Woreda is characterized by highland agro ecology, experiencing significant soil erosion due to steep slopes, intensive cultivation, and high rainfall variability. The target population includes smallholder farmers engaged in subsistence agriculture, as they are the primary actors in soil conservation efforts. A stratified random sampling technique was

employed to ensure the representation of diverse farming households based on landholding size, slope gradient, and farming practices (Singh, 2014).

First, three representative kebeles , which are known small administrative units, were purposively selected based on erosion severity and conservation intervention presence. Second, households were randomly selected from each kebele using a systematic sampling approach. Additionally, purposive sampling was used for the selection of key informants (e.g., agricultural extension officers, local leaders, and government officials), as their insights will provide valuable context for understanding the institutional and policy factors influencing soil conservation practices.

The study was further refined by considering key variables such as land tenure status, age, education level, and farm size to ensure that different socio-economic groups are adequately represented. The study aims to survey a sample size that is statistically representative of the farming community in Arbegona Woreda. According to the size of the target population, a sample size of 156 farmers will be chosen to ensure sufficient data for analysis. The sample size was determined using (Yamane, 1967) formula, ensuring statistical representativeness. The formula for sample determination at 95% confidence level and 8% level of precision is described as follows:

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

Where **n** = sample size; **N** = total population, **1**= designates the probability of the occurrence of the event, and **e** = the level of precision (± 9) for this study.

Using the total households of 1,725 and an error margin of 0.09, the sample size is calculated as follows:

$$n = \frac{1,725}{1 + 1,725 (0.08)^2}$$

There fore, even though the common alpha value were 5%, this study, considering the availability of data utilization and data management, will be used 9%, when this formula is applied to the above, gives 156 as the sample size determination. The sample was classified into each kebele according to Kothari, (2004) was presented in table 3.1;

$P = (n \times P) / N$, For example, Hure Kebele, $156 \times 720 / 1,725 = 65$

Table 3.1: Distribution of sample size across agro-ecological zones of selected kebeles.

Zone	Woreda	Selected Kebeles	Agroecology	Total HHs	Sample size
Central	Arbegona	Hure	Dega	720	65
Sidama		Kalalcho	Dega	401	36
		Mayou	Dega	604	55
Total				1,725	156

3.5 Methods for Data Collection

3.5.1 Survey Questionnaire

The study employed both primary and secondary data collection methods to obtain comprehensive and well-rounded information. The primary method of data collection was administered through a semi-structured questionnaire to farmers in Arbegona Woreda. The survey was designed to capture both quantitative and qualitative data from 148 respondents . Key components of the survey include: Demographic information questions on age, gender, education level, land size, farming experience, and household income; Perception of soil erosion questions regarding of farmers’ understanding of the causes, impacts, and trends of soil erosion on their land and livelihoods; adoption of soil conservation practices questions to assess whether farmers have adopted any physical soil conservation measures, such as terracing, bundling, and water harvesting, and the extent of adoption; barriers to adoption questions to exploring the challenges faced by farmers in adopting soil conservation measures, including financial, technical, and knowledge-related barriers; and motivating factors questions about the factors that encourage or hinder farmers in adopting conservation measures, such as government programs, extension services, and peer influence.

3.5.2 Key Informant Interviews (KIIs)

In number 8 key informant interviews(KIIs)with office experts and development agents (DAs) insights into conservation policies and barriers to adoption (Megento, 2017). These semi-structured interviews provided insight into institutional support for soil conservation measures, historical and regional trends in soil erosion, and the effectiveness of government policies and interventions in addressing soil erosion.

3.5.3 Focus Group Discussions (FGD)

A total 3 Focus group discussions (in each kebele 1) and in number 25 respondents were organized with small groups of farmers to explore collective perceptions and shared experiences regarding soil erosion and conservation practices. The focus groups were allowed for a more nuanced understanding of communal knowledge, as well as an exploration of social dynamics that may influence the adoption of soil conservation measures.

3.5.4 Field Observations

Field observations were carried out to visually assess the extent of soil erosion in the district and the physical state of soil conservation measures such as terraces, bunds, and management structures. This also help validate the information collected through surveys and interviews.

3.6 Methods of Data Analysis

The study used a combination of descriptive statistics and qualitative thematic analysis to analyze the data in *Statistical Package for Social Science* (SPSS) version 27. Quantitative data from the structured surveys were analyzed using descriptive statistics to summarize farmers' demographic characteristics, perceptions of soil erosion, and the extent of adoption of conservation practices. This includes frequencies, percentages, and means. Cross-tabulation analysis was conducted to explore relationships between variables such as education level, farm size, and the adoption of soil conservation practices. Additionally, inferential statistical methods such as chi-square tests and logistic regression were used to assess the influence of socio-economic and perception variables on the likelihood of adopting soil conservation measures (Martin, 2024).

For the qualitative data, thematic analysis was used to identify recurring themes and patterns across the interview, focus group, and field observation data. The analysis was focused on farmers' perceptions of soil erosion, the barriers to adoption of conservation practices, and the role of local institutions in supporting or hindering conservation efforts. Thematic analysis allowed the researcher to explore farmers' experiences and perceptions in-depth, offering a deeper understanding of the factors influencing adoption behavior (Braun & Clarke, 2006). This qualitative analysis provided deeper insights into the social

and institutional dynamics that influence conservation practices, which might not be fully captured through quantitative surveys (Fanta, 2014).

To increase the validity and reliability of the findings, data triangulation was employed by cross-verifying results from the quantitative surveys, qualitative interviews, focus groups, and field observations. This provided a more comprehensive understanding of the complex dynamics surrounding soil erosion and conservation in the study area.

3.7 Ethical Considerations

Taking the severity of the ethical considerations in mind, this study was done with the highest importance placed on ethics, confidentiality, and anonymity. In this study, confidentiality and anonymity of the respondents were emphasized to protect their privacy and dignity (Cohen *et al.*, 2007). Thus, on the cover page of the survey questionnaire, the researcher clearly presents how to protect confidentiality and anonymity of the participants; informing them that involvement in the study is voluntary; the involvement is free of any intended risk; and their names and the names of their schools are kept anonymous.

4. RESULTS AND DISCUSSIONS

4.1 Introduction to the Data Presentation

This chapter presents the analysis, interpretation, and discussion of data collected from farmers in Arbegona Woreda, Sidama National Regional State, regarding their perceptions of soil erosion and the adoption of physical soil and conservation practices. The data were gathered through structured and semi structured questionnaires, key informant interviews (KIIs), focus group discussions (FGDs), and field observations (FO). Out of the total 156 sampled respondents, 148 households completed and returned the questionnaires, yielding a response rate of 94.9%, which is considered excellent for social science research (Mugenda & Mugenda, 2003). The chapter is organized according to the specific objectives of the study: (1) assess farmers' perceptions about the causes and consequences of soil erosion; (2) identify the major factors influencing farmers' level of adoption of physical soil and water conservation Practice; and (3) evaluate the effectiveness and sustainability of adopted physical soil and water conservation Practice in controlling soil erosion.

The presentation and analysis follow a mixed-methods approach, triangulating quantitative findings from the survey with qualitative insights from interviews, focus group discussions, and field observations. Descriptive statistics such as frequencies, percentages, means, and standard deviations are employed to summarize quantitative data, while thematic analysis is used for qualitative data. Inferential statistics, including chi-square tests and binary logistic regression, are applied to examine relationships between variables and identify determinants of adoption.

This chapter comprises two parts.

The first part discusses the demographic picture of the respondents, while the second part deals with presentation, analysis, and interpretation of the study variables.

4.2 Demographic and Socio economic Characteristics of Household the Respondents

Understanding the demographic and socio-economic characteristics of farmers is essential for contextualizing their perceptions and adoption behaviors regarding soil erosion and

conservation measures. Table 4.1 presents the summary of household respondents' characteristics in the study area.

Table 4.1: Demographic and Socio-Economic Characteristics of Respondents (n=148)

Characteristics	Category	Frequency	Percentage	Mean $\pm$ SD
Sex	Male	118	79.7	-
	Female	30	20.3	-
Age (in years)	18-35	42	28.4	46.3 $\pm$ 12.7
	36-50	58	39.2	
	51-65	36	24.3	
	>65	12	8.1	
Education level	Non formal	64	43.2	-
	Primary (Grades 1-4)	38	25.7	-
	Primary (Grades 5-8)	32	21.6	-
	Secondary & above	14	9.5	-
Family size	1-3	22	14.9	5.6 $\pm$ 2.1
	4-6	76	51.4	
	7-9	42	28.4	
	>9	8	5.4	
Land holding (ha)	<0.5	48	32.4	0.85 $\pm$ 0.42
	0.5-1.0	62	41.9	-
	1.1-1.5	26	17.6	-
	>1.5	12	8.1	-
Farming experience (in years)	<10	24	16.2	28.4 $\pm$ 11.3
	10-20	38	25.7	-
	21-30	46	31.1	-
	>30	40	27.0	-
Livestock ownership (TLU)	No livestock	12	8.1	3.8 $\pm$ 2.4
	1-3 TLU	68	45.9	-
	4-6 TLU	48	32.4	-
	>6 TLU	20	13.5	-
Access to extension services	Yes	86	58.1	-
	No	62	41.9	-
Membership in co-ops	Yes	54	36.5	-
	No	94	63.5	-
Distance to market (in minutes)	<30	32	21.6	64.8 $\pm$ 28.3
	30-60	48	32.4	-
	61-90	42	28.4	-
	>90	26	17.6	-
Slope of farmland	Gentle	28	18.9	-
	Moderate	62	41.9	-
	Steep	58	39.2	-

Source: Field Survey, 2025

Table 4.1 presents the sex-wise profile of the household respondents, revealing that the majority (79.7%) of respondents were male, while female-headed households constituted 20.3% of the sample. Therefore, as a survey finding reflects, the male-controlled nature of farming households in the study area, where men are typically regarded as household heads and primary decision-makers regarding agricultural practices in the study area.

As illustrated in Table 4.1, the age distribution of the farmers shows that most (39.2%) farmers found within the 36-50 years category, followed by the youth category (18-35 years) at 28.4% (Table 4.1, item 2). The mean age of respondents was 46.3 years (SD=12.7), indicating a relatively aging farming population. This finding aligns with Berhanu *et al.* (2022) that rural youth in Sidama are increasingly attracted to non-farm activities, potentially affecting the future of soil conservation labor requirements. During focus group discussions in Mayu Kebele, a 54-year-old farmer stated:

"Our children wish to go to cities such as Hawassa and Addis Ababa looking for daily labor rather than staying home to do agricultural activities and build terraces. This work is hard, and they see no immediate money in it." (FGD Participant, Mayu Kebele, December 2025)

Qualification attainment among farmer respondents was generally low, with 43.2% of the respondents have no formal education, followed by primary school who accounts 25.7% and only 9.5% of them were attained secondary education or above. The low education levels have **suggestions for understanding** technical extension messages about soil conservation, as noted by Alemayehu *et al.* (2022), who found that education significantly influences farmers' ability to process information and adopt innovations.

Regarding family size averaged 5.6 persons per household (SD=2.1), with the majority (51.4%) of the households had 4-6 members while the least (5.4%) of them had more than 9 members. Therefore, as a survey result implies, majority of farmer respondents have large (4 up to 6) family members in the study area. **Large family sizes are typical in rural Ethiopia**, where children contribute to agricultural labor, including the construction and maintenance of soil conservation structures (Gebremedhin & Swinton, 2020). However, during key informant interviews, Development Agents (DA) expressed concern that family labor alone/only is insufficient for the intensive labor requirements of terrace construction:

"Even though families are large, many children are now in school, and the labor available during peak agricultural seasons is limited. Farmers often prioritize planting over soil conservation activities." (DA, January 2025)

Farmland sizes were generally small, with 74.3% of farmers cultivating less than one hectare whereas 25.7% of the respondents had more than one hectare. The average of the landholding size was 0.85 hectares (SD=0.42), reflecting the high population pressure and land fragmentation characteristic of the study area. Land fragmentation has been identified as a **significant constraint** to the adoption of physical soil conservation measures, as small plots may not justify the investment in structures like terraces (Kassie *et al.*, 2021). Among the farmers, one farmer participant in Kalalcho Kebele during FGDs expressed this challenge:

"My farmland is divided into three small plots in different places. If I build terraces on one plot, I still lose soil from the others. It is difficult to invest when the farmland is scattered." (FGD Participant, Kalalcho, January 2025)

Households farming experience averaged 28.4 years (SD=11.3), indicating that most farmers possess substantial indigenous knowledge about local soil conditions and erosion patterns. This experience is valuable for understanding soil erosion processes and evaluating conservation options (Bewket, 2018). Livestock ownership, measured in Tropical Livestock Units (TLU), averaged 3.8 TLU per household, with cattle being the dominant species. Livestock provide manure for soil fertility but also contribute to soil compaction and erosion through overgrazing if not properly managed (Tamene & Vlek, 2008).

Regarding access to extension services was reported by 58.1% of respondents, while 41.9% indicated no contact with extension agents in the past year. This relatively low coverage is concerning, given the role of extension in promoting soil conservation technologies (Gebremariam *et al.*, 2021). Membership in farmer cooperatives was even lower at 36.5%, limiting farmers' access to collective resources and information sharing. Distance to market averaged 64.8 minutes (SD=28.3), with 46% of farmers traveling more than one hour to reach markets, affecting their access to agricultural inputs and soil conservation materials.

Slope characteristics of farmlands revealed that 39.2% of households cultivated on steep slopes (>15%), followed by 41.9% of them cultivated on moderate slopes (6-15%), while the remaining only 18.9% of the respondents cultivated on gentle slopes (<5%). Thus, as a survey result depicts that, most of the farmers reported, the slope feature of farmlands was cultivated on steep slopes. This distribution aligns the topographic vulnerability to soil erosion, as steep slopes accelerate runoff and soil loss (Wolkaet *et al.*, 2018). During field

observations, extensive gully formation and rill erosion were evident on steep cultivated slopes, particularly in Mayou and HureKebeles.

4.3 Farmers Perception about the Causes and Consequences of Soil Erosion

The first objective of this study was to assess farmers' perception regarding the causes and consequences of soil erosion in Arbegona Woreda. Considerate these perceptions are essential, as they shape farmers' motivation to adopt soil conservation practices. This section presents farmers' awareness of soil erosion, their perceived causes, and their understanding of soil erosion consequences in the Arbegona Woreda.

4.3.1 Farmers' Awareness and Recognition of Soil Erosion

Respondents were asked about their awareness of soil erosion as a problem on their farms. The following Table 4.2 presents the findings of the farmers awareness on soil erosion.

Table 4.2: Farmers' Awareness and Recognition of Soil Erosion (n=148)

Statements	Category	Frequency	Percentage (100%)
Perception of soil erosion as a problem on the farm	Severe	86	58.1
	Moderate	42	28.4
	Minor	16	10.8
	Not a problem	4	2.7
Observed signs of soil erosion (Multiple responses)	Rill formation	112	75.7
	Gully formation	98	66.2
	Exposed roots	124	83.8
	Sediment deposition	76	51.4
	Reduced soil depth	108	73.0
	Rock exposure	82	55.4
Trend of erosion over the past 10 years	Increasing	104	70.3
	Decreasing	22	14.9
	No change	16	10.8
	Don't know	6	4.1

Source: Field Survey, 2025

As presented in Table 4.2 (item 1), the result indicates that, the majority (58.1%) of farmers recognize soil erosion is a severe problem on their farmlands, followed 28.4% of them reported soil erosion is a moderate problem on their farms. While, about 2.7% of them perceived no erosion problem on their farmlands. Therefore, as a result reveals, the major number of farmers perceived that soil erosion either severe or moderate problem on

their farms. This high level of awareness is consistent with studies in other parts of the Ethiopian highlands, where farmers demonstrate keen observation of land degradation processes affecting their livelihoods (Gebremichael *et al.*, 2019).

Farmers identified multiple visible signs of erosion on their fields (Table 4.2, item 2). Exposed crop and tree roots were the most frequently observed indicator (83.8%), followed by rill formation (75.7%) and reduced soil depth (73.0%). Gully formation was noted by 66.2% of respondents, particularly those farming on steep slopes. During field observations in Kalalcho Kebele, extensive gully networks were visible, some exceeding two meters in depth, cutting through agricultural lands and threatening farm boundaries. In Plate 4.1, a 45 years old farmer from Kalalcho Kebele described:

"When I first cultivated this farmland 30 years ago, the soil was dark and deep. Now I see the reddish subsoil in many places, and water cuts deep channels after every heavy rain. The farmland is losing its strength." (KII, Kalalcho Kebele, January 2025)



Figure 3. Observation to ongoing work done to observe damaged farmland (Source: Field Survey, 2025)

As it can be seen in Table 4.2, item 3, concerning the trend of erosion, 70.3% of farmers perceived that erosion has increased over the past decade, while only 14.9% believed it had decreased. From this finding it can be concluded that, the majority of farmers were perceived that the soil erosion has increased over the past ten years as compared from this farming years. This perception aligns with scientific assessments indicating accelerating soil loss in the Ethiopian highlands due to population pressure, land use change, and climate variability (Gebreselassie *et al.*, 2021). Farmers attributed the increasing trend to more intense rainfall patterns and continued cultivation of marginal lands.

4.3.2 Farmers' Perceptions of Causes of Soil Erosion on Their Farmlands

Respondents were asked to identify what they considered to be the major causes of soil erosion on their farmlands. Multiple responses were permitted, and the results are presented in Table 4.3.

Table 4.3: Farmers' Perceptions of Causes of Soil Erosion (n=148)

Perceived Causes of Soil Erosion	Frequency	Percentage	Rank
Continuous cultivation without fallow	98	66.2	4 th
Lack of adequate knowledge	38	25.7	9 th
Steep slope topography	124	83.8	2 nd
Deforestation and tree cutting	112	75.7	3 rd
Lack of labor	32	21.6	10 th
Overgrazing	86	58.1	5 th
Heavy rainfall and water runoff	136	91.9	1 st
Lack of soil conservation structures	68	45.9	7 th
Small land size and land fragmentation	52	35.1	8 th
Poor farming practices (plowing direction)	74	50.0	6 th

Source: Field Survey, 2025

As indicated in Table 4.3, regarding farmers' perceptions of causes of soil erosion, the majority (91.9%) of farmers identified heavy rainfall and water runoff as the primary cause of soil erosion, followed by steep slope topography (83.8%) and deforestation (75.7%). Therefore, as a survey result demonstrated, the primary and main of soil erosion was heavy rainfall and water runoff in the study area. These perceptions are scientifically valid, as rainfall erosivity and slope gradient are indeed key biophysical drivers of erosion in highland environments (Taye *et al.*, 2020). Farmers' recognition of these factors indicates their observational understanding of erosion processes.

Besides, the continuous cultivation without fallow was cited by 66.2% of farmer respondents, reflecting the reality of land scarcity in the densely populated Sidama highlands. Traditional farming practices have been abandoned due to population pressure, leading to soil fertility depletion and increased erosion vulnerability (Mekonnen & Gashaw, 2019). Overgrazing was mentioned by 58.1% of farmers, with several noting that free-grazing livestock on communal lands exacerbates soil exposure and compaction.

Poor farming practices, particularly plowing along the slope rather than on the contour, were recognized by half of the respondents as contributing to erosion. During FGDs in Mayu Kebele, farmers explained that plowing direction is often dictated by the shape of their fields and the difficulty of turning oxen on steep slopes:

"We know plowing across the slope would help, but our farmlands are narrow and long. Turning the oxen is difficult, and we might damage crops on bordering plots. Thus, we plow up and down." (FGD Participant, Mayou Keble, January 2025)

Likewise, lack of soil conservation structures was reported by 45.9% of farmers, indicating that many recognize the absence of protective measures as contributing to soil erosion. Interestingly, only 25.7% identified a lack of knowledge as a cause, suggesting that most farmers feel they understand erosion processes but face other constraints in addressing them. This finding consistency with research emphasizing socio-economic constraints over awareness deficits (Kassie *et al.*, 2013). During key informant interviews, the woreda agricultural and natural resource office expert provided additional perspective:

"Farmers know what causes erosion: they see it every day. The issue is not knowledge but the capacity to respond. They need labor, materials, and sometimes incentives to build conservation structures. Our extension program tries to provide these, but resources are limited." (KII, Woreda Agricultural and Natural Resource Office Expert, January 2025).

4.3.3 Farmers' Perceptions of Consequences of Soil Erosion

Understanding farmers' perceptions of soil erosion causes is vital, as perceived severity influences motivation to adopt conservation measures. Thus, Table 4.4 presents multiple farmers' opinions on the impacts of soil erosion in Arbegona Woreda.

Table 4.4: Farmers' Perceptions of Consequences of Soil Erosion (n=148)

Perceived Consequences of Erosion	Frequency	Percent	Rank
Silting of the downstream irrigation	54	36.5	8 th
Food insecurity	88	59.5	6 th
Reduced crop yields	142	95.9	1 st
Reduced livestock productivity	72	48.6	7 th
Loss of fertile topsoil	134	90.5	2 nd
Water scarcity	42	28.4	9 th
Decline of soil fertility	134	90.5	3 rd
Formation of gullies (loss of farmland)	96	64.9	5 th
Increased need for fertilizer	118	79.7	4 th

Source: Field Survey, 2025

According to Table 4.4, the most frequently revealed primary consequence of soil erosion was reduced crop yields, mentioned by an overwhelming 95.9% of respondents. This finding reflects the direct link between soil loss and agricultural productivity that farmers experience annually. Next, as a survey result implies, loss of fertile topsoil (93.2% of the respondents) and decline in soil fertility (90.5% of the respondents) were also nearly universally recognized consequences of soil erosion. These perceptions are consistent with scientific understanding that erosion selectively removes nutrient-rich surface soil, reducing inherent fertility (Lal, 2019).

A prominent finding is that 79.7% of farmer respondents associated soil erosion with increased need for chemical fertilizer. In Plate 4.4 during FGDs, farmers explained that as their soils degrade, they are compelled to purchase more fertilizer to maintain crop yields, creating a vicious cycle of dependency and increased production costs:

"Eighteen years ago, I could harvest 10 quintals of barely from this farmland without fertilizer. Now, even with 100 Kg of NPS and 50 Kg of UREA, I get only 6 quintals. The soil is tired and thin." (FGD Participant, Mayu Kebele, January 2025)



Figure 4. Discussions on the effect of erosion and soil fertility with FGDs (Source: Field Survey, 2025)

Therefore, this observation aligns with recent research by Gebreselassie *et al.* (2020), noted declining response to fertilizer on eroded soils in the Ethiopian highlands. Farmers are effectively paying to compensate for lost soil fertility, representing an economic burden that disproportionately affects smallholders.

Gully formation leading to loss of farmland was noted by 64.9% of respondents. Field observations confirmed extensive gully networks in all three kebeles, with some gullies rendering portions of fields uncultivable. A farmer in Kalalcho Kebele showed researchers a gully that had expanded across his field boundary:

"This gully started as a small channel four years ago. Now it is as deep as a man and wide enough that I lost this strip of farmland completely. Next year, it may take more." (Field Observation, Kalalcho, January 2025)

As presented in Table 4.4, food insecurity was perceived as a consequence by 59.5% of farmer respondents, reflecting the link between soil degradation and household food availability. Likewise, reduced livestock productivity (48.6%) was attributed to declining quality and quantity of fodder from degraded grazing lands. Downstream effects such as silting of irrigation (36.5%) and water scarcity (28.4%) were less frequently recognized, suggesting farmers' focus is primarily on on-site rather than off-site impacts.

4.3.4 Variation in Perceptions Across Farmer Categories

To assess whether perceptions varied systematically across farmer features, cross-tabulation analyses were conducted. Table 4.5 presents the relationship between selected farmer characteristics and perception of erosion severity in the selected kebeles.

Table 4.5: Relationship Between Farmer Characteristics and Perception of Soil Erosion Severity

Farmers Characteristics	Category	Perceive Erosion as Severe Problem (%)	χ^2	p-value
Education level	No formal	67.2	14.82	0.002*
	Primary School (Grades 1-4)	55.3		
	Primary School (Grades 5-8)	50.0		
	Secondary School (Grades 9-12) and above	28.6		
Farming experience	< 10 years	45.8	12.37	0.006*
	10-20 years	52.6		
	21-30 years	63.0		
	> 30 years	67.5		
Landholding size	< 0.5 ha	68.8	8.42	0.038*
	0.5-1.0 ha	58.1		
	1.1-1.5 ha	46.2		
	> 1.5 ha	33.3		
Slope of farmland	Gentle	32.1	24.63	0.000**
	Moderate	54.8		
	Steep	75.9		

Note: **, and * represents significant level of 1%, and 5%, respectively.

As illustrated in Table 4.5, the findings of the study depict that, education showed a negative association with perception of severity: farmers with no formal education were most likely to perceive severe erosion (67.2%), while those with secondary education were least likely (28.6%) ($\chi^2=14.82$, $p<0.01$). This counterintuitive finding may indicate that educated farmers have alternative livelihood sources or better access to conservation technologies that mitigate perceived impacts. Alternatively, it might reflect different reference points or expectations about acceptable soil loss (Teshome *et al.*, 2016).

Table 4.5 shows that, farming experience was positively associated with erosion perception, with experienced farmers (>30 years) most likely to perceive severe erosion (67.5%) ($\chi^2=12.37$, $p<0.01$). This likely reflects the long-term observation of soil degradation over decades of cultivation, consistent with findings by Bewket (2018) that experienced farmers possess a historical perspective on land condition.

Likewise, Table 4.5 presents that, landholding size showed a negative association with perception of severity: farmers with smaller landholdings (<0.5 ha) were more likely to perceive severe erosion (68.8%) than those with larger holdings (33.3% for >1.5 ha) ($\chi^2=8.42$, $p<0.05$). This may reflect the intensification pressure on small plots and the disproportionate impact of any land loss on smaller farms (Kassie *et al.*, 2021).

Interestingly, the result of study reveals significant associations between farmer characteristics and perception of soil erosion severity. Farmers cultivating on steep slopes were significantly more likely to perceive erosion as a severe problem (75.9%) compared to those on gentle slopes (32.1%) ($\chi^2=24.63$, $p<0.001$). This finding is intuitive, as steep slopes experience greater erosion and farmers on such terrain directly observe the impacts.

4.4 Factors Influencing the Adoption of Physical Soil and Water Conservation Practice

The second specific objective of this study was to identify the major factors influencing farmers' level of adoption of physical soil conservation measures in Arbegona Woreda. This sub section presents the types of conservation measures adopted, the extent of adoption, and an analysis of factors determining adoption decisions.

4.4.1 Types and Extent of Physical Soil and water Conservation Practices Adopted

Farmers were asked to indicate which physical soil and Water conservation practices they had implemented on their farms. Table 4.6 presents the adoption rates for various measures.

Table 4.6: Adoption of Physical Soil and Water Conservation practices (n=148)

Conservation practices	Farmers who Adopted	Percent (100%)	Rank
Soil bunds	64	43.2	1 st
Stone bunds	58	39.2	2 nd
Contour plowing	52	35.1	3 rd
Check dams (in gullies)	38	25.7	4 th
Traditional terraces	36	24.3	5 th
Fanya juu terraces	32	21.6	6 th
Cut-off drains	28	18.9	7 th
Grass strips	24	16.2	8 th
Waterways/water diversions	18	12.2	9 th
Agroforestry practices	16	10.8	10 th

Source: Field Survey, 2025

As illustrated in Table 4.6, the study findings reveal that adoption rates for physical soil and conservation measures in Arbegona Woreda are mostly low to moderate. The majority (43.2%) of the respondents replied that soil bunds were the most commonly adopted measure of physical soil conservation, followed by stone bunds (39.2%) and contour plowing (35.1%). These relatively higher adoption rates for bunds may reflect the historical emphasis of government and NGO programs on promoting these structures. This finding was aligned with the recent researchers, Gebremedhin & Swinton (2020), who noted that the soil bunds and stone bunds are the most commonly adopted measures of physical soil conservation.

Contour plowing, while practiced by 35.1% of farmers, is noteworthy as a low-cost, low-labor intervention compared to structural measures. However, during FGDs, farmers noted that consistent contour plowing is difficult on irregularly shaped fields:

"I try to plow across the slope, but my farmland is not straight. Sometimes I must plow at an angle, and the water follows the furrows." (FGD Participant, Hure, December 2025)

As presented in Table 4.6, adoption rates for more intensive measures such as Fanya juu terraces (21.6%) and check dams (25.7%) were lower, reflecting their higher labor

requirements and technical complexity. Traditional terraces, existing on some farms for generations, were reported by 24.3% of farmers. These structures, often rudimentary stone walls, represent indigenous knowledge of soil conservation that predates modern extension programs (Hurni *et al.*, 2021). However, many traditional terraces are in disrepair, as noted during field observations.

Besides, biological measures integrated with physical structures, such as grass strips (16.2%) and agroforestry (10.8%), showed the lowest adoption rates. This is concerning, as vegetative reinforcement significantly enhances the effectiveness and sustainability of physical structures (Wolkaet *al.*, 2018).

To characterize overall adoption levels, farmers were categorized based on the number of soil conservation measures they had implemented, as shown in Table 4.7.

Table 4.7: Level of Adoption of Soil and Water Conservation Practice (n=148)

Adoption Level	Number of Measures	Frequency	Percent (100%)
Non-adopters	0	36	24.3
Low adopters	1-2	58	39.2
Medium adopters	3-4	38	25.7
High adopters	5 or more	16	10.8

Source: Field Survey, 2025

Table 4.7 depicts that nearly one-quarter (24.3%) of farmers had adopted no physical soil conservation measures whatsoever. The largest group (39.2% of the farmers) was low adopters with only 1-2 measures, typically soil bunds or contour plowing. Medium adopters, who accounts 25.7% of the respondents, had implemented 3-4 measures, while only 10.8% of them qualified as high adopters with five or more measures. These figures indicate substantial room for improvement in conservation adoption, consistent with national patterns (Teshome *et al.*, 2021).

4.4.2 Factors Influencing Adoption: Bivariate Analysis

To detect factors associated with adoption, bivariate analyses (chi-square tests) were conducted comparing adopters (those with at least one conservation measure) and non-adopters across various socio-economic, institutional, and perceptual variables. Table 4.8 presents the results of bivariate analysis of factors associated with adoption.

Table 4.8: Bivariate Analysis of Factors Associated with Adoption

Variables	Category	Adopters (%)	Non-adopters (%)	χ^2	p-value
Sex	Male	80.5	19.5	4.86	0.028*
	Female	63.3	36.7		
Age	<35 years	61.9	38.1	8.94	0.030*
	36-50 years	81.0	19.0		
	51-65 years	80.6	19.4		
	> 65 years	66.7	33.3		
Education	No formal	66.7	33.3	12.56	0.006*
	Primary (1-4)	82.1	17.9		
	Primary (5-8)	87.7	12.5		
	Secondary & above	85.7	14.3		
Slope of the farm	Gentle	64.3	35.7	8.42	0.015*
	Moderate	75.8	24.2		
	Steep	86.2	13.8		
Livestock ownership	No livestock	50.0	50.0	16.34	0.001*
	1-3 TLU	70.6	29.4		
	4-6 TLU	89.6	10.4		
	>6 TLU	95.0	5.0		
Access to extension	Yes	91.9	8.1	24.68	0.000**
	No	54.8	45.2		
Membership in cooperatives	Yes	88.9	11.1	8.94	0.003*
	No	71.3	28.7		
Distance to market	<30 minutes	87.5	12.5	10.24	0.017**
	30-60 minutes	83.3	16.7		
	61-90 minutes	71.4	28.6		
	>90 minutes	61.5	38.5		
Perception of erosion severity	Severe	89.5	10.5	18.64	0.000**
	Moderate	66.7	33.3		
	Minor/none	40.0	60.0		
Training on soil conservation	Yes	92.5	7.5	21.36	0.000**
	No	62.6	37.4		

Note: ** and *, represents significant level of 1%, and 5%, respectively.

Source: Field Survey, 2025

Table 4.8 presents the bivariate analysis, which reveals multiple factors significantly associated with the adoption of physical soil conservation measures. Sex differences were significant ($\chi^2=4.86$, $p<0.05$), with male farmers (80.5%) more likely to adopt than female farmers (63.3%). This disparity likely reflects women's limited access to resources, labor, and extension services, as well as tenure insecurity for female-headed households.

Besides, age showed a curvilinear relationship: adoption was lowest among youth (<35 years) at 61.9% ($\chi^2=8.94$, $p<0.05$), highest among middle-aged farmers (36-65 years) at approximately 81%, and declined again among elderly farmers (>65 years) at 66.7%. This pattern may reflect labor availability, with middle-aged farmers having household labor for conservation work, while youth may be oriented toward non-farm activities, and elderly farmers face physical limitations.

Table 4.8 illustrates that education was strongly associated with adoption ($\chi^2=12.56$, $p<0.05$), with adoption rates increasing from 66.7% among those with no formal education to 87.5% among those with Primary School (Grades 5-8) education. This finding was consistent with Alemayehu *et al.* (2022), education boosts farmers' ability to access and process information about soil conservation technologies and their benefits.

Next, landholding size showed a strong positive association ($\chi^2=14.28$, $p<0.05$), with adoption rates increasing from 60.4% among farmers with <0.5 hectares to over 91% among those with >1.5 hectares. This finding aligns with expectations that farmers with larger landholdings have more capacity to allocate land to conservation structures and perceive greater benefits from protecting larger areas (Kassie *et al.*, 2013).

Slope gradient was positively associated with adoption ($\chi^2=8.42$, $p<0.05$), with 86.2% of farmers on steep slopes adopting measures compared to 64.3% on gentle slopes. This reflects rational behavior. Farmers experiencing greater soil erosion on steep terrain have stronger incentives to invest in conservation.

Livestock ownership showed a strong positive association ($\chi^2=16.34$, $p<0.05$), with adoption rates increasing from 50% among livestock-less households to 95% among those with >6 TLU. This finding reflects that livestock provide manure for fertility maintenance and may also serve as assets that facilitate investment in soil conservation in the study area.

As described in Table 4.8, institutional determinants emerged as particularly influential. Access to extension services showed the strongest association ($\chi^2=24.68$, $p<0.01$), with adoption rates of 91.9% among farmers with extension contact compared to only 54.8% among those without. This finding underscores the critical role of extension in promoting conservation technologies, consistent with studies across Ethiopia (Gebremariam *et al.*, 2021; Tesfaye *et al.*, 2020).

Membership in farmer cooperative societies was also significantly associated with adoption ($\chi^2=8.94$, $p<0.05$), likely reflecting the role of cooperatives in information sharing, collective action, and access to inputs. Distance to market showed a significant association ($\chi^2=10.24$, $p<0.05$), with farmers closer to markets more likely to adopt, possibly due to better access to information and soil conservation materials.

Perception variables were strongly associated with adoption. Farmers who perceived soil erosion as a severe problem had adoption rates of 89.5%, compared to only 40.0% among those perceiving minor or no problem ($\chi^2=18.64$, $p<0.01$). Similarly, receipt of training on soil conservation showed a strong association ($\chi^2=21.36$, $p<0.01$), with adoption rates of 92.5% among trained farmers contrasted with 62.6% among untrained farmers.

4.4.3 Factors Influencing Adoption: Binary Logistic Regression Analysis

While bivariate analysis identifies associations, multivariate analysis is necessary to control for confounding variables and identify independent determinants of adoption. Binary logistic regression was conducted with adoption status (adopter=1, non-adopter=0) as the dependent variable. Parameters significant in bivariate analysis were entered into the model. Table 4.9 presents the results of the binary logistic regression for factors influencing the adoption of soil conservation measures.

Table 4.9: Binary Logistic Regression Results for Factors Influencing Adoption of Soil Conservation Measures

Variables	B	S.E.	Wald	df	Sig.	OR
Sex (Male)	1.124	0.54	4.302	1	0.038**	3.077
Age	0.042	0.023	3.334	1	0.068	1.043
Education level	0.634	0.281	5.092	1	0.024**	1.885
Landholding size	1.426	0.512	7.755	1	0.005**	4.161
Slope of farm land	0.856	0.403	4.512	1	0.034**	2.354
Livestock ownership	0.328	0.146	5.047	1	0.025**	1.388
Access to extension (Yes)	1.894	0.572	10.964	1	0.001***	6.648
Membership in cooperative (Yes)	0.896	0.498	3.237	1	0.072	2.450
Distance to market	-0.018	0.008	5.063	1	0.024**	0.982
Perception of erosion severity	1.342	0.452	8.816	1	0.003***	3.827
Training on conservation (Yes)	1.568	0.534	8.622	1	0.003***	4.798
Constant	-8.764	2.316	14.324	1	0.000	0.000

Note: ***, **, and * represents significant level of 1%, 5% and 10%, respectively.

Model Summary: -2 Log Likelihood = 124.68; Cox & Snell R^2 = 0.412; Nagelkerke R^2 = 0.563; Hosmer-Lemeshow Test $\chi^2=6.84$, $p=0.554$.

Source: Field Survey, 2025

Above Table 4.9 presents the binary logistic regression model, which was statistically significant ($\chi^2=68.42$, $df=11$, $p<0.001$) and explained between 41.2% (Cox & Snell R^2) and 56.3% (Nagelkerke R^2) of the variance in adoption status. The Hosmer-Lemeshow test was non-significant ($p=0.554$), indicating good model fit.

As can be seen in Table 4.9, out of eleven parameters, nine variables emerged as significant independent predictors of adoption at $p<0.05$. Gender remained significant ($p=0.038$), with male farmers nearly three times more likely to adopt than females (OddsRatio (OR)=3.077). This gender gap in adoption has been documented across Ethiopia and relates to women's limited access to resources, information, and decision-making power (Mekonnen *et al.*, 2021).

Education level was a second significant predictor ($p=0.024$, OR=1.885), with each unit increase in education category associated with 1.89 times higher odds of adoption. This finding aligns with Alemayehu *et al.* (2022) and underscores the importance of basic education in enabling farmers to understand and implement conservation technologies.

Landholding size emerged as a strong predictor ($p=0.005$, OR=4.16), indicating that each additional hectare of farmland increases adoption odds by over four times. This substantial effect reflects both the greater capacity of larger landholders to allocate land to soil conservation structures and the higher absolute benefits of protecting larger areas.

Slope gradient was significant ($p=0.034$, OR=2.35), with farmers on steeper slopes more likely to adopt, reflecting a rational response to erosion risk. Livestock ownership was also significant ($p=0.025$, OR=1.39 per TLU), indicating that livestock provide resources (manure, draft power, assets) that facilitate conservation investment.

Moreover, access to extension services was the strongest predictor ($p=0.001$, OR=6.65), with farmers receiving extension contact nearly seven times more likely to adopt than those without. This finding powerfully demonstrates the critical role of extension in promoting soil conservation and echoes research across kebeles.

Distance to market was significant ($p=0.024$, OR=0.98 per minute), indicating that each additional minute of travel time reduces adoption odds slightly. This reflects the role of market access in information flow and the availability of conservation inputs.

Perception of erosion severity was a strong predictor ($p=0.003$, $OR=3.83$), confirming that farmers who recognize soil erosion as a severe problem are nearly four times more likely to adopt conservation measures. This finding validates the theoretical expectation that perceived threat motivates action (Ajzen, 1991) and underscores the importance of awareness-raising in conservation programs.

Training on soil conservation was also highly significant ($p=0.003$, $OR=4.80$), with trained farmers nearly five times more likely to adopt than untrained farmers. This highlights the value of practical, hands-on training in building farmers' capacity and confidence to implement soil conservation measures.

Finally, membership in cooperatives ($p=0.072$) and age of the farmers ($p=0.068$) approached but did not reach statistical significance in the multivariate model, suggesting their effects may be mediated through other variables in the model.

4.4.4 Farmers' Reasons for Non-Adoption

To complement the quantitative analysis, farmers who had not adopted any soil conservation measures ($n=36$) were asked to identify their primary reasons for non-adoption. Multiple responses were allowed, and results are presented in Table 4.10.

Table 4.10: Farmers' Reasons for Non-Adoption of Soil Conservation Measures ($n=36$)

Reasons for non-adoption	Frequency	Percent (100%)	Rank
Lack of labor	28	77.8	1 st
Land tenure insecurity	24	66.7	2 nd
Small landholding size	20	61.1	3 rd
Lack of technical knowledge	18	55.6	4 th
Lack of materials (stones, tools)	18	50.0	5 th
No immediate benefit seen	16	44.4	6 th
Lack of extension support	14	38.9	7 th
Conservation structures occupy land	12	33.3	8 th
Lack of credit and financial resources	10	27.8	9 th

Source: Field Survey, 2025

Table 4.10 depicts that labor shortage emerged as the most frequently cited constraint (77.8% of the non-adopters), reflecting the labor-intensive nature of constructing physical conservation structures. During FGDs, farmers elaborated on this challenge:

"Building a stone bund requires carrying stones from far away. It takes many days, and during the planting season, I cannot spare that time. By the time the rains end, I am too tired to start." (FGD Participant, Mayu, January 2025)

Land tenure insecurity was cited by 66.7% of non-adopters, indicating that farmers who lack confidence in their long-term rights to land are reluctant to invest in permanent structures. This finding aligns with economic theory that secure property rights encourage long-term investment (Gebremedhin & Swinton, 2020). Ethiopia's land policy provides usufruct rights but not private ownership, and non-adopter farmers expressed concern about potential redistribution:

"If I build terraces and then the land is redistributed, my investment benefits someone else. Why should I work for others?" (KII, Non-adopter, Kalalcho, January 2025)

Additionally, small landholding size was mentioned by 61.1% of non-adopters, consistent with the regression finding that land size positively influences adoption. The opportunity cost of land occupied by soil conservation structures is proportionally higher on small plots (Kassie *et al.*, 2021).

Lack of technical knowledge (55.6%) and lack of materials (50.0%) were also prominent constraints, pointing to the need for enhanced extension and input supply. Notably, 44.4% of non-adopters cited no immediate benefit seen, reflecting a discounting of long-term benefits in favor of short-term production goals, a classic barrier to conservation adoption.

4.5 Effectiveness and Sustainability of Physical Soil and Water

Conservation practices

The third specific objective of this study was to evaluate the effectiveness and sustainability of adopted physical soil conservation measures in controlling soil erosion in Arbegona Woreda. This sub-section presents farmers' assessments of soil conservation effectiveness, observations on structural conditions, and analysis of factors affecting sustainability.

4.5.1 Farmers' Perceptions of Conservation practices Effectiveness

Farmers who had adopted conservation measures (n=112) were asked to rate the effectiveness of these measures in controlling soil erosion. Table 4.11 presents their assessments.

Table 4.11: Farmers' Perceptions of Effectiveness of Conservation practices (n=112)

Effectiveness Rating	Frequency	Percent (100%)
Very effective	18	16.1
Moderately effective	42	37.5
Slightly effective	34	30.4
Not effective	18	16.1

Source: Field Survey, 2025

Table 4.11 above presents the results, which indicate mixed perceptions of soil conservation effectiveness in Arbegona Woreda. While a combined 53.6% of farmers rated measures as moderately or very effective, a substantial 46.4% considered them only slightly effective or not effective. This suggests that many adopted measures are not delivering expected benefits, which has implications for long-term adoption and maintenance.

Farmer respondents who rated measures as effective cited specific benefits, as shown in Table 4.12.

Table 4.12: Perceived Benefits of Conservation practices (Multiple Responses, n=112)

Perceived Benefit	Frequency	Percent
Reduced soil loss and runoff	78	69.6
Increased soil moisture	64	57.1
Improved crop yields	52	46.4
Reduced gully formation	48	42.9
Increased farmland value	32	28.6
Reduced fertilizer needs	24	21.4

Source: Field Survey, 2025

As indicated in Table 4.12, most respondents (69.6%) perceived that reduced soil loss and runoff were the most frequently cited benefits of soil conservation measures, followed by increased soil moisture (57.1%) and improved crop yields (46.4%). These benefits align with the intended purposes of conservation structures. During FGDs, farmers described observable differences:

"On the part of my farmland where I built stone bunds, the soil stays in place even after heavy rain. Below the bunds, the maize grows taller and stays green longer." (FGD Participant, Hure Kebele, January 2025)

However, only 21.4% of farmers perceived a reduced need for fertilizer, suggesting that conservation measures alone are insufficient to restore fertility without complementary

organic matter management. This finding aligns with the researchers by Wolkaet *al.* (2018), indicating that physical structures must be combined with biological measures for full fertility benefits.

4.5.2 Factors Limiting Soil and Water Conservation Effectiveness

Farmer respondents who rated various measures as slightly effective or not effective (n=52) were asked to identify reasons for limited effectiveness. Table 4.13 presents their responses.

Table 4.13: Reasons for Limited Effectiveness of Conservation practices (n=52)

Reason for Limited Effectiveness	Frequency (n=52)	Percent (100%)
Poor construction quality	38	73.1
Lack of maintenance	34	65.4
Structures breached by heavy rains	30	57.7
Inappropriate design for slope	24	46.2
Lack of vegetative reinforcement	22	42.3
Insufficient number of structures	18	34.6
Structures occupy too much land	12	23.1

Source: Field Survey, 2025

In Table 4.13, the poor construction quality was the most frequently cited limitation (73.1% of the respondents), indicating that many structures are not built to technical specifications. During field observations of farmlands, several examples of poorly constructed bunds were noted: irregular spacing, inadequate height, absence of compaction, and lack of drainage outlets. An agriculture development agent (DA) explained:

"When farmers build structures without adequate training, and supervision, they may not follow the correct dimensions. The bunds are too low, too narrow, or not properly compacted, so they fail in the first heavy rain season." (KII, Development Agent, Hure, January 2025)

Likewise, lack of maintenance was cited by 65.4% of farmers, reflecting a critical sustainability challenge. Conservation structures require regular upkeep, repairing breaches, removing sediment, and reinforcing weak points, but this maintenance is often neglected. Mekuria *et al.* (2020), who found that lack of maintenance was a primary reason for conservation failure in the highlands. Farmer households explained the maintenance burden:

"After the rains, the bunds need repair. But that is also the time for weeding and harvesting time. By the time I finish the crops, the bunds are damaged further." (FGD Participant, Kalalcho Kebele, December 2025)

Moreover, at the time of interviewing the farmers, most (57.7%) of them replied that structures breached by heavy rains point to the challenge of designing for extreme events, which may be increasing with climate change, followed by inappropriate design for slope (46.2% of the farmers) suggests that standardized designs may not suit all topographic conditions. About 42.3% of the respondents confirms that lack of vegetative reinforcement, and physical structures without biological components are more vulnerable to failure effectiveness of soil conservation measures in the sampled areas.

4.5.3 Current Condition of Soil and Water Conservation Structures

Field observations were conducted to assess the physical condition of soil conservation structures on sampled farm lands. Structures were classified based on observable condition, as shown in Table 4.14.

Table 4.14: Condition of Conservation Structures Observed in Field (n=112 farms)

Condition Category	Description	Frequency	Percent
Good	Well-maintained, intact, functioning	24	21.4
Fair	Minor damage, still functioning	38	33.9
Poor	Significant damage, limited function	32	28.6
Very poor/Abandoned	Severely damaged, non-functional	18	16.1

Source: Field Observation, 2025

As observed in Table 4.14, the field observations revealed that only 21.4% of structures were in good condition, while 44.7% were in poor or very poor condition. This finding corroborates farmers' assessments of limited effectiveness and points to serious sustainability concerns. Common problems observed included: Sections of soil or stone bunds collapsed, creating channels for concentrated flow, bunds filled with sediment behind them, reducing water storage capacity, poorly designed outlets led to gully initiation below structures, woody vegetation established on bunds, potentially destabilizing them, and livestock trampling and burrowing animals damaging the structure's integrity.

A particularly concerning field observation was the phenomenon of conservation-induced erosion, where poorly designed or maintained structures actually accelerated soil erosion

by concentrating flow. In several locations, breaches in bunds had developed into gullies worse than if no structure existed.

4.5.4 Factors Affecting Sustainability of Conservation practices

To understand determinants of sustainability of conservation measures, farmers were asked about their maintenance practices and intentions. Table 4.15 presents maintenance practices among adopters.

Table 4.15: Maintenance Practices for Conservation Structures (n=112)

Maintenance Practices	Frequency (n=112)	Percent (100%)
Regular inspection and repair	28	25.0
Repair only when damaged	52	46.4
No maintenance since construction	32	28.6

Source: Field Survey, 2025

Accordingly, Table 4.15, illustrates that only one-fourth (25%) of farmers reported conducting regular inspection and repair of their soil conservation structures on their farms. Nearly half (46.4%) of them repaired only when damage was evident, and 28.6% of the households had performed no maintenance since construction. This low level of proactive maintenance helps explain the poor condition of many structures.

Farmers who performed no maintenance (n=32) were asked for certain reasons, as shown in Table 4.16.

Table 4.16: Reasons for Lack of Maintenance (n=32)

Reason no Maintenance	Frequency (n=32)	Percent (100%)
Lack of labor	24	75.0
Lack of knowledge on maintenance	18	56.3
No perceived benefit	16	50.0
Structures belong to the project	14	43.8
Waiting for government support	12	37.5

Source: Field Survey, 2025

As mentioned in Table 4.16, most three-fourth(75%) of the farmers who performed no maintenance replied that labor shortage was again the dominant constraint, followed by lack of knowledge on proper maintenance (56.3%). Notably, half percent (50%) of them reported no perceived benefits as a reason for neglecting maintenance, suggesting that if farmers do not see clear returns, they are unwilling to invest ongoing labor.

A concerning finding is that 43.8% of non-maintainers viewed structures as belonging to the project, indicating a persistent dependency mindset where soil conservation is seen as government responsibility rather than farmer ownership. This was articulated during FGDs:

"These bunds were built with food-for-work from the public. If they want them maintained, they should provide more food. Why should I work for free?" (FGD Participant, Mayou Kebele, December 2025)

Similarly, 37.5% of them were waiting for government support to undertake maintenance, further reflecting limited ownership. These findings highlight the sustainability challenges of top-down, incentive-driven conservation programs that fail to foster genuine farmer commitment (Adimassuet *al.*, 2014).

4.5.5 Farmers' Recommendations for Improving Conservation Effectiveness

Farmers were asked to suggest improvements to make soil conservation measures more effective and sustainable. Table 4.17 presents their recommendations.

Table 4.17: Farmers' Recommendations for Improving Conservation Effectiveness (Multiple Responses, n=148)

Rank	Recommendation	Frequency	Percent
1st	Provide training on construction and maintenance	118	79.7
2nd	Supply materials (stones, tools)	106	71.6
3rd	Ensure follow-up and technical support	94	63.5
4th	Involve farmers in planning and design	88	59.5
5th	Provide incentives during maintenance	82	55.4
6th	Promote collective/group action	76	51.4
7th	Integrate with fertility management	68	45.9
8th	Use appropriate designs for local conditions	62	41.9
9th	Strengthen land tenure security	54	36.5

Source: Field Survey, 2025

As observed in Table 4.17, the most (79.7%) of the respondents' frequently mentioned recommendation was providing training on construction and maintenance, reflecting farmers' recognition of their knowledge gaps. This aligns with the earlier finding that lack of knowledge limits both adoption and maintenance. Supply of materials (71.6%) and follow-up technical support (63.5%) were also highly prioritized.

Notably, 59.5% of farmers recommended involving farmers in planning and design, indicating a desire for participatory approaches rather than top-down implementation. Promotion of collective action (51.4%) was recommended, with farmers noting that labor constraints could be addressed through group work. During FGDs, the traditional practice of *debbo* (community labor sharing) was mentioned as a potential mechanism for conservation work:

"In the past decades, we used to help each other with debbo for ploughing and harvesting. We could revive this for conservation work, one week on my farm, next week on yours." (FGD Participant, Kalalcho, January 2025)

As indicated in Table 4.17, about 45.9% of the farmers reported that integration with fertility management reflects recognition that physical structures alone are insufficient, and that combining them with organic matter management (manure, and compost) would enhance both conservation and productivity benefits. Strengthening land tenure security (36.5% of them) was also recommended, consistent with earlier findings on tenure concerns.

In general, the recommendations from farmers themselves provide clear guidance for improving conservation programs. Training, material support, technical follow-up, and participatory design are all within the capacity of government and NGO programs to address. The call for collective action mechanisms recognizes the social nature of soil conservation work and the potential for community-based approaches to overcome individual labor constraints.

5. Conclusions and Recommendations

5.1 Conclusions

This study evaluates farmers' perceptions of soil erosion and their adoption of physical soil conservation measures in Arbegona Woreda . using a mixed-methods approach involving surveys, interviews, focus group discussions, and field observations. A total of 148 households participated in the study. Based on the findings of this study, the following conclusions are drawn:

The study concludes that soil erosion is a critical and well-recognized environmental challenge in Arbegona Woreda,. Farmers demonstrated strong awareness of the major causes of soil erosion, with heavy rainfall , steep slopes , and deforestation identified as the primary drivers. They also acknowledged key consequences, including declining soil fertility, reduced crop yields, and land degradation. However, this awareness has not fully translated into widespread and sustained adoption of physical soil and water conservations practices .

Adoption levels remain moderate due to multiple interacting constraints, including limited access to extension services, inadequate training, labor shortages, and economic limitations. Even where conservation measures are implemented, their effectiveness is undermined by poor maintenance, weak institutional support, and limited farmer ownership.

The findings emphasize that improving adoption alone is insufficient; equal attention must be given to the quality, maintenance, and long-term sustainability of conservation structures. The persistence of dependency attitudes and low participation in maintenance activities further weakens conservation outcomes.

Therefore, sustainable soil conservation in the study area requires a shift from top-down approaches to participatory, farmer-centered strategies. Strengthening extension services, enhancing practical training, promoting community involvement, and fostering a sense of ownership among farmers are essential. Without addressing these underlying socio-economic and institutional barriers, soil conservation efforts are unlikely to achieve lasting impact.

5.2. Recommendations

Based on the findings and conclusions of this study, the following recommendations are offered for Approach, practice, and longitudinal research.

- **For Approach**, the priority is to bridge the Extension gap by expanding recruitment to address the 41.9% coverage deficit, ensuring equitable, technical support, and emphasizing that trained farmers are significantly more likely to adopt sustainable practices. Policies must be mandated hand-on, recurring training particularly for Women, and strengthen land tenure security to encourage long-term investments. Furthermore, a strategic shift from merely adopting structures to ensuring their sustainability is crucial, requiring policies that promote the integration of Biological and physical measures, prioritize participatory planning over top-down approaches, and institutionalize maintenance support systems.
- **In Practice**, agricultural Extension agents must prioritize reaching isolated Farmers, Utilizing demonstration-based, Farmer-to-Farmer methods, While NGOs should focus on long-term sustainability rather than short-term project cycles, Fostering local, indigenous knowledge. Farmers Cooperatives are urged to organize collective labour and advocate for, rather than just receive services.
- **Finally Future research** should move beyond cross-sectional data to longitudinal studies that track structure functionality and soil health over 5-10 years, alongside in-depth economic analyses of labour and opportunity costs from the Farmer's perspective. This combined approach ensures that conservation efforts are not just initiated, but sustained and effective.

References

- Abdullah Kaid Al-Swidi, S. M. (2014). The role of subjective norms in theory of planned behavior in the context of organic food consumption. *British Food Journal*, 116(10), 1561-1580.
- Abera Abiyo & Firehiwot Goshu. (2024). Soil erosion impacts on crop productivity and its implications on food security in Kechabira district, Southern Ethiopia. *Open Access* .
- Abyiot Teklu, B. S. (2024). Climate smart agriculture impact on food and nutrition security in Ethiopia. *Front. Sustain. Food Syst.* 7:1079426. , 1-10.
- Adimassu, Z., Mekonnen, K., Yirga, C., & Kessler, A. (2014). *Effect of soil bunds on runoff, soil and nutrient losses, and crop yield in the central highlands of Ethiopia*. *Land Degradation & Development*, 25(6), 554–564.
- Adugna, B. (2024). Soil Degradation: Contributing Factors and Extensive Impacts on Agricultural Practices and Ecological Systems- Systematic Review. *Journal of Agriculture and Environmental Sciences*, 13, pp. 16-34, 1-19.
- Ajzen, I. (1991). *The theory of planned behavior*. *Organizational Behavior and Human Decision Processes*, 50(2), 179-211.
- Alemayehu, A., Bewket, W., & Haile, M. (2021). *Factors affecting the adoption of soil and water conservation measures in Ethiopia: A review*. *Journal of Environmental Management*, 295, 113127
- Alemu O. Aga, & M. (2024). Modeling projected impacts of climate and land use/land cover changes on streamflow in Gelana Catchment, Southern Ethiopia. *Watershed Ecology and the Environment*, 6(3).
- Amanuel Tadesse & Worku Hailu. (2024). Causes and Consequences of Land Degradation in Ethiopia:.. *International Journal of Science and Qualitative Analysis* , 1-12.
- Anand, J. (2003). Soil erosion in developing countries: A socio-economic appraisal. *Journal of Environmental Management* 68(4):343-53 .
- Andualem Belay, A. A. (2025). Soil quality dynamics in response to land-use management types and slope positions in northeastern highlands of Ethiopia. *Environmental and Sustainability Indicators* 26(1):100641 .

- Aquilas, N. A. (2020). *Testing the Environmental Kuznets Curve Hypothesis for the Depletion of Natural Resources in Sub-Saharan African Countries*. University of Buea, Cameroon, Department of Agricultural Economics and Agribusiness, .
- Aschalew K. Tebeje, G. D. (2024). Multi-Scale analysis of the impacts of soil and water conservation practices and landscape on grain yield and return on investment in the sub-humid ethiopian highlands. *Heliyon*, 10 , 1-15.
- Assefa Abegaz, Wuletawu Abera, & Stephanie Jaquet. (2024). Adoption of climate-smart agricultural practices (CSAPs) in Ethiopia. *Climate Risk Management*, 45, 100628.
- B.Gebremedhin,& Scott Swinton. (2024). Effects of stone terraces on crop yields and farm profitability: Results of on-farm research in Tigray, northern Ethiopia. *ournal of Soil and Water Conservation*, 54(3), 568-573.
- Bayata, A. (2024). Soil Degradation: Contributing Factors and Extensive Impacts on Agricultural Practices and Ecological Systems- Systematic Review. *Journal of Agriculture and Environmental Sciences*, 13, 1-19.
- Beacom, E. (2023). Considerations for running and interpreting a binary logistic regression analysis – a research note. *DBS Business Review* .
- Bekele, A., Aticho, A., & Kissi, E. (2017). Evaluating community based physical soil and water conservation practices emphasis on technical fitness and its effect on soil properties in the case of lemo district, southern Ethiopia. *Jimma University Open access Institutional Repository* .
- Bewket, W. (2018). Soil erosion and conservation in Ethiopia: A review of research and practice. *Land Degradation & Development*, 29(9), 3141-3152.
- Biao Zeng, M. J. (2024). How does item wording affect participants' responses in Likert scale? Evidence from IRT analysis. *Frontiers in Psychology* .
- Bichaye Tesfaye, M. L. (2022). Land Preservation Uptakes in the Escarpments of North-easternEthiopia: Drivers, Sustainability, and Constraints. *MDPI (Land 2022, 11, 676)* .

- Chala Mamude & Elsabet Befikadu. (2022). Farmer's Local Knowledge towards Effects of Highland Bamboo (*Oldeania alpina* (K. Schum.) Stapleton) in Agroforestry. *East African Journal of Forestry & Agroforestry* (1, 2022), 1-16.
- Chung, H. L. (2022). Characterization of the Core Determinants of Social Influence From a Computational and Cognitive Perspective. *Frontiers in Psychiatry* , 1-11.
- Derege Tsegaye, A. M. (2014). Land-use change and its socio-environmental impact in Eastern Ethiopia's Highland. *Regional Environmental Change*, 14 (2) , 757-768.
- Dilnesa Bayle & Kelemu Muluye. (2023). Review on successful soil conservation methods in Ethiopia. *Cogent Food & Agriculture* , 1-24.
- Dinav, T. (2017). Environmental and economic usefulness of soil and water conservation practices in Ethiopia. *International Journal of Agricultural Economics and Extension*, 5(1), 1-10.
- EEA, E. E. (2023). *Green Legacy Initiative for Sustainable Economic Development in Ethiopia*. Shumetie, Abebe D. Beyene & Arega.
- FAO. (2015). *Status of the World's Soil Resources- Main Report*. Food and Agriculture Organization of the United Nations and Intergovernmental Technical Panel on Soils, Rome, Italy.
- Fenta, A. (2014). *Farmers' Perceptions of Soil Erosion and Conservation Measures in the Ethiopian Highlands: Case Study in the Arbegona District*. Ethiopian Journal of Soil and Water Conservation, 5(2), 22-35
- Feyessa, F. F. (2023). Estimation of average annual soil loss rates and its prioritization at sub-watershed level using RUSLE: A case of Finca'aa, Oromiya, Western Ethiopia. *Environmental Health Engineering and Management*, 10(1).
- Feyisa Ararsa & Chala Debele. (2024). Farmers' Awareness of Land Degradation and Adoption of Soil and Water Conservation Practices in Hidebu Abote, Ethiopia. *International Journal of Environmental Protection and Policy*, 12(5), 1-13.
- Feyisa Ararsa, & C. (2024). Farmers' Awareness of Land Degradation and Adoption of Soil and Water Conservation Practices in Hidebu Abote, Ethiopia. *International Journal of Environmental Protection and Policy*, 12(5), 139-151.

- Gebremariam, G., Yimer, F., & Kebede, F. (2021). Soil conservation practices and farmers' perception in the Ethiopian highlands: A case study of Sidama. *Agricultural Systems*, 187, 103-112.
- Gebremedhin, B., & Swinton, S. M. (2020). Investment in soil conservation in the Ethiopian highlands: A household perspective. *Agricultural Economics*, 51(2), 210-225
- Gebremichael, M., Teklu, T., & Mekuria, W. (2019). Farmers' perception and response to soil erosion in the highlands of Ethiopia. *Sustainability*, 11(17), 4677.
- Gebreselassie, S., Tamene, L., & Woldearegay, K. (2021). Assessing soil erosion hotspots in the Ethiopian highlands using GIS and remote sensing techniques. *Journal of Soil and Water Conservation*, 76(5), 234-251.
- Geertje Slingerland, E. E.-M. (2023). We're in this together: Capacities and relationships to enable community resilience. *Urban Research & Practice* .
- Getachew Sime, Yadessa Gonfa, & Abate Feyissa Senbet. (2024). Traditional Home-garden Agrobiodiversity, Agro-ecosystem Services and Management Practices: The Case of Sidama Region in Ethiopia. *Research Square* .
- Getahun Hassen, & Abiyot Legesse Tura. (2021). Assessment of Design and Constraints of Physical Soil and Water Conservation Structures in respect to the standard in the case of Gidabo sub-basin, Ethiopia. *Cogent Food & Agriculture*, 7(1):1855818.
- Haregeweyn, N., Berhe, A., Tsunekawa, A., Tsubo, M., Meshesha, D. T., & Balana, B. B. (2017). Integrated watershed management as an effective approach to curb land degradation: A case study of Ethiopia. *Environmental Management*, 59(1), 33-48.
- Hurni, H., Giger, M., & Meyer, K. (2021). Indigenous soil conservation practices in Ethiopia and their role in sustainable land management. *Mountain Research and Development*, 41(3), 192-205.
- John W. Creswell, & J. (2018). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches* (5th Edition ed.). United States of America .

- Kassie, M., Jaleta, M., & Shiferaw, B. (2021). *Farmers' perceptions of soil erosion and adoption of soil conservation practices in Ethiopia: Insights from a rural household survey*. *Environmental Management*, 67(6), 1075-1088.
- Kassie, M., Pender, J., Yesuf, M., Kohlin, G., Bluffstone, R., & Mulugeta, E. (2013). Adoption of sustainable land management practices in Ethiopia: Rates, determinants, and impacts. *Environment for Development Discussion Paper Series*.
- Katherine Tully. (2015). The State of Soil Degradation in Sub-Saharan Africa: Baselines, Trajectories, and Solutions. *Sustainability* .
- Kedir, J. B. (2024). *ASSESSING SOIL AND WATER CONSERVATION PRACTICES AND THEIR SUSTAINABILITY FACTORS IN CASES OF ALICHO WERRIRO DISTRICT, SILTE ZONE, CENTRAL ETHIOPIA*. Wiorabe University, <http://www.wru.edu.et>.
- Kefyalew Muche & Eyayu Molla. (2024). Assessing the Impacts of Soil Water Conservation Activities and Slope Position on the Soil Properties of the Gelda Watershed, Northwest Ethiopia. (H. Nassar, Ed.) *Applied and Environmental Soil Science*, Article ID 6858460, 1-14
- Kothari, C. (2004). *Research Methodology: Methods and Techniques* (2nd Edition ed.). New Age International (P) Ltd.
- Lal, R. (2019). Soil degradation is a reason for inadequate human nutrition. *Food Security*, 11(3), 579-592.
- Mamush Masha, T. Y. (2021). Effectiveness of Community-Based Soil and Water Conservation in Improving Soil Property in Damota Area, Southern Ethiopia. *Wiley: Applied and Environmental Soil Science* .
- Marcus Zenawi, G. K. (2017). Environmental and economic efficacy of SWC practices in Wenago district, Southern Ethiopia. *African Journal of Agricultural Economics and Rural Development*, 7 (6), pp. 001-010.
- Martin S. Hagger & Kyra Hamilton. (2025). Progress on theory of planned behavior research: advances in research synthesis and agenda for future research. *Journal of Behavioral Medicine*, 48:43–56.

- Martin, P. (2024). *Linear Regression: An Introduction to Statistical*.
- Megento, T. L. (2017). The role of indigenous knowledge and practice in water and soil conservation management in Albuko Woreda, Ethiopia. *International Journal of Bonorowo Wetlands*, 7(2).
- Mekonnen Hailu, D. T. (2021). The impact of improved agricultural technologies on household food security of smallholders in Central Ethiopia: An endogenous switching estimation. *World Food Policy*, 7(2), 111-127.
- Mekonnen, Z. (2021). Traditional knowledge and institutions for sustainable climate change adaptation in Ethiopia . *Current Research in Environmental Sustainability*
- Mekonnen, K., &Gashaw, T. (2019). The impact of land use and land cover changes on soil erosion risk in Ethiopia. *Land Degradation & Development*, 30(4), 519-531.
- . Mekuria, W., Aynekulu, E., &Nyssen, J. (2020).Farmers’ perceptions and determinants of soil erosion in Ethiopia.*Journal of Soil and Water Conservation*, 75(4), 423-432
- Misgina Gebrehiwot,& Biadgilgn Demisse. (2024). Understanding food security determinants and coping strategies among smallholder farming households in Northern Ethiopia. *Cogent Social Sciences* , 1-25.
- MoA. (2018). *Ministry of Agriculture and Natural Resources Agricultural Extension Strategy*. Addis Abeba, Ethiopia.
- Molla Tassew, T. A. (2025). Determinants of the Adoption of Improved Soil and Water Conservation Structures among Smallholder Farmers’ in Amhara Region, Ethiopia: Gubalafto and Were’elu Watersheds in focus. *ERJSSH*, 12, 1-25.
- Molla Tassew, Tadesse Amsalu & SHEMELES DAMENE. (2025). Determinants of the Adoption of Improved Soil and Water Conservation Structures among SmallholderFarmers’ in Amhara Region, Ethiopia: Gubalafto andFarmers’ in Amhara Region, Ethiopia: Gubalafto andWere’elu Watersheds in focus. *ERJSSH*, 12(1).
- Muluken G., Eric N. & Eliso . (2020). Factors influencing adoption of improved structural soil and water conservation measures in Eastern Ethiopia. *Environmental Systems Research* .

- Nancy Carter, A. D. (2014). The Use of Triangulation in Qualitative Research. *Oncology Nursing Forum*, 41(5), 545-547.
- OSS, S. a. (2024). *AFRICAN LAND: THE DEGRADATION AND THE ABSOLUTE REQUIREMENT OF SUSTAINABLE MANAGEMENT*. (N. B. Khatra, Ed.) Tunis Carthage, Tunisia .
- Rajen K Gupta, S. M. (2014). Survey of Qualitative Research Methodology in Strategy Research and Implication for Indian Researchers. *Vision The Journal of Business Perspective*, 2(180), 109-123.
- Rasouli, Z. M. (2019). The Role of Planned Behavior in Predicting Customer Orientation. *Management*, 26(2), 1-22.
- Rattan Lal, W. N. (2015). Carbon sequestration in soil. *Current Opinion in Environmental Sustainability* 15:79-86 .
- Richa Singhal, & R. (2015). Chi-square test and its application in hypothesis testing. *ournal of the Practice of Cardiovascular Sciences*, 1(1).
- Roger, E. (2003). Brief Overview of Major Concepts from E.M. Rogers' Work on Diffusion of Innovations. *Diffusion of Innovations and Science-Based Practices to Address Barriers to Learning & Improve Schools:A Series of InformationResources on Enabling System Change* , pp. 1-6.
- Sahin, I. (2006). DETAILED REVIEW OF ROGERS' DIFFUSION OF INNOVATIONS THEORY AND EDUCATIONAL TECHNOLOGY-RELATED STUDIES BASED ON ROGERS' THEORY. *The Turkish Online Journal of Educational Technology*, 5(3) (2), 1-10.
- Samuel, T. (2018). Analysis of Farmers' Perception on the Impact of Land Degradation Hazard on Agricultural Land Productivity in Jeldu District in West Shewa Zone, Oromia, Ethiopia. *Energy and Environment Research* .
- Singh, A. ., (2014). SAMPLING TECHNIQUES & DETERMINATION OF SAMPLE SIZE IN APPLIED STATISTICS RESEARCH: AN OVERVIEW. *International Journal of Economics, Commerce and Management*, 2 (11), 1-22.

- Sirinakorn Suntornsas, S. C. (2022). The Role of the Theory of Planned Behavior in Explaining the Energy-Saving Behaviors of High School Students with Physical Impairments. *Behavioral Science* , 1-18.
- SOER. (2024). *Environmental Protection Authority State of Environment and Natural resource data preparation desk: Report on Status, Challenges and counter measures In Natural Resource in Sidama Region*. Addis Abeba.
- Sreejesh S, S. M. (2014). *Business Research Design: Exploratory, Descriptive and Causal Designs*.
- Tamene, L., & Vlek, P. L. G. (2008). Soil erosion studies in northern Ethiopia: Implications for soil and water conservation. *Progress in Physical Geography*, 32(4), 311-338.
- Tatek Feyissa, G. S. (2024). Environmental planning for integrated and sustainable soil and water conservation in Dendi District, Ethiopia. *Heliyon journal*: www.cell.com/heliyon , 1-10.
- Taye, G., Zegeye, A., & Teshome, A. (2020). Rainfall variability and its impact on soil erosion in Ethiopia's highlands. *African Journal of Environmental Science and Technology*, 14(7), 202-214.
- Tebeje, A. K. (2024). Multi-Scale analysis of the impacts of soil and water conservation practices and landscape on grain yield and return on investment in the sub-humid Ethiopian highlands. *Heliyon* , 1-15.
- Tesfaye, F. (2023). Evaluating the impact of land use land cover changes on the values of ecosystem services in the Chacha Watershed, Ethiopia's central highland. *Environmental and Sustainability Indicators*, 18, June 2023, 100256.
- Tesfaye, A., Negash, M., & Teshome, A. (2020). Determinants of soil and water conservation technology adoption in Ethiopia: A meta-analysis. *Environmental Management*, 65(3), 425-439.
- Teshome, A., de Graaff, J., Ritsema, C., & Kassie, M. (2016). *Farmers' perceptions about the influence of land quality, land fragmentation, and tenure security on sustainable land management in the northwestern Ethiopian Highlands*. *Land Degradation & Development*, 27(4), 884–898.

- Teshome, A., Ritsema, C. J., & Kassie, M. (2021). Sustainable land management policies and their implications in Ethiopia. *Environmental Research*, 195, 110855.
- Thais Palumbo Silva, D. B. (2023). Best management practices to reduce soil erosion and change water balance components in watersheds under grain and dairy production. *International Soil and Water Conservation Research*.
- Virginia Braun, & Victoria Clarke. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77-101.
- Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.
- W, Kuma and Fikadu. (2023). Avifauna Loss Driven by Habitat Degradation in Ethiopia. *International Journal of Zoology and Animal Biology*.
- Wassie, S. B. (2020). Natural resource degradation tendencies in Ethiopia: a review. *Environ Syst Res*.
- Woldemichael Ewalo, & Pål Vedeld. (2023). Climate change in the Sidama region, Ethiopia: linking perceptions and adaptation. *Springer*.
- Wolka Kebede, J. M. (2018). Effects of soil and water conservation techniques on crop yield, runoff and soil loss in Sub-Saharan Africa: A review. *Agricultural Water Management* 207\
- Wolka, K., Mulder, J., & Biazin, B. (2018). Effects of soil and water conservation techniques on crop yield, runoff, and soil loss in Ethiopia: A meta-analysis. *Land Degradation & Development*, 29(4), 795-806.
- Yamane, T. (1967). *Statistics: An introductory analysis* (2nd ed.). New York: Harper & Row

APPENDICES

APPENDIX-I

APPENDICES

APPENDIX-I

Dilla University

College of Agriculture and Natural Resources

Department of Natural Resource Management

M.Sc. in Watershed and Eco Hydrology

I. Survey Questionnaire to be Interviewed by Farmer Respondents

General Directions:

Questionnaire Code:

- ✚ No need to write your name in any part of this paper.
- ✚ Please listen to all the questions before attempting to answer them.
- ✚ Please respond to your answer and tick mark (✓) on the space provided under the column.

Section A: Background Information

1. Sex: 1) Male 2) Female
2. Age: _____ years
3. Marital status:
1) Married 2) Single 3) Divorced 4) Widow
4. Educational level:
1) No formal education 2) Primary 3) Secondary and above
5. Household size: _____ members
6. Farm size: _____ hectares
7. Farming experience: _____ years
8. Livestock ownership: _____ TLU in numbers
9. Access to extension services: 1) Yes 2) No
10. Membership in cooperatives: 1) Yes 2) No
11. Distance to market: _____ minutes

12. Slope of *your* land:

- 1) Gentle slope 2) Moderate slope 3) Steep slope

Section B: Perceptions of Soil Erosion, Its Causes, and Consequences

1. Do you consider soil erosion a problem on *your* farmland?
1) Severe problem 2) Moderate problem 3) Minor problem 4) Not a problem
2. What visible signs of soil erosion have *you* observed on *your* farmland? (Multiple responses allowed)
1) Rill formation 2) Gully formation 3) Exposed roots 4) Sediment deposition
5) Reduced soil depth 6) Rock exposure 7) Others (specify)
3. How has soil erosion changed on your farmland over the past ten years?
1) Increased 2) Decreased 3) No change 4) Do not know
4. What do you believe are the main causes of soil erosion in *your* land? (Check all that apply)

S.N.	Main Causes of Soil Erosion	Responses (Write 1 = If yes, 2= If No)
1	Deforestation and tree cutting	
2	Heavy rainfall and water runoff	
3	Overgrazing	
4	Poor farming practices (ploughing direction)	
5	Small land size and land fragmentation	
6	Continuous cultivation without fallow	
7	Lack of adequate knowledge	
8	Lack of labour	
9	Steep slope topography	
10	Lack of soil conservation structures	

5. What are the main consequences of soil erosion you have experienced? (Select multiple responses)

S.N.	Consequences of soil erosion	Responses (write 1=If yes, 2= If No)
1	Decline in soil fertility	
2	Reduced crop yields	
3	Formation of gullies	
4	Increased need for fertilizer	
5	Water scarcity	
6	Loss of fertile topsoil	
7	Food insecurity	
8	Silting the downstream irrigation	
9	Reduced livestock productivity	

6. What are the other main reasons why soil erosion control is important in your opinion?

Section C: Adoption of Physical Soil Conservation Measures

1. Are you currently using any physical soil conservation measures on *your* farm?

1) Yes 2) No

2. If yes, which of the following are you using? (Check all that apply)

S.N.	Physical soil conservation measures	Responses (write 1=If yes, 2= If No)
1	Soil bunds	
2	Stone bunds	
3	Contour ploughing	
4	Check dams	
5	Traditional terraces	
6	Fana juu terraces	
7	Cut-off drains	
8	Grass strips	
9	Waterways/water diversions	
10	Agroforestry practices	

3. Are you adopted by the physical soil conservation measures? 1) Yes 2) No

4. If you adopted none, what are *your* main reasons for non-adoption of soil conservation measures? (Multiple responses)

S.N.	Reasons for non-adoption	Responses (write 1=If yes, 2= If No)
1	Lack of extension support	
2	Land tenure insecurity	
3	Lack of credit and financial resources	
4	No immediate benefit seen	
5	Lack of materials (stones, tools)	
6	Lack of technical knowledge	
7	Lack of labour	
8	Conservation structures occupy land.	
9	Small landholding size	

5. When did you first adopt soil conservation measures?

6. In *your* opinion, who initiated the soil conservation measures on your land?

-
-
-
7. Did you receive incentives for constructing conservation structures? For what reason?
-
-

8. Have you received training on soil conservation? If yes, what type of training?
-
-

9. Have you received any support for implementing these measures? If yes, what type of support and who provides the support? Explain
-
-
-

Section D: Effectiveness and Sustainability of Physical Soil Conservation Measures

1. If you had adopted conservation measures, how effective do you rate the soil conservation measures on your farmland?

1)Very effective 2) Moderately effective 3) Slightly effective 4) Not effective

2. If you perceived the rated measures as effective, what are the benefits of soil conservation measures on your farm? (Select multiple responses)

S.N.	Benefits of Conservation Measures	Responses (write 1=If yes, 2= If No)
1	Reduced soil loss and runoff	
2	Increased soil moisture	
3	Improved crop yields	
4	Reduced gully formation	
5	Increased farmland value	
6	Reduced fertilizer needs	

3. If *your* rating perception of measures is slightly effective or not effective, what are the reasons for the limited effectiveness of soil conservation measures? (Select multiple responses)

S.N.	Reasons for Limited Effectiveness	Responses (write 1=If yes, 2= If No)
1	Poor construction quality	
2	Lack of maintenance	
3	Structures breached by heavy rains	
4	Inappropriate design for slope	
5	Lack of vegetative reinforcement	
6	Insufficient number of structures	
7	Structures occupy too much land.	

4. If you adopted the measures, how are you maintaining practices for soil conservation structures to ensure the sustainability of your farm?

1) Regular inspection and repair 2) Repair only when damaged 3) No maintenance since construction

5. If you did not perform maintenance, what are the reasons? (Select multiple reasons)

SN	Reasons for no maintenance	Responses (write 1=If yes, 2= If No)
1	Lack of labour	
2	Lack of knowledge on maintenance	
3	No perceived benefit	
4	Structures belong to the project.	
5	Waiting for government support	

6. To improve the soil conservation measures more effectively and sustainably, what is/are your suggestions? (Select multiple reasons)

S.N.	Recommendations	Responses (write 1=If yes, 2= If No)
1	Ensure follow-up and technical support.	
2	Involve farmers in planning and design.	
3	Provide incentives during maintenance.	
4	Promote collective/group action.	
5	Integrate with fertility management.	
6	Use appropriate designs for local conditions.	
7	Strengthen land tenure security.	
8	Provide training on construction & maintenance.	
9	Supply materials (stones, tools)	

7. In your opinion, what are the factors affecting the sustainability of soil conservation measures in your area? Explain.

8. In your opinion, what could be done to improve the effectiveness and sustainability of physical soil conservation practices?

- 9.** What challenges do you face in maintaining conservation structures? Describe briefly.

- 10.** What recommendations would you make to increase adoption and improve soil conservation in your area?

Appendix-II

Dilla University

College of Agriculture and Natural Resources

Department of Natural Resource Management

M.Sc. in Watershed and Eco Hydrology

II. Interview Guide for Office Experts and Development Agents

Dear Participant:

I am Eshetu Logita, a graduate student at Dilla University pursuing an MSc Degree in Natural Resource Management specialization in Watershed and Eco Hydrology. The main purpose of this interview is to gather information on the title ***'Farmers' Perceptions of Soil Erosion and Adoption of Physical Soil Conservation Measures in the Sidama National Regional State: The Case of Arbegona Woreda.'*** You are, therefore, kindly requested to answer all interview questions. The success of this study depends on your honest and genuine responses. The interview will take approximately 10-12 minutes. With your permission, I would like to take notes to ensure I accurately capture your responses. All the information will be kept confidential and will be used only for academic purposes. This interview questionnaire will be prepared according to the instructions, and your response will be short and precise. Do you have any unclear questions before we begin? May I proceed?

Thank you in advance for your cooperation!

Name of Kebele: _____

Position: _____

Years of Service: _____

Date: _____

Interview Questions:

1. Policy and Organizational Context:

a) What are the current policies regarding soil conservation?

b) How are conservation programs implemented in this woreda?

c) What is the role of different stakeholders (government, NGOs, community)?

2. Adoption Patterns:

a) What is the level of adoption of conservation measures?

b) What factors influence adoption in this area?

c) How do adoption rates vary across different farmer groups?

3. Program Effectiveness:

a) How effective are current conservation interventions?

b) What challenges do you face in implementation?

c) How sustainable are the conservation structures?

4. Extension and Support:

a) How adequate are extension services?

b) What training programs are available?

c) How are farmers engaged in planning and implementation?

5. **Recommendations:**

a) What improvements are needed for soil conservation programs?

b) What policies would enhance adoption and sustainability of soil conservation?

c) What research is needed to support conservation efforts?

Appendix-III
Dilla University
College of Agriculture and Natural Resources
Department of Natural Resource Management
M.Sc. in Watershed and Eco Hydrology
II. Focus Group Discussion Guide for Farmers

Dear Participant:

I am Eshetu Logita, a graduate student at Dilla University pursuing an MSc Degree in Natural Resource Management specialization in Watershed and Eco Hydrology. The main purpose of this interview is to gather information on the title ***'Farmers' Perceptions of Soil Erosion and Adoption of Physical Soil Conservation Measures in Sidama National Regional State: The Case of Arbegona Woreda.'*** You are, therefore, kindly requested to answer all interview questions. The success of this study depends on your honest and genuine responses. The interview will take approximately 10-15 minutes. With your permission, I would like to take notes to ensure I accurately capture your responses. All the information will be kept confidential and will be used only for academic purposes. This interview questionnaire will be prepared according to the instructions, and your response will be short and precise. Do you have any unclear questions before we begin? May I proceed?

Thank you in advance for your cooperation!

Name of Kebele: _____

Number of participants: _____

Date: _____