Transform Soil Fertility Management in Ethiopia (TRANSFORM Program)

Baseline Study Report in Amhara, Oromia and Central Ethiopia Regional State, Ethiopia



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ACRONYMS AND ABBREVIATIONS

4Rs	Right Source, Right Rate, Right Time, Right Place
2MC	2merkato.com
ARARI	Amhara Agricultural Research Institute
AOSS	Agricultural One Stop Shops
ATI	Agricultural Transformation Institute
ATVET	Agricultural Technical and Vocational Education and Training
BLM	Biophysical Land Management
C	Control
CER	Central Ethiopia Region
DAs	Development Agents
DST	Decision Support Tool
EDHS	Ethiopian Demographic and Health Survey
EHPEA	Ethiopian Horticulture Producer Exporters Association
EIAR	Ethiopian Institute of Agricultural Research
MoA	Ministry of Agriculture
EthioSIS	Ethiopian Soil Information System
FAO	Food and Agriculture Organization
FCS	Food Consumption Scores
FFS	Farmer Field Schools
FGD	Focus Group Discussion
FRG	Farmer Research Group
FTC	Farmer Training Center
HDDS	Household Dietary Diversity Score
HH	Household
ICRAF	International Centre for Research in Agroforestry
IF	Investment Forum
IFDC	International Fertilizer Development Center
KII	Key Informant Interview
PR	Participatory Research
RARIs	Regional Agricultural Research Institutes
SCI	Soil and Climate Initiative
SLM	Sustainable Land Management
T	Intervention
WB	World Bank

EXECUTIVE SUMMARY

The main goal of the TRANSFORM baseline study was to gain a fundamental understanding of soil health and fertility conditions among rural households in 48 kebeles and 12 woredas of the Amhara, Oromia, and Central Ethiopia regions. Both quantitative and qualitative data collection methods and analysis were used, employing a mixed-method approach. A stratified random sampling technique ensured balanced representation of demographic groups, with 1,248 households sampled: 860 males (68.9%) and 388 females (31.1%), and 452 youths (36.2%) versus 796 adults (over 35 years old, 63.8%). A total of 70 KIIs were conducted with stakeholders at various levels, and 24 FGDs were held, including 6 from control kebeles and 18 from intervention kebeles, ensuring gender representation with eight groups of women and 16 of men. Featuring over two decades of farming experience at an average age of 44 years, the household demographic local knowledge has led to strong soil health and fertility wisdom. Youth-headed households show greater potential for adopting new technologies. Literacy among intervention households stands at 69%, with a significant gap between male and female heads, the latter recording 40%. The average family size is 5, and each household manages about 1.2 hectares of land, which is above the national average of 0.96 hectares. However, only 3% of the land is irrigated, and 73% is allocated to crop production. Households manage an average of 2.8 fragmented plots located approximately 1.3 kilometers apart, limiting efficient land use. Annual farm income averages Birr 43,836, with cereal production as the primary income source. High dependency ratios at an average value of 86% indicate higher dependencies on working-age individuals, placing a strain on productive investment and increasing the risk of food insecurity. The study also reveals essential findings on household dynamics, gender roles, and community structures that shape agricultural productivity. Although women in intervention kebeles are actively engaged in soil fertility and crop management, they face productivity barriers due to unequal access to resources. Social networks are strong, with over two-thirds of household heads connected to local groups, enhancing information flow and technology uptake. A high percentage of cooperative membership is reported, supporting collective input, use, and marketing. Disabilities were reported in 5% of the respondents, who face significant limitations in labor, input access, and productivity. These findings emphasize the need for inclusive, gender-responsive, and community-based development approaches to strengthen household resilience and sustainability. While national initiatives like EthioSIS and NSIS have built significant capacity in soil data collection and analysis, continuous efforts are needed to comply with soil dynamics and update the results. Although the review of old soil maps (2012-2016) revealed substantial variations across the study woredas, most areas exhibit neutral to moderately acidic pH levels with most salt-free zones. However, widespread deficiencies in key nutrients, especially available phosphorus (P), sulfur (S), and extractable boron (B), are common, posing severe constraints to crop productivity. Regular soil testing is recommended to update these baseline conditions for better soil nutrient planning. Despite the varied HH responses (%) in the 12 baseline woredas, the custom of extension services pertinent to soil health, fertility, and agro-ecological practices the public extension service has been known to pay good attention, of course, aiming at improving productivity and food security. The baseline values (% HH responses) on farmers' practices on sustainable land management (SLM), soil fertility, and crops or agronomic practices reported varied degrees of engagement in Household Inclusive and Participatory Extension Services. The findings indicate significant disparities in the adoption of Sustainable Land Management (SLM), soil fertility practices, and agronomic techniques across different regions and demographic groups. Overall, the average land size for intervention households was 1.21 hectares, with an average of 0.25 hectares (25.8% of total land) covered by SLM practices. In contrast, control households managed 1.16 hectares on average, with only 0.22 hectares (26.4%) under SLM. Perceptions of farmers regarding their participation in inclusive extension services varied widely. Farmer's engagement in household inclusive and participatory extension services showed significant variability. The overall engagement rate averaged 28.2% in control kebeles and 20.7% in intervention kebeles. In the Amhara region,

specific perceptions ranged from 11.5% in Tehuledere to 50.0% in Basona Worena among intervention kebeles. For control kebeles in Amhara, engagement was 26.9% in Kalu and 46.2% in Basona Worena, with an overall average of 33.1%. In Oromia, the engagement levels were notably low, with no participation reported in Sire and Tiyo, while only 2.6% of intervention households in Tiyo were engaged. Digelu Tijo saw 38.5% participation in control households but only 5.1% in intervention households. Omo Nada had an engagement rate of 42.3% in control and 38.5% in intervention kebeles. Gera reported 19.2% in control and 14.1% in intervention, while Abaya had 38.5% in control and 33.3% in intervention kebeles. In the Central Ethiopia Region, Weira woreda exhibited a similar pattern, with 34.6% engagement among control households and 32.1% among intervention households. These findings highlight the need for targeted strategies to improve farmer participation in extension services, especially in underperforming woredas. Regarding the coverage of SLM practices was highest in Kalu, where intervention households covered an average of 0.38 hectares (57.4%), compared to lower rates in other woredas, such as Basona Worena (12.6%) and Gera (8.6%). The willingness of farmers to invest in SLM practices was generally positive, with many expressing readiness to adopt multiple SLM strategies. Awareness of soil degradation issues was high, particularly in Amhara, where 88.5% of control households and 78.7% of intervention households recognized the problem. In contrast, awareness was lower in Oromia (48.1% control; 46.6% intervention).

The combined food security measure (FCS and HDDS) reveals that 58% of households were food secure, while 7% were severely food insecure. This integrated food security indicator approach highlights significant gaps in household access to diverse and adequate diets, suggesting limitations in food access and utilization of food resources. Farm-level costs varied significantly. Farm-level expenditure patterns revealed inequalities. Labor costs were highest in Kalu (20,500 ETB) and Tiyo (19,441 ETB), reflecting intensive management, while Omo Nada (5,382 ETB), Gera (6,303 ETB), Abaya (5,730 ETB), and Weira (2,200 ETB) reported much lower spending. Fertilizer use was highest in Basona Worena (5,326 Birr in controls; 4,141 Birr in interventions) and Tiyo (5,904 Birr), but minimal in Omo Nada and Weira (<2,000 Birr). Youths often spend more time than adults, particularly in Digelu Tijo and Sire. This baseline also synthesized key findings on the vibrancy of current soil input use, accessibility, soil input supply, lime application, private sector engagement, research and innovation, soil test review, and indigenous and innovative knowledge levels of farmers. Smallholder farmers in the target woredas primarily use mineral fertilizers (Urea and NPS) and traditional organic amendments (compost, farmyard manure). However, soil inputs like micronutrients, lime, gypsum, and biochar are critically low or virtually absent, indicating a significant gap. A major economic barrier is the consistently low affordability of soil inputs, where most households exhibited prohibitive soil input prices and extremely scarce credit services, which were common across all demographics. The supply chain for soil inputs heavily relies on cooperative and government channels, with limited private sector engagement, restricting farmer choice and access to diverse soil inputs. Soil acidity impacts an estimated 40-41% of Ethiopia's cultivated land (MoA, 2017). In response, the federal government in the 2024/25 targeted reclaiming 300,000 hectares with a 1.4 billion ETB (~ USD 12 million) lime subsidy (MoA, 2024c), though the achievement at ground level is only 3.5%. Besides, national lime production remains largely unquantified, highlighting a significant value chain gap. Moreover, the baseline data showed extremely low farmer use of lime (0-4.1% in intervention kebels, 0.3-1.5% overall mean), indicating nascent use trends. The private sector and Micro, Small, and Medium Enterprises (MSMEs) have acknowledged the potential to invigorate the soil input sector. Still, their current engagement, particularly in organic input production and distribution, is minimal. Challenges include sourcing raw materials, quality control, standardization, and fragmented supply chains. Opportunities exist in the growing demand for sustainable practices, local production initiatives, market linkages, and supportive government policies for organic agriculture. Woredas in the Amhara region address degradation and conflict impacts, while Oromia focuses on diverse soil types and participatory research, and Central Ethiopia emphasizes climate-smart practices and organic input incubation. Despite these advancements, farmer-led soil input on-farm trials are very low (averaging 9.23% nationally, near 0% in Amhara), suggesting limited

farmer awareness or direct engagement. Assessed along ten major types of soil related knowledge levels, the HH survey revealed varied level of farmers' awareness with significant demographic disparities. In Amhara, for example, knowledge on soil characteristics, input recommendations, and the 4Rs was extremely low, particularly among women and youth. Oromia reported higher awareness and use of recommended fertilizer practices and conservation techniques, although implementation remained uneven. Through KIIs' qualitative methods and literature reviews, this baseline survey also disclosed poor linkages among the agricultural research, extension, and education (focusing on vocational training systems). Farmer-led research trials and participatory learning platforms were found to be nearly non-existent in Amhara and only modestly present in Oromia, indicating limited opportunities for farmer-research linkage and farmers' engagements in participatory technology validation and co-learning. Disaggregated data revealed that adult males had slightly higher participation and knowledge, underscoring a need for more inclusive approaches. KIIs and literature further highlighted systemic constraints of the working linkage and soil input sector to be weak extension support, a lack of tailored soil recommendations, limited access to inputs, and poor market linkages. They also identified ample opportunities to scale sustainable practices through improving advisory services, strengthening institutional coordination, and supporting localized research. Challenges persist in translating research into widespread farmer adoption, limited adaptive trials, and resource constraints to ensure cohesive innovation systems and effective knowledge transfer, despite the emerging digital platforms. Through capacitating them, the ATVETs would be instrumental in practical outreach and hands-on training, translating research into farm-level practices. This baseline finding also touched on the policy environment of the soil health and fertility sector. According to the KIIs with various policy officials and reviews, policy and legal frameworks remain fragmented, with unrevised regulations and weak institutional coordination, underscoring the need for stronger governance, modernized soil health and fertilizer laws, and improved soil testing and research capacity. While the underlying policy and regulatory challenges remained a bottleneck of the sector, updating the entire policy environment and addressing the missed ones should be instrumental. Prudently aligning and integrating them with in-country agricultural laws/regulations and with global initiatives, particularly with the African Fertilizer and Soil Health (AFSH) Action Plan (2023-2033), would be paramount.

1. INTRODUCTION

Soil health and fertility are critical components of agricultural productivity and environmental sustainability in Ethiopia, where the majority of agriculture is rain-fed and relies on healthy soils to support the livelihoods of millions of smallholder farmers (MoA, 2020). However, significant soil degradation driven by erosion, nutrient depletion, and acidification threatens agricultural yields and exacerbates food insecurity, particularly in rural areas (Haileselassie et al., 2016; World Bank, 2021). According to a recent study, soil degradation reduces agricultural productivity by 5–10% annually and causes economic losses exceeding $1 billion, approximately 2% of Ethiopia's GDP (Teklu and Derbib, 2025).

The Ethiopian government recognizes the importance of sustainable soil management in its agricultural policies advocating for Integrated Soil Fertility Management (ISFM) to enhance soil health and resilience (ATI, 2021). Despite its potential benefits, the adoption of ISFM remains low due to barriers such as limited access to quality fertilizers, inadequate knowledge of sustainable practices, and socio-economic challenges like poverty and gender disparities (Duncan et al., 2020; Tadesse et al., 2019). Community engagement and private sector involvement are crucial for successful soil health initiatives to address the impacts of climate change on soil resilience (Tesfaye et al., 2020).

The Transform Soil Fertility Management (TRANSFORM) Program in Ethiopia aims to improve soil health and fertility management among smallholder farmers in the Amhara, Oromia, and Central Ethiopia Regional States. These regions were selected based on the Government of Ethiopia's prioritization of agricultural initiatives in the highlands, which account for most of the country's surplus production, making them representative of broader national issues. Funded by the Embassy of the Kingdom of the Netherlands and the European Union, and implemented by the International Fertilizer Development Centre (IFDC) in collaboration with partners including World Soil Information (ISRIC), Environment and Coffee Forest Forum (ECFF), SOS Sahel Ethiopia, and Stitching Wageningen Research-Wageningen Environmental Research (SWR-WENR), the program targets 100,000 small-scale food producers.

The program's objectives include enhancing agricultural productivity through training in sustainable practices, improving access to quality soil inputs, and promoting the sustainable use of 65,000 hectares of farmland. It encompasses four strategic components: Customize Extension Service and Empower Farmer Household and Communities to Adopt Soil Health and Fertility Best Agro-ecological Practices; Building a Vibrant Sector for Soil Inputs; Strengthening Linkages between Research and Extension through Farmer-Led Action Research; and Promoting an Enabling Environment for Soil Health and Fertility in Ethiopia. By adopting a multi-faceted approach focused on smallholder farmers, the TRANSFORM Program seeks to foster sustainable agricultural practices that enhance productivity and resilience, aligning with Ethiopia's broader agricultural development strategies and promoting food security across the country.

This baseline study was aimed to establish a comprehensive understanding of soil health and fertility among smallholder farmers in the target regions and woredas. The assessment also generated empirical data to benchmark the program's impact over four years by documenting current agricultural practices, socio-economic conditions, and challenges faced by farmers. Additionally, it evaluated farmers' knowledge and attitudes towards soil fertility management, aligning baseline objectives with measurable outcomes, such as increases in crop yields and adoption rates of sustainable practices. The findings also informed about participatory action research initiatives that encourage the adoption of innovative practices and support longitudinal monitoring by providing a basis for evaluating progress and adjusting strategies as needed. By integrating indigenous knowledge with modern techniques, the study fostered a holistic approach to sustainable soil management.

2. METHODOLOGY

2.1 Study Area

The baseline study was conducted across three key regions of Ethiopia: Amhara, Oromia, and Central Ethiopia, focusing on 12 selected woredas. Specifically, the baseline areas included five woredas in Amhara (four from South Wollo and one from North Shewa zones), six in Oromia (three from Arsi, two from Jimma, and one from West Guji zones), and one woreda from Halaba zone in Central Ethiopia (Figure 1). The selection of these woredas was guided by the following criteria to ensure representativeness:

1. **Agro-Ecological Diversity**: Capturing a range of agro-ecological conditions to understand various soil health and fertility management practices.
2. **Soil Health Conditions**: Including woredas with varying levels of soil degradation and management practices to identify effective interventions.
3. **Socio-Economic Factors**: Ensuring representation of regions with diverse agricultural practices, market access, and economic challenges.
4. **Gender and Youth Representation**: Addressing the roles and challenges faced by gender and youth in agriculture.

The woreda selection was in consultation with the Regional Bureaus of Agriculture (RBoAs) and Regional Agricultural Transformation Centers (RATCs), based on alignment with MoA flagship programs, presence of agricultural support structures, commercial crop varieties in the woredas, complementarity with other initiative, presence of national research centers, RATC units, TVETs, universities, and agro-input suppliers and accessibility. This strategic approach ensures effective monitoring and evaluation of the program's interventions, ultimately supporting sustainable agricultural practices and enhancing food security for smallholder farmers. This comprehensive assessment comprised of 48 kebeles (four from each woreda), effectively capturing diverse agricultural practices and conditions. The study emphasized on soil health and fertility management, socio-economic factors, and market linkages, while also focusing on gender and youth aspects.

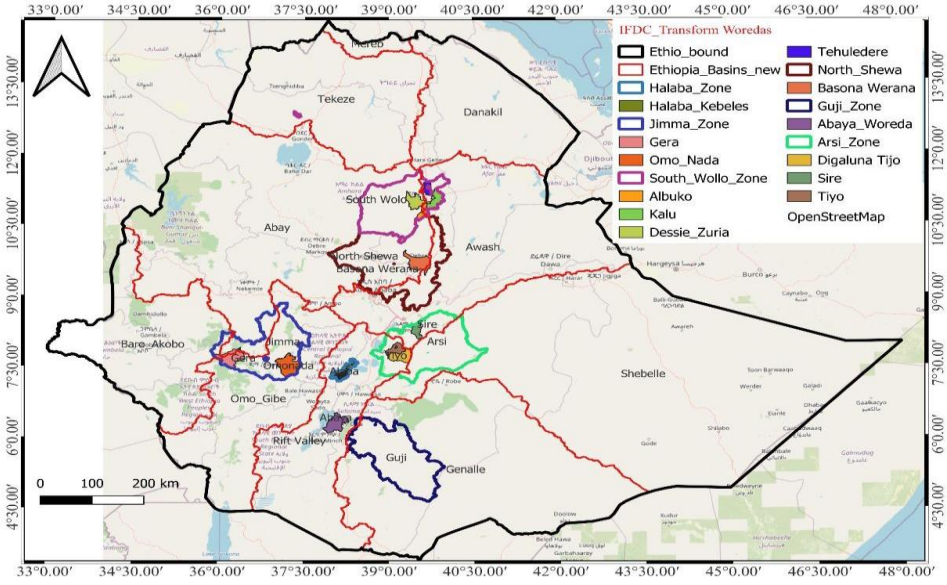


Figure 1: Baseline Study Map of the Target Woredas Across the three Regional States

2.2 The Study Design

2.2.1 Mixed-Method Approach

The study design employed a mixed-methods approach, integrating both quantitative and qualitative data collection techniques to ensure a comprehensive understanding of soil health and fertility management in the targeted regions. Structured household surveys were administered to gather quantitative data on farming and soil management practices, crop yields, and socio-economic conditions, with a justified sample size of 1,248 households across 12 woredas. This sample size was determined using Kothari's (2004) formula for sample size determination, which is based on the total target population of smallholder farmers 100,000, allowing for robust statistical analysis that can detect significant trends and variances at a 95% confidence level, DE = 2 (Design effect for population heterogeneity) and a - 5% acceptable error.

$$\mathbf{n} = DE * \left[\frac{z^2 pqN}{e^2(N-1)+z^2 pq}\right] * \frac{1}{R} \quad \text{.....1}$$

Where:
N=100,000 (total target small-scale farmers)
n = desired sample size
DE=2, (design effect for population heterogeneity)
p= 0.50, q=0.50 (acceptable precision, 5%)
z= 1.96 (Z score for 95% confidence)
R= 0.9 (overall response rate)

After accounting for potential non-response (10%), the final sample size was set at 1248. Equal proportion techniques were applied to allocate samples among the target Kebeles. The use of a stratified random sampling method ensures adequate representation of diverse demographic groups, enhancing the scientific rigor of the study. The target regions Amhara, Oromia, and Central Ethiopia Regional State were selected based on the Government of Ethiopia's prioritization of agricultural initiatives in the highlands, which account for most of the country's surplus production. Within these regions, the program will implement a full set of activities in 12 prioritized woredas, facilitating a targeted approach to soil fertility management.

The selection of 48 kebeles within these 12 woredas was guided by several factors. The kebeles were chosen to represent a spectrum of soil health conditions, including areas severely impacted by soil degradation and those with effective soil management practices. This diversity allows for a comprehensive analysis of the factors influencing soil fertility management in various contexts. Inclusion of both control and intervention kebeles facilitates comparative analysis of soil health management practices and their outcomes. Qualitative insights were gathered concurrently through key informant interviews (KIIs) and focus group discussions (FGDs), enabling an in-depth exploration of community perspectives and experiences related to soil fertility management practices. By employing a participatory approach, the study design fostered engagement with various stakeholders, including smallholder farmers, agricultural extension workers, and local institutions. This collaborative method enriches the data collection process and enhances the relevance of the findings to local contexts. The integration of gender-specific and socio-economic factors into the data analysis ensures that the interventions proposed by the TRANSFORM program are inclusive and effective. Overall, this robust study design aims to establish a solid baseline for ongoing monitoring and evaluation, ultimately supporting the program's objectives of improving agricultural productivity and sustainability in Ethiopia.

2.2.2 Sampling Strategy

The baseline study collected quantitative data from 48 kebeles, comprising 12 control and 36 intervention kebeles, to enable a robust assessment of agricultural practices, soil health and fertility management, and socio-economic conditions. A stratified random sampling method was applied, initially Kebeles were stratified based on the *'Got*[1] *framework*. From this stratification, a Got with severe soil degradation were purposefully selected, ensuring a focus on areas with the most critical needs. Finally, households were then randomly selected from these *Gots*.

To ensure comprehensive representation, we utilized a household listing from each kebele, from which 26 households were randomly chosen. Each selection aimed for proportional representation, with 8 households (30%) designated for women, 8 households (30%) for youth, and 10 households (40%) for adults. In cases where the number of women was insufficient in a kebele, we compensated by selecting additional women from the next kebele, ensuring balanced representation across demographics. Additionally, we maintained a reserve list of households to replace any that were missing, ensuring that the sample size remained intact. A total of 1,248 households were selected based on Kothari's formula for sample size determination, incorporating a 10% allowance for non-response and ensuring balance in gender and age representation. Each woreda contributed four kebeles with 26 households each, totaling 104 households per woreda. This design resulted in 312 control households and 936 intervention kebele households, providing sufficient and reliable baseline data aligned with project requirements and generalizable to the target population.

To mitigate potential sampling biases, such as underrepresentation of certain demographic groups or skewed agricultural practices, we employed the following strategies:

- Stratification: By stratifying kebeles based on soil degradation levels, we ensured that different farming contexts were adequately represented.
- Purposeful Selection: Gots with severe soil degradation were specifically chosen to address critical issues.
- Random Selection: Households within these kebeles were randomly selected to reduce selection bias and enhance the representativeness of the sample.
- Monitoring and Adjustment: Ongoing monitoring of the sampling process allowed for adjustments if any biases were identified during data collection.

Overall, these strategies aimed to enhance the validity and reliability of the study's findings, ensuring they effectively inform the program's interventions.

2.3 Data collection approaches

2.3.1 Quantitative Data Collection (Household Surveys)

The quantitative data collection for the baseline study involved structured household surveys targeting small-scale food producers in selected woredas to gather comprehensive information on soil health and fertility management, agricultural practices, socio-economic conditions, and soil health indicators. Prior to full implementation, the questionnaire underwent validation through a pilot testing phase conducted in **Sendafa town**, with the consent of smallholder farmers. Following the pilot, debriefings were held with the data collectors to discuss their experiences, gather feedback on the questionnaire, and identify any ambiguities or issues that needed addressing. This collaborative process ensured clarity and relevance in the questions before the main data collection commenced. Using Computer-Assisted Personal Interviewing (CAPI) methodology, trained enumerators employed digital tools for accurate data capture, real-time validation, and secure storage.

[1] Got is a neighborhood level administrative unit within kebele and is the primary contact for citizens living in a given Kebele.

A stratified random sampling method ensured balanced representation of demographic groups, with 1,248 households sampled: Male 860 (68.9%) versus Female 388 (31.1%), and Youth 452 (36.2%) versus adult (>35 years old) 796 (63.8%). The structured questionnaires covered key areas such as input usage, crop yields, and household income, thereby establishing a solid foundation for assessing the program's impact.
To address missing data or non-responses during analysis, a systematic approach was employed. Cases with incomplete responses were flagged, and efforts were made to follow up with households to obtain the necessary information. Additionally, we maintained a reserve list of households to replace any that were missing, ensuring that the sample size remained intact and representative.

2.3.2 Qualitative Data Collection (KIIs and FGDs)

The baseline study employed Key Informant Interviews (KIIs) and Focus Group Discussions (FGDs) to gain insights into soil health and fertility management practices. A total of 70 KIIs were conducted, with 16 at the federal level (including consortium members), 21 in Amhara, 25 in Oromia, and 8 in central Ethiopia regional states. Key stakeholders included representatives from the Ministry of Agriculture, Agricultural Regulatory Authority, Environmental Protection Authority, International Fertilizer Development Center (IFDC), ISRIC, Environment and Coffee Forest Forum (ECFF), SOS Sahel Ethiopia, Ethiopian Institute of Agricultural Research (EIAR), Regional Agricultural Research Institutes (RARIs) and Bureau of Agriculture, Zonal and Woreda Agricultural Offices, Research Centers, Agricultural Technical and Vocational Education and Training (ATVET), agro-input dealers, and Development Agents (DAs).

FGDs comprised 24 discussions, with 10 in Amhara, 12 in Oromia, and 2 in central Ethiopian regional states. Gender representation was ensured, with eight women's groups and sixteen men's groups. Participants were selected based on their expertise and involvement in soil management practices, and saturation was determined when no new insights emerged. Gender-sensitive facilitation was conducted, with female FGDs led by female qualitative data collectors, creating a comfortable and inclusive environment for participants to share their experiences. The breakdown of the qualitative data is presented in Appendices 35 and 36.

Table 1: Breakdown of Key Informant Interviews (KIIs) and Focus Group Discussions (FGDs)

Region	Woreda	Sample Distribution of KIIs and FGD	
		FGD	KII
Federal Level			16
Amhara	Regional level	-	2
	South Wollo Zone		1
	Kalu	2	3
	Albuko	2	2
	Desse Zuria	2	5
	Tehuledere	2	4
	North Shewa zone		1
	Basona Worena	2	3
Oromia	Regional level	-	5
	Arsi zone		1
	Sire	2	2
	Tiyo	2	3
	Digelu Tijo	2	3
	Jimma Zone		1
	Omo Nada	2	3
	Gera	2	3
	West Guji zone		1
	Abaya	2	3

Central Ethiopia	Regional level	-	4
	Halaba zone		1
	Weira	2	3
Total		**24**	**70**

Note: - *FGD = focus group discussion, KIIs = key informant's interview*

2.4 Data Management and Quality Assurance Mechanisms

The baseline study implemented rigorous data management and quality assurance procedures to ensure the integrity and reliability of the findings. A comprehensive data management plan was established, detailing protocols for data collection, entry, storage, and backup using secure digital platforms. Informed consent was obtained from all participants, emphasizing confidentiality and ethical engagement.

Data collectors received training on ethical guidelines and data protection measures, ensuring compliance with relevant regulations. To maintain data quality, standardized protocols were followed throughout the data collection process. Regular audits were conducted, with a frequency of checks at 5% of the collected data by supervisors. Error-checking thresholds were established to identify discrepancies, ensuring that any data inconsistencies were addressed promptly. Further, based on the feedback during validation workshop resurvey was undertaken especially on extension service indicators. Additionally, data anonymization procedures were implemented to strengthen confidentiality measures, ensuring that individual identities were not disclosed in any reports or analyses. These combined efforts enhanced the reliability and validity of the results.

2.5 Data Analysis

The study employed both quantitative and qualitative data analysis approaches. Quantitative analysis utilized statistical software STATA v. 17 and SPSS v. 27 to evaluate household survey data. Descriptive statistics and correlation analysis were employed to understand relationships between certain variables. This analysis provided insights into the effectiveness of current practices and established benchmarks for future monitoring, considering variations by gender and age. Qualitative analysis involved systematic coding and thematic review of KIIs and FGDs, identifying key themes related to soil health and community perspectives. To ensure the reliability of qualitative findings, inter-coder reliability checks were conducted, where multiple researchers independently coded the same data segments. Discrepancies were discussed and resolved collaboratively, enhancing the consistency and credibility of the analysis. This combination of methods enriched the overall findings, offering a comprehensive understanding of the factors influencing soil fertility management and informing targeted interventions.

2.6 Ethical Considerations

Ethical considerations were paramount throughout the baseline study, ensuring adherence to high ethical standards. Informed consent was secured from all participants, clearly explaining the study's objectives and the voluntary nature of participation. Participants were assured that their responses would remain confidential and used solely for research purposes. To ensure inclusivity, special attention was given to vulnerable populations, including women, youth, and individuals with disabilities. Measures were implemented to facilitate their participation, such as providing accessible information and ensuring gender-sensitive engagement during data collection.

3. FINDINGS OF THE BASELINE STUDY

3.1 Farm Household Analysis

3.1.1 Age of the Household Heads

The average ages of household heads were 44 and 42 years in the intervention and control kebeles, respectively, with a standard deviation of 12. A significant mean age difference was observed between the control and intervention groups (p = 0.017) (Table 2). The average ages of the youth and adult household heads were 31 and 50 years, respectively.

Although agriculture heavily relies on manual labor, farmers' increased experience in farming is likely to lead to a greater adoption of technologies and innovations, ultimately enhancing farming productivity. As age increases more than 55 years, however, productivity could decline. For instance, Hago and Mberengwa (2019) reported that farmers aged more than 55 years experienced a 15-20% lower crop yield compared to those in the middle-aged group (35-50 years). Similarly, CSA (2018) indicated that farms managed by older farmers (over 60 years) had 13% lower yields per hectare than those run by farmers aged 30-50 years. In addition to this, CSA (2023) reported that youth farmers demonstrated higher adoption rates of innovative practices. Yield decline becomes more pronounced among older female household heads due to a lack of labor and limited access to extension services. The findings reported by ActionAid Ethiopia (2021) revealed that older women (over 50 years) faced greater yield declines than men of the same age. Earlier findings indicate that farms managed by youth in Ethiopia, along with the supply of improved technologies and better access to extension services, tend to be more productive.

Table 2: Average age of household heads in the study areas, 2025.

Region	Woredas	Control HHs		Intervention HHs	
		n	Mean (SD)	n	Mean (SD)
Amhara	Kalu	26	39(10)	78	45(13)
	Albuko	26	44(10)	78	43(12)
	Desse Zuria	26	42(13)	78	42(12)
	Tehuledere	26	45(12)	78	44(14)
	Basona Worena	26	44(14)	78	45(13)
Oromia	Sire	26	39(12)	78	44(11)
	Tiyo	26	41(10)	78	44(12)
	Digelu Tijo	26	43(14)	78	43(12)
	Omo Nada	26	43(13)	78	44(13)
	Gera	26	46(13)	78	41(14)
	Abaya	26	34(10)	78	42(10)
CER	Weira	26	43(13)	78	47(14)
Overall Total	**Count and mean (SD)**	**312**	**42(12)**	**936**	**44(12)**
	T-test (p-value)	**2.4 (0.017)**			

3.1.2 Level of Education

The literacy levels of households in control and intervention kebeles were 62% and 69%, respectively, with a significant difference between the two groups (p = 0.008) (Table 3). The proportions of literate households were 73, 65, and 61% for the Oromia, Amhara, and the CE

Regional States, respectively. The literacy level was high for male-headed households (MHH) (82%), while it was far less for female-headed households (40%), indicating limited access to educational services for rural women. In the age category, youth (18 - 35 years old) are more literate (85%) compared to adults (35 years old and above) (60%), which is a natural expectation.

Studies indicate that education significantly improves farm productivity by enhancing farmers' ability to adopt modern techniques, manage resources efficiently, and access markets. For instance, the study by the World Bank (2020) revealed that farmers with basic education are 30-50% more likely to use chemical fertilizers and hybrid seeds. The study conducted in the Oromia region by the Ethiopian Economics Association reported that farmers with primary education achieved 25% higher wheat yield than illiterate farmers (EEA, 2019). The other report by MOA (2020) reported that educated farmers in the Amhara region reduced soil erosion by 35% using terracing. Overall, several research findings revealed the positive role of education in enhancing agricultural production and productivity. The existing literacy level of intervention kebeles (69%) presents a favourable opportunity to introduce, expand, and enhance the adoption of soil health and fertility management technologies and innovations. In this assessment, the simple logistic regression analysis indicated that formally educated households are 1.73 times more likely to use inputs compared to those that are not formally educated. The effect is statistically significant ($P < 0.05$), indicating that education makes a real difference in input use (Table 3).

Table 3: Illiteracy status of rural households in the study areas, 2025.

Region	Woreda	Control HHs		Intervention HHs	
		n	%	N	%
Amhara	Kalu	7	27	33	42
	Albuko	19	73	44	56
	Desse Zuria	12	46	20	26
	Tehuledere	8	31	21	27
	Basona Worena	7	27	18	23
Oromia	Sire	5	19	15	19
	Tiyo	7	27	15	19
	Digelu Tijo	7	27	9	12
	Omo Nada	18	69	36	46
	Gera	9	35	32	41
	Abaya	5	19	20	26
CER	Weira	15	58	30	38
Overall Total	**Count and percent**	**119**	**38**	**293**	**31**
	T-test	**2.6397 (0.008)**			
	Regression Odds ratio (p-value)	**1.73 (0.000)**			

3.1.3 Family Sizes of Rural Households

The overall average family size in the study areas was 5.2, with a range of 1 to 19. Among the control and intervention respondents, the average family sizes were 4.9 and 5.3, respectively, with a statistically significant difference between them ($p = 0.005$). The average family sizes of households in Central Ethiopia (CE), Oromia, and Amhara National Regional States were 6, 5.6, and 4.6, respectively (Table 4). The average family sizes in male and female-headed households were 6 and 5, respectively. Some woredas, such as Omo Nada and Abaya in the Oromia region, have large family sizes (7-8).

While some studies indicate the positive contribution of large family sizes, others have reported negative impacts. Hagos et al. (2019) reported that, despite higher labor availability, households with more than 6 family members had lower land productivity due to fragmentation. They also indicated that smallholder households (3-5 people) adopted improved seeds and fertilizers more efficiently. Families with 6-8 members produced 1.5 times higher maize yields than smaller households, primarily due to the availability of adequate labour (Tsegay & Bekele, 2017). On the other hand, households with more than 10 members demonstrated yield declines

due to land fragmentation. In this assessment, the simple regression analysis results indicate that family size and productivity are negatively related, with a coefficient of -1.69. This means that for each additional family member, productivity decreases by 1.69 quintals. The level of significance (P=0.034) indicates that the relationship between family size and productivity is statistically significant, revealing solid evidence that a larger family size is associated with lower productivity (Table 4). This could be due to lower investments in improved inputs and technologies because most of the family's earnings are primarily spent on food and basic necessities for family members.

Overall, the impact of family size on agricultural productivity depends on the nature of farming. For instance, a larger family size has a positive impact on labour-intensive farming, while a smaller family size has a positive impact on technology adoption. However, larger family sizes can significantly affect households' ability to invest in agricultural technologies due to resource dispersion and the intention to allocate more income to food and household demands.

Table 4: Family size of households in the study woredas, 2025.

Region	Woreda	Control HHs		Intervention HHs	
		n	Mean	N	Mean
Amhara	Kalu	26	5(1)	78	5(2)
	Albuko	26	5(1)	78	4(2)
	Desse Zuria	26	5(1)	78	5(2)
	Tehuledere	26	4(1)	78	4(2)
	Basona Worena	26	4(1)	78	5(2)
Oromia	Sire	26	5(2)	78	4(1)
	Tiyo	26	6(2)	78	5(2)
	Digelu Tijo	26	5(2)	78	6(2)
	Omo Nada	26	6(2)	78	6(2)
	Gera	26	4(2)	78	5(2)
	Abaya	26	6(2)	78	8(3)
CER	Weira	26	5(2)	78	6(2)
Overall Total	**Count and mean (SD)**	**312**	**4.9(2)**	**936**	**5.3(2)**
	T-test(p-values)	**2.8151(0.005)**			
	Regression coefficient (p-value)	**-1.691 (0.034)**			

3.1.4 Farm Sizes

The size of farmland is directly associated with food security, resource allocation, productivity, incomes, and labor efficiency. Managing the small size of farmland often increases costs and lowers farm incomes. On the other hand, the large size of farmland can reduce labor costs and generate higher incomes per unit of land. This is because of the principle of economies of scale. Studies indicate that small farms are often fragmented, increasing travel time and efforts required for farming activities, making the process more labor-intensive and high-cost per hectare (Dafa Gudina, 2025). In addition to this, farmers managing small plots cannot easily spread costs to cover larger areas, which lead to higher costs per unit of production (Ashok et al., 2023). On the other hand, larger farms can invest in technologies and spread costs per unit area. It also enables better planning and optimized input use, reducing per-unit costs in input use (Dafa Gudina, 2025).

The average landholding of households was 1.21 hectares (Table 5), which is 25% higher than the national average of 0.96 ha (FAO, 2023). The average landholding of Oromia, CE, and Amhara Regional states was 1.4, 1.1, and < 0.9 ha, respectively. The average landholding for control and intervention households was 1.21 and 1.16 ha, respectively, with no statistically significant difference between them (p = 0.379). Male-headed households owned 26% more land than female-headed households. On the other hand, adult-headed households owned 24% more land than youths. Land allocated for crop production, livestock, and irrigation was 0.87 ha (73%), 0.15 ha (13%), and 0.036 ha (3%), respectively (Table 6). Farm size usually affects agricultural productivity. Different studies have reported varying findings on the relationship between farm size and productivity.

Similarly, in this assessment, the simple regression analysis between farm size and income reveals a positive relationship with a coefficient of 81,980.85. This indicates that for every 1-hectare increase in farm size, income increases by 81,980.85 Birr. The statistically significant relationship (P < 0.001) provides strong evidence that land size positively impacts income (Table 5).

Table 5: Average total area of farmland in the study areas, 2025

Region	Woreda	Control HHs		Intervention HHs	
		n	Mean (SD)	n	Mean (SD)
Amhara	Kalu	26	0.52(0.55)	78	0.73(0.5)
	Albuko	26	1.11(0.63)	78	0.78(0.47)
	Desse Zuria	26	0.75(0.38)	78	0.9(0.44)
	Tehuledere	26	0.74(0.58)	78	0.81(0.51)
	Basona Worena	26	1.47(0.93)	78	1.49(0.96)
Oromia	Sire	26	1.98(1.13)	78	1.49(0.95)
	Tiyo	26	1.6(1.25)	78	1.69(1.07)
	Digelu Tijo	26	1.67(1.03)	78	1.64(1.04)
	Omo Nada	26	1.22(1.08)	78	1.42(1.07)
	Gera	26	0.97(0.87)	78	1.37(1.1)
	Abaya	26	0.56(0.18)	78	1.14(0.71)
CER	Weira	26	1.28(0.85)	78	1.03(0.5)
Total	**Count and mean (SD)**	**312**	**1.16(0.95)**	**936**	**1.21(0.88)**
	T-test(p-value)	**0.881 (0.379)**			
	Regression coefficient (p-value)	**81980.85 (0.000)**			

TRANSFORM program areas are operated by smallholder farmers who own a small amount of land (1.2 ha) to support the lives of 5 family members per household. Maximizing farm productivity per unit of land is one way to ensure adequate food production. This can be sustainably achieved by introducing, distributing, and scaling best practices for improved soil health and fertility management. Job creation in off-farm sectors is another option for youths, as there is often an inadequate amount of land available for farming businesses.

Table 6: Land use patterns for different farming operations, 2025.

	Amhara	Oromia	Central Ethiopia	Total

Land use patterns	n	Mean	n	Mean	N	Mean	n	Mean
Cultivated land for crops (ha)	390	0.71	468	1.02	78	0.72	936	0.87
Area of land used for livestock	390	0.15	468	0.15	78	0.2	936	0.15
Area of land used for forest/wood	390	0.04	468	0.08	78	0.01	936	0.06
Area of land under fallow	390	0.01	468	0.03	78	0.05	936	0.02
Area of land used for other purposes	390	0.01	468	0.11	78	0.01	936	0.06
Area of irrigated land	390	0.05	468	0.01	78	0	936	0.03

In Ethiopia, farm plot fragmentation is widespread due to inheritance systems, population pressure, and land redistribution policies. It is believed that fragmented plots reduce productivity, increase costs, and degrade the soil. The average farm plot fragmentation number in the Amhara, Oromia, and CE regional States was 3.2, 2.7, and 1.6 per household, respectively (Table 7). Hagos et al. (2019) reported that households with more than three plots had 22% lower barley yields compared to those with one to two plots. They reported that managing multiple small plots increases operational inefficiency, making timely coordination of agricultural activities difficult. Scattered plots are also less suitable for efficient input use, resulting in over-utilization at one plot and under-utilization at another. In addition, the study in the Oromia region reported that each additional plot reduced maize yields by 8% due to uneven input use (Taffesse et al., 2020). Smallholders with <0.5 ha/plot had 34% higher soil erosion rates in the Amhara region (Tesfaye et al., 2021). The average distance between the plots across all studied areas was 1.3 km, with distances ranging from 0.12 to 5 km (Table 7).

Table 7: Farm plot fragmentation and average distance between the plots, 2025.

	Region	n	Mean	Minimum	Maximum
Average number of fragmented plots	Amhara	520	3.2	1	19
	Oromia	624	2.7	1	10
	Central Ethiopia	104	1.6	1	4
	Total	1248	2.8	1	19
Average distance between the plots (Km)	Amhara	441	1.5	0.2	5
	Oromia	551	1.1	0.12	5
	Central Ethiopia	62	1.5	0.12	3
	Total	1054	1.3	0.12	5

To the greatest extent possible, scaling and adopting a cluster-based farming approach could enhance the efficient utilization of soil inputs. Cluster-based soil health and fertility management practices could maximize soil input use practices and enhance productivity. For instance, the study in the Arsi zone, Oromia region, by ATA (2021) reported that wheat clusters produced 30% higher yields than non-clustered farms. Cluster farming could also reduce costs per farm. The study conducted in the Amhara region by Mekonnen et al. (2021) indicated that cluster farms saved 25% on fertilizer costs. Clusters also enable bulk purchasing and optimal application of organic or mineral fertilizers. The study in the Tigray region has also reported that cluster-managed watersheds reduced soil erosion by 40-60%. Therefore, it is recommended that the program introduce and scale cluster-based watershed management and soil fertility improvement mechanisms.

3.1.5 Household Crop Productivity Level

The baseline assessment of average crop productivity (qt/ha) revealed noticeable variations between control and intervention kebeles across the target woredas for different crop types. For teff, the average yield was slightly higher in control kebeles (9.0 qt/ha) compared to intervention kebeles (8.0 qt/ha), though the difference was not statistically significant ($p = 0.1168$). Maize productivity was significantly higher in intervention kebeles (12.0 qt/ha) than in

control kebeles (10.0 qt/ha) (p = 0.0219). Wheat yields were almost identical between the two groups, averaging 18.9 qt/ha in control and 19.2 qt/ha in intervention kebeles (p = 0.8509) (Table, 8).

Barley productivity was considerably higher in intervention kebeles (20.4 qt/ha) compared to control kebeles (15.1 qt/ha), a statistically significant difference (p = 0.006), possibly reflecting better adoption of improved agronomic practices or varieties. Sorghum yields were nearly the same in both groups, averaging 11.0 qt/ha in control and 10.4 qt/ha in intervention kebeles (p = 0.6467). Haricot bean productivity, however, was significantly higher in intervention kebeles (13.5 qt/ha) than in control kebeles (10.7 qt/ha) (p = 0.0398) (Table, 8).

Overall, these results suggest that productivity differences are both crop- and location-specific. Intervention kebeles showed better performance in maize, barley, and haricot beans, while control kebeles had relatively higher yields in teff and sorghum. These findings highlight the importance of tailoring agricultural interventions to specific crop–location contexts rather than applying uniform strategies across all crops and woredas.

Table 8: Average Crop Productivity (quintals per hectare) for Main Crops in the Target Woredas

Woreda	Kebele	Teff		Maize		Wheat		Barley		Sorghum		Haricot bean	
		n	Mean	n	Mean	n	Mean	n	Mean	n	Mea	n	Mean
Kalu	Intervention	51	8.7	5	13.9					66	11.3		
	Control	10	7.7							25	13.3		
Albuko	Intervention	56	6.2	12	13.2	55	7.7	21	5.9			17	6.8
	Control	19	6.0			26	8.1					12	6.2
Desse Zuria	Intervention	50	9.8	2	21.3	51	18.1	33	8.1			3	9.1
	Control							26	7.9				
Tehule dere	Intervention	51	5.4	6	5.1	33	7.7			12	9.1	8	5.4
	Control	26	5.9	7	6.4					16	8.8		
Basona Worena	Intervention	25	15.0			42	21.5	47	15.1			55	12.7
	Control	26	13.3			25	19.9	5	13.9			13	13.8
Sire	Intervention	61	12.3	12	18.3	65	22.4	8	20.6			7	11.3
	Control	25	12.8	15	22.0	16	15.5						
Tiyo	Intervention	11	14.6			37	34.2	59	29.6			31	18.7
	Control					25	32.9	10	27.5			6	22.8
Digelu Tijo	Intervention					24	27.9	69	26.8			35	18.8
	Control					19	19.0	7	25.0			7	10.2
Omo Nada	Intervention	43	6.0	78	16.9					5	8.0		
	Control	13	8.9	26	11.6					6	6.2		
Gera	Intervention	30	5.5	58	9.5					8	6.0	4	9.0
	Control			22	11.0								
Abaya	Intervention	15	5.0	76	8.7							8	4.6
	Control			26	3.6								
Weira	Intervention	37	2.9	73	10.7					9	6.6		
	Control	6	1.2	26	8.3								
Total	Intervention	430	8.0	326	12.0	310	19.2	238	20.4	105	10.4	169	13.5
	Control	133	9.0	128	10.0	116	18.9	50	15.1	53	11.0	48	10.7
T-test	T-value	1.5707		2.3002		0.1881		2.8001		0.4592		2.069	
	P-value	0.1168		0.0219		0.8509		0.006		0.6467		0.0398	

3.1.6 Average Farm Incomes

Farm incomes have direct implications for the use of high-quality farm inputs, including seeds, fertilizers, and machinery. Increased farm income enables farmers to invest in improved agricultural technologies and inputs, thereby enhancing their productivity. It also determines access to irrigation and risk management. Financially secure farmers can diversify businesses

and tolerate climate hazards. The overall average annual household farm income was Ethiopian Birr 43,836. This total average income was derived from crop production, livestock production, off-farm, the Productive Safety Net Program (PSNP), and remittances. The major source of income was cereal crop production. The average income in intervention kebeles was ETB 45,895, compared to ETB 38,623 in control kebeles, with no statistically significant difference (p = 0.077) (Table 8). Male-headed households generated 56% more income compared to female-headed counterparts. In the age category, households in the youth age range generated 26% more income than households in the adult age range. Youth adopt new technologies faster than adults/old farmers, and they also shift production strategies according to market demands (AGRA, 2025). Youth farmers are more willing to take risks and tend to be more open to innovation and change.

Table 9: Average household farm income in the target woredas, 2025

Region	Woreda	Control HH		Intervention HH					
		n	Mean	n	Mean	Min	Max	Income per capita	SD
Amhara	Kalu	25	13326	75	14013	400	80000	2998.73	3586.88
	Albuko	19	17848	59	17796	2000	62000	5051.46	7283.75
	Desse Zuria	24	11375	90	33342	1000	600000	6008.57	8272.73
	Tehuledere	27	18749	105	22194	1000	200000	5131.41	6016.13
	Basona Worena	53	36053	174	40709	900	588000	8310.85	10586.31
Oromia	Sire	58	74116	215	86753	600	900000	21050.10	32691.33
	Tiyo	66	108696	229	87396	500	1000000	17429.96	30589.30
	Digelu Tijo	68	73287	255	84707	500	948000	16166.39	28127.20
	Omo Nada	70	10486	163	15260	200	176700	2528.21	3624.96
	Gera	51	4970	147	11103	200	100000	2966.54	4090.29
	Abaya	52	2612	225	10533	200	210000	1775.28	7286.81
CER	Weira	42	11760	95	29568	1500	400000	5159.75	9557.17
Overall Total	Count and mean	555	38623	1832	45895	200	1000000	9512.04	20808.78
	T-test (P-value)	1.7698(0.077)							

Different studies have reported positive impacts of increased incomes on household productivity. A 10% increase in farm income resulted in a 6.5% increase in cereal yields, attributed to improved input utilization (Abay et al., 2021). A 1,000 Birr increase in annual farm income led to 18% higher fertilizer use, 12% greater adoption of improved seeds, and 9% increases in cereal yields and 10% increase in off-farm incomes, increasing farm productivity by 4.2% (Minten et al., 2019). Farmers in the study area diversify income sources, which contributed to the overall farm income and resilience. About 71% of the income was generated from mixed crop-livestock farming businesses, such as cereals (27%), animal fattening (10%), perennial crops (10%), poultry production (9%), dairy production (8%), and root crops production (7%) (Figure 2). In an environment frequently affected by climate-related challenges and soil degradation, diversifying incomes will help Program beneficiaries to minimize risks and enhance climate resilience. Crop-livestock and soil fertility integration will also enhance farm incomes.

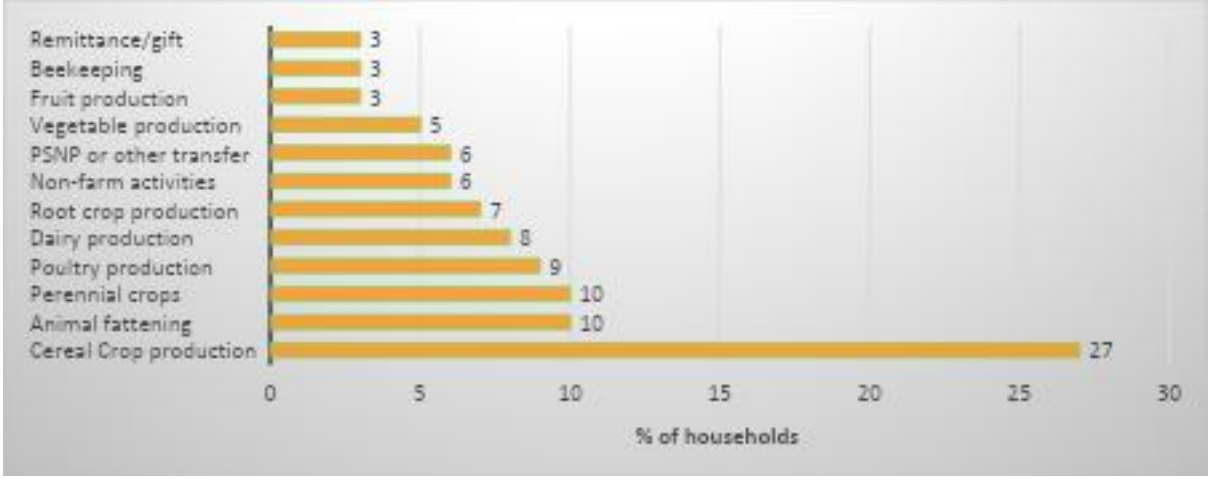


Figure 2: Diversified income sources of intervention households in the study areas, 2025.

3.1.7 Dependency Ratio

The dependency ratio is a demographic measure that compares the economically dependent population (those in the young and old age ranges) to the working-age population (the economically active population that supports the dependents). The study of the dependency ratio is crucial because it helps determine the proportion of the economically active population that supports a given proportion of dependents. For instance, a higher dependency ratio means fewer workers support more dependents.

According to the findings of this baseline study, the average total dependency ratio is 77 in the intervention group and 75 in the control group. This means that every 100 economically active individuals (aged 15–64) support themselves plus an additional 75 and 77 dependents, respectively (Table 9).

In general, a dependency ratio below 50 is considered favorable. Ratios between 50–70 are regarded as moderately risky, while values above 70 indicate high risk, as they impose a significant economic burden. In this study, the overall average dependency ratio is 75 for the control group and 77 for the intervention group, both exceeding the 70 threshold. This suggests a high risk of households facing food shortages, particularly in the CER, where the dependency ratio surpasses 100. Similarly, some woredas in Oromia, such as Omo Nada and Abaya, also show very high dependency ratios (>100.These woredas are more likely to face severe food shortages because they support a higher number of dependents.

The implication is that a household with higher dependents spends very little on agricultural investments (such as improved seeds and fertilizers), as most of the earnings are allocated to food and meeting the other needs of dependents. Integrated approaches are required to address this challenge, one of which is increasing productivity per unit of area through improved soil health and fertility, as well as other technologies. Riskier households require special attention in development support.

Table 10: Dependency ratio (DR) of farming households in the study areas (%), 2025.

Region	Amhara	DR for Control HHs			DR for Intervention HHs		
		n	Mean	SD	n	Mean	SD
Amhara	Kalu	25	85	61	77	76	58
	Albuko	26	55	43	78	50	50
	Desse Zuria	24	52	44	78	55	51
	Tehuledere	26	46	51	76	57	56
	Basona Worena	26	47	54	77	62	57
Oromia	Sire	24	77	70	77	56	50
	Tiyo	24	98	80	72	70	65
	Digelu Tijo	25	62	60	77	80	69

	Omo Nada	25	112	86	71	98	68
	Gera	24	56	54	69	92	71
	Abaya	24	130	76	73	122	70
CER	Weira	25	87	56	74	108	72
Total		298	75	67	899	77	65

3.2 Cross-Cutting Themes

3.2.1 Household Decision Making

In Ethiopia, household-level decision-making is strongly influenced by gender dynamics, access to resources, and socio-economic conditions, which in turn shape crop choices, labor allocation, technology adoption, and productivity. Traditionally, in patriarchal communities where men dominate, most household decisions were made by men. However, years of gender-focused interventions have begun to shift these dynamics.

This baseline assessment focused on male-headed households with both husband-and-wife present, excluding female-headed households, to assess joint decision-making on resources such as land, inputs, income, housing, and assets. Findings indicate that joint decision-making accounted for 56% in intervention households and 51% in control households. The highest proportion in the intervention group was observed in the CER at 83%, followed by Amhara at 60% and Oromia at 48% (Table 11). It is believed that joint decision-making of men and women contributes to productivity growth. The study on land productivity by Kumar and Quisumbing (2015) in the Oromia region revealed that joint decision-making reduced the productivity gap by 12%. Additionally, female participation in decision-making increased compost uses by 25% (Mekonnen et al., 2021).

According to the findings, it is recommended that the TRANSFORM program involve both men and women in its implementation of activities. In youth category households, more awareness-raising efforts are required for both men and women on shared household-level decision-making and its contributions to productivity growth.

Table 11: Households' decision-making practices on resources, 2025.

Region	HH members	Control HHs		Intervention HHs	
		n	%	n	%
Amhara	Husband	30	33.0	101	38.3
	Wife	2	2.2	1	0.4
	Joint decision	59	64.8	159	60.2
	Others	0	0.0	3	1.1
Oromia	Husband	60	56.1	167	50.9
	Wife	0	0.0	2	0.6
	Joint decision	47	43.9	158	48.2
	Others	0	0.0	1	0.3
Central Ethiopia	Husband	13	72.2	6	11.5
	Wife	0	0.0	1	1.9
	Joint decision	5	27.8	43	82.7
	Others	0	0.0	2	3.9
Overall	Husband	103	47.7	274	42.6
	Wife	2	0.9	4	0.6
	Joint decision	111	51.4	360	55.9
	Others	0	0.0	6	0.9

3.2.2 Gender Roles and Access in Crop Production and Soil Fertility Management

In smallholder farming systems, where family labor is central, all working-age household members contribute to varying degrees. Findings show that in intervention kebeles, 70% of men and 65% of women participate in soil health and fertility management, compared to 69% of men and 63% of women in control kebeles (Table 12). The relatively higher participation of women

in this baseline, compared to what is often observed on the ground, is partly due to the intentional inclusion of 30% female-headed households in the sample in this baseline assessment. Among youth households, men's participation (86%) exceeded that of women (55%), whereas in adult households, women's involvement (70%) was higher than men's (62%). No child labor was reported in crop or soil fertility management activities.

In female-headed households, 96% of women were involved in crop production, while 93% in soil fertility management activities. Despite the dominant role they play, their productivity is often lower than that of their male-headed counterparts, primarily due to economic reasons. This aligns with the study by Bezabih et al. (2021) in the Amhara region, who reported that female-managed plots yielded 23% less teff due to less fertilizer use. In addition to this, Mekonnen et al. (2021) in their studies in the Tigray region revealed that male-headed farmers adopted improved seeds twice as often as female-headed farmers.

Low productivity of women is mainly attributed to limited access to improved agricultural inputs. If women get access to improved inputs, skill-based training, and extension services, they can enhance their productivity and economic gain. To address unequal access to resources, there is a need to empower women and help them enhance their economic capacities through the provision of in-kind input loans, create access to financial services, and engage in IGAs (income-generating activities) through demand assessments.

The finding was supported by the World Bank (2023), which reported that empowering women could increase GDP by USD 5 billion per year. To maximize the economic contribution of women, the program is recommended to empower women substantially by creating access to improved soil health and fertility management technologies, as well as capacity-building supports. In the study areas, a gender gap was observed in households belonging to the youth category. The TRANSFORM program should also provide a focus on closing the gender gap in youth families through awareness creation and women's empowerment.

Table 12: Gender Roles in Soil Health and Fertility Management Activities, 2025.

Region	HH members	Control HH		Intervention HH	
		n	%	n	%
Amhara	Husband	87	67	269	69
	Wife	88	68	253	65
	Children (>18 years)	17	13	44	11
Oromia	Husband	111	71	338	72
	Wife	95	61	307	66
	Children (>18 years)	12	8	35	7
Central Ethiopia	Husband	18	69	50	64
	Wife	14	54	48	62
	Children (>18 years)	4	15	2	3
Total	Husband	216	69	657	70
	Wife	197	63	608	65
	Children (>18 years)	33	11	81	9

3.2.3 Social Networks and Youth Participation

Social networks are webs of relationships among the farmers. This can take the form of farmers' linkages with their peers, neighbors, relatives, farmers' cooperatives, extension agents, traders, community associations, and others. In the context of Ethiopia, social networks facilitate the sharing of information, pooling of resources, and collective action. In the study areas, nearly 70% of both men and women in both intervention and control kebeles have established social networks (Table 13).

A substantial set of information related to new technologies, practices, and services is often conveyed through these social networks. For instance, the study by Abate et al. (2016) has revealed that farmers learn about fertilizers, seeds, and irrigation from peers. Households connected to strong social networks are also more likely to adopt new technologies faster. The

TRANSFORM program presents a favorable opportunity to convey improved information on soil health and fertility management practices through these social networks.

Table 13: Membership of households in social networks, 2025.

Region	HH Members	Control HH		Intervention HH	
		n	%	n	%
Amhara	Husband	88	68	262	67
	Wife /FHH	86	66	259	66
	Children (>18 years)	4	3	15	4
Oromia	Husband	109	70	321	69
	Wife /FHH	105	67	328	70
	Children (>18 years)	4	3	11	2
Central Ethiopia	Husband	18	69	51	65
	Wife /FHH	19	73	60	77
	Children (>18 years)	1	4	2	3
Total	Husband	215	69	634	68
	Wife /FHH	210	67	647	69
	Children (>18 years)	9	3	28	3

3.2.4 Farmers' Organizations and Social Capital

In Ethiopia, farmers' cooperatives/unions and groups play essential roles in increasing agricultural productivity through input distribution, creating market linkages, and providing extension services and information for their farmers. According to a 2024 report by the Ethiopian Cooperative Commission, there are more than 80,000 registered farmers' cooperatives across various agricultural sectors, including crop production, coffee, horticulture, dairy, livestock, and others. However, there were no cooperatives organized specifically for natural resources management, including soil health and fertility.

In intervention and control kebeles, 55% and 47% of the households, respectively, were members of farmers' cooperatives at the time of the baseline study (Table 13). Membership was high in some woredas, such as in Abaya woreda of Oromia region (67%) and Kalu woreda in Amhara region (60%). In Weira woreda of CER, 54% of the households were members of farmers' cooperatives.

Membership in cooperatives helps farmers reduce costs, access farm inputs, and engage in bulk purchasing or sales of products. According to Bernard et al. (2020), cooperative members borrow 3 times more than non-members. Bulk purchase of fertilizers and seeds also reduces costs by 20-30%. In the livestock sector, farmers who are members of dairy cooperatives have also increased milk sales by 40%. Additionally, farmer groups organized in agricultural commodity clusters increased wheat yields by 1.5 tons/ha (ATA, 2021). Overall, cooperatives enhanced farm productivity by 20-40% through collection actions, joint marketing, and risk sharing.

Households that joined cooperatives are also members of social groups, which enables them to have strong social capital. Social capital, in turn, boosts agricultural productivity by facilitating the faster dissemination of information among peer networks. It also serves as a risk-sharing mechanism in times of climate change or other hazards. Farmers in the study areas have developed substantial social capital, which can be considered a favorable foundation for introducing soil health and fertility management practices that require community mobilization for sustainability and resilience.

Existing cooperatives can serve as entry points for the program to convey extension messages on improved technologies for soil health and fertility management, and disseminate information more efficiently among members and beyond. This is because cooperatives disseminate messages 5 times faster than individual farmers (ATA, 2021). Moreover, the

program can also facilitate group purchases and distribution of soil inputs (fertilizer, lime) via cooperatives to minimize costs per household. Activities that can be implemented through community mobilization, such as physical soil and water conservation mechanisms, can also be easily managed by cooperative members. TRANSFORM can also target women-led cooperatives to further empower them and ensure they receive economic benefits.

Table 14: Households' involvement in Cooperatives and Farmers' Groups, 2025.

Region	Woreda	HH members	Control HHs		Intervention HHs	
			n	%	n	%
Amhara	Kalu	Husband	11	42	47	60
		Wife /FHH*	12	46	27	35
	Albuko	Husband	10	38	32	41
		Wife /FHH	5	19	12	15
	Desse Zuria	Husband	9	35	38	49
		Wife /FHH	6	23	18	23
	Tehuledere	Husband	8	31	37	47
		Wife /FHH	5	19	15	19
	Basona Worena	Husband	16	62	45	58
		Wife /FHH	16	62	53	68
Oromia	Sire	Husband	14	54	44	56
		Wife /FHH	10	38	36	46
	Tiyo	Husband	16	62	47	60
		Wife /FHH	10	38	33	42
	Digelu Tijo	Husband	18	69	48	62
		Wife /FHH	9	35	36	46
	Omo Nada	Husband	13	50	45	58
		Wife /FHH	7	27	29	37
	Gera	Husband	10	38	36	46
		Wife	12	46	35	45
	Abaya	Husband	12	46	52	67
		Wife /FHH	11	42	39	50
CER	Weira	Husband	10	38	42	54
		Wife /FHH	4	15	33	42
Overall Total		Husband	147	47	513	55
		Wife /FHH	107	34	366	39

*FHH=Female Headed Household

3.2.5 Disability Inclusion and Accessibility

Disability is often understood as a physical and mental impairment that limits the full participation of the victim in life and economic activities, including farming. According to the Ethiopian Demographic and Health Survey reported by CSA, 15% of the population in Ethiopia lives with disabilities (CSA & ICF, 2017). It was also reported that rural areas had higher disability rates (16%) than urban areas (12%). However, the findings of this baseline study indicate that the disability rate in the rural population of the study areas at the time of the study was 5% (Table 14). Among those households with persons with disability, half of them reported the type to be physical disability, followed by visual and mental impairment. EDHS has also reported that the common type of disability was mobility or physical impairment.

It is believed that disability significantly reduces agricultural productivity mainly by limiting labor efficiency, technology adoption, and access to resources. For instance, Merga et al. (2022) have reported that households with disabled members produced 20-30% less due to the inability to perform and a slower work pace. It was also reported that disabled farmers are 50% less likely to use improved seeds and fertilizers (Tilahun et al., 2021). EDHS has also revealed that disabled-headed households are 3 times more likely to face hunger, and the children in these households suffer 2 times higher stunting rates.

Given the realities, it is essential to raise awareness about disability inclusion for development agents (DAs), Woreda Agriculture Offices, and other stakeholders to introduce and strengthen disability-inclusive extension services. DAs could be trained on how to communicate and support the farmers with disabilities. Policy support is also required for subsidized support of farming tools. In addition to this, integrated approaches are required with other stakeholders who can support persons with disabilities by providing low-cost ergonomic tools that help reduce physical strain and improve mobility. The other option for the program is to establish disability-inclusive farmer field schools to raise awareness about technologies, promote experimentation, and increase adoption. The reasons for this advice are that 90% of the disabled farmers have not received any support so far.

Table 15: Incidence of disability status in the households of the study areas, 2025.

Region	Woreda	Control HHs		Intervention HHs	
		n	%	n	%
Amhara	Kalu	2	8	6	8
	Albuko	3	12	2	3
	Desse Zuria	0	0	2	3
	Tehuledere	3	12	3	4
	Basona Worena	1	4	3	4
Oromia	Sire	2	8	2	3
	Tiyo	0	0	2	3
	Digelu Tijo	1	4	3	4
	Omo Nada	0	0	4	5
	Gera	3	12	6	8
	Abaya	0	0	10	13
CER	Weira	0	0	5	6
Overall		15	5	48	5

3.3 Customize Extension Service and Empower Farmer Household and Communities to Adopt Soil Health and Fertility Best Agroecological Practices

3.3.1 Soil Fertility Status of the Intervention Woredas based upon EthioSIS Maps

In the absence of recent soil test results, the following baseline maps derived from the NSIS-EthioSIS Project (MoANR and ATA, 2016 for Amhara (A), Oromia (O) and SNNPR (S), specifically from soil samples collected between 2012 and 2016, are depicted and synthesized to establish an initial understanding of soil conditions in the 102 baseline woredas. Despite their oldness, these existing woreda-level maps can provide modest insights into the prevailing soil pH and nutrient status, thereby serving as an indicative baseline for informing agricultural interventions and monitoring future changes in soil health. Given the soil's dynamic nature, a current soil test will be recommended during the TRANSFORM Program's project life period to assess the soil's current status and establish baseline soil test values and analytical outcomes.

The below woreda maps are presented and briefly discussed in the following order: Basona Worana, Tehuledere, Kalu, Albuka, and Dessie Zuria (Amhara region); Gera, Omo Nada, Sire, and Tiyo (Oromia region); and the previous Halaba woreda, which consisted of the recent target woreda of Weira as well as Wera Dijo and Atoto woredas with their central administrative town of Kulito.

i. Basona Worana Woreda (North Shoa zone, Amhara region):

[2]*Although the baseline woredas are 12, NSIS-EthioSIS's Woreda Maps for Digalu Tigo and Abaya woredas of Oromia region are not available.*

An analysis of soil conditions in Basona Worana Woreda revealed that the majority of kebeles exhibited neutral pH levels (Appendix 22). A small number of moderately acidic kebeles were identified, primarily in the western and northern parts of the Woreda. Importantly, nearly all kebeles were classified as salt-free zones, with consistently low levels of calcium carbonate. Regarding nutrient availability, most kebeles showed significant deficiencies. There were very low levels of available phosphorus (P), available sulfur (S), and extractable boron (B). Furthermore, total nitrogen (N), organic matter (OM), and the potassium (K) to magnesium (Mg) ratio were all low. In contrast, the majority of kebeles were characterized by high concentrations of calcium (Ca), iron (Fe), and silicon (Si), alongside a high carbon (C) to nitrogen (N) ratio.

ii. Tehulederie Woreda (South Wollo zone, Amhara region):

Like Basona Worana Woreda, Tehulederie Woreda predominantly exhibits a neutral pH level across most of its kebeles (Appendix 23). A significant positive finding is that nearly all kebeles in Tehulederie are classified as salt-free zones, indicating minimal salinity issues. However, the soil map analysis also reveals widespread nutrient deficiencies. Most kebeles in Tehulederie Woreda are characterized by low levels of total nitrogen (N), available phosphorus (P), boron (B), and copper (Cu). Furthermore, the potassium (K) to magnesium (Mg) ratio is also consistently low. Of particular concern is the very low level of available sulfur (S) found across the majority of kebeles, which could significantly impact agricultural productivity.

iii. Kalu Woreda (South Wollo zone, Amhara region):

Similar to the previously discussed woredas in the Amhara region, soil analysis in Kalu Woreda reveals that most areas exhibit a neutral soil pH (Appendix 24). Encouragingly, nearly all kebeles within Kalu Woreda are classified as salt-free zones, indicating a favorable absence of salinity issues. However, nutrient availability presents a mixed picture. Available phosphorus (P) and boron (B) levels generally fall within the range of very low to low. Of particular concern is the consistently very low level of available sulfur (S) across the woreda. Conversely, the analysis indicates a healthy supply of certain other nutrients. Exchangeable potassium (K) and extractable iron (Fe) appear at high levels in most kebeles. Furthermore, calcium (Ca) levels are notably abundant, with most kebeles showing concentrations ranging from high to very high.

iv. Albuko Woreda (South Wollo zone, Amhara region):

Soil map analysis in Alubuko Woreda indicates that while a few kebeles are experiencing moderately acidic conditions, the majority maintain a neutral pH level (Appendix 25). A significant positive finding is that nearly all kebeles are salt-free zones, which is favorable for agricultural practices. Regarding soil nutrients, the report highlights some critical deficiencies. Both available sulfur (S) and extractable boron (B) are present at very low levels across the woreda. Similarly, total nitrogen (N) is predominantly found at low levels. In contrast, the woreda exhibits healthy levels of certain other essential nutrients, with exchangeable potassium (K), magnesium (Mg), and extractable copper (Cu) all present at optimum levels.

v. Dessie Zuria Woreda (South Wollo zone, Amhara region):

Similar to Kalu Woreda, Dessie Zuria Woreda faces moderately acidic conditions in a few of its kebeles (Appendix 26). However, the majority of kebeles in Dessie Zuria maintain a neutral pH level, and almost all are fortunately salt-free zones. Regarding soil nutrients, several elements are present at low levels across Dessie Zuria Woreda. These include total nitrogen (N), organic matter, extractable molybdenum (Mo), potassium (K) to magnesium (Mg) ratio, and calcium (Ca) to magnesium (Mg) ratio. More critically, available phosphorus (P) and extractable boron (B) are found at very low levels, which could significantly impact agricultural productivity.

vi. Gera Woreda (Jimma zone, Oromia region):

Unlike the woredas previously discussed in the Amhara region, Gera Woreda in Oromia exhibits a significant challenge with soil acidity (Appendix 27). The majority of kebeles in Gera Woreda face either strongly or moderately acidic soil problems, with no areas recording a neutral pH level. Despite this, a positive environmental factor is that almost all kebeles are salt-free zones, indicating a minimal presence of salinity with a very low level of calcium carbonate. In terms of soil nutrient levels, Gera Woreda presents a varied profile. Many kebeles show very high levels of exchangeable potassium (K), along with high levels of calcium (Ca) and extractable iron (Fe). Furthermore, a considerable number of kebeles also exhibit high levels of total nitrogen (N) and organic matter (OM), which are crucial for soil fertility. Conversely, several key nutrients are critically low. Available phosphorus (P) and extractable boron (B) are all present at very low levels. The ratios of potassium (K) to magnesium (Mg) and calcium (Ca) to magnesium (Mg), as well as extractable cobalt (Co), display a wide range, falling somewhere between high and low levels across the woreda. Lastly, the carbon (C) to nitrogen (N) ratio is generally low to medium in most kebeles, with only a few isolated areas showing a high C-N ratio.

vii. Omo Nada Woreda (Jimma zone, Oromia region):

Soil analysis in Omo Nada Woreda reveals a different acidity profile compared to Gera Woreda, though still challenging (Appendix 28). Most kebeles in Omo Nada are grappling with moderately acidic soil problems, with a few areas exhibiting strongly acidic soils. Conversely, very few areas in the woreda maintain a neutral soil pH. Similar to Gera Woreda, a positive finding for Omo Nada is the widespread absence of salinity, as almost all kebeles are free from soil salinity problems. Regarding nutrient availability, several key elements are present at very low levels. Notably, available phosphorus (P), calcium carbonate, and extractable boron (B) are all deficient. However, the woreda shows healthy levels of other essential nutrients: exchangeable potassium (K), magnesium (Mg) saturation percentage, and extractable zinc (Zn) are all at optimum levels. Additionally, extractable copper (Cu) is predominantly at an optimum level, though a few isolated areas within some kebeles do show lower concentrations.

viii. Sire Woreda (Arsi zone, Oromia region):

Soil analysis in Sire Woreda reveals a unique pH distribution (Appendix 29). The majority of kebeles exhibit moderately alkaline conditions, followed in prevalence by areas with moderately acidic and then neutral pH levels. A significant positive finding across the woreda is that almost all kebeles are salt-free zones, indicating no widespread issues with soil salinity. Regarding nutrient levels, there's a distinct geographical pattern for total nitrogen. Most kebeles in the southern part of Sire Woreda show low levels of total nitrogen (N), while a smaller number of kebeles in the north exhibit high levels of total N. Available phosphorus (P) is consistently very low throughout Sire Woreda. Conversely, many kebeles have optimum levels of extractable copper (Cu), zinc (Zn), and iron (Fe). Magnesium (Mg) is also at optimum levels, though in a smaller number of kebeles. Finally, the ratios of carbon (C) to nitrogen (N), potassium (K) to magnesium (Mg), and calcium (Ca) to magnesium (Mg) are high in a few southern kebeles. However, these same ratios are generally between low and medium in the majority of kebeles located in the northern part of the woreda.

ix. Tiyo Woreda (Arsi zone, Oromia region):

Soil analysis in Tiyo Woreda reveals that most kebeles contend with moderately acidic soil conditions, with a smaller number experiencing strongly acidic soils (Appendix 30). A few kebeles in the eastern part of the woreda do exhibit a neutral pH level, and interestingly, some areas in the north-east show moderately alkaline soils. With regard to nutrient levels, the most significant deficiency in Tiyo Woreda is available phosphorus (P), which is present at very low levels. Sulfur (S) is also a concern, with low levels found in most kebeles. On a positive note, extractable zinc (Zn) and copper (Cu) are generally present at optimum levels. In terms of area

coverage, exchangeable potassium (K) appears to be in better supply than total nitrogen (N). While only a few kebeles in Tiyo Woreda have high levels of total N, several exhibit very high to high levels of K. Extractable boron (B) shows variability, being very low in many kebeles but low to optimum in some others. Finally, a number of kebeles show low to medium levels for the calcium (Ca) to magnesium (Mg) ratio, the carbon (C) to nitrogen (N) ratio, extractable cobalt (Co), and extractable molybdenum.

x. Halaba Woreda of SNNPR for Weira Woreda of the Central Ethiopia region:

A neutral pH level characterizes most kebeles in the Halaba Zone (Appendix 31). However, some areas face challenges, with a few kebeles experiencing moderately acidic soil problems, and a small number of kebeles in specific areas exhibiting moderately alkaline soils. Based on electrical conductivity levels, Halaba is largely a salt-free zone, which is beneficial for agricultural activities. The zone also predominantly shows low to medium levels of calcium carbonate. Nutrient distribution in Halaba Zone presents a varied picture. There are significant deficiencies in several key nutrients across the kebeles. Available phosphorus (P) and available sulfur (S) show very low levels in numerous kebeles, while magnesium (Mg) and extractable boron (B) are found at low levels in a smaller number of kebeles. Conversely, the zone boasts healthy to abundant levels of other important nutrients. Exchangeable potassium (K), extractable iron (Fe), and extractable molybdenum (Mo) are all available at very high levels. Similarly, calcium (Ca), extractable zinc (Zn), and extractable copper (Cu) are present at optimum levels in most kebeles, contributing positively to overall soil fertility.

3.3.2 Engagement in Household Inclusive and Participatory Extension Services

The updated baseline survey results highlight disparities in engagement with inclusive and participatory extension services among smallholder farmers in Amhara, Oromia, and the Central Ethiopia Region (CER). In Amhara, engagement rates varied significantly, with Kalu showing 26.9% of control households and 29.5% of intervention households participating, while Basona Worena had higher rates at 46.2% for controls and 50.0% for interventions. Overall, however, participation rates were lower among intervention households in Amhara, averaging 24.6%. This situation underscores the need for refined household selection processes to ensure that extension services effectively reach the intended beneficiaries.
In Oromia, the gap in engagement was more pronounced, with Sire showing no participation and Tiyo only 2.6% among intervention households. Omo Nada had the highest participation, with 42.3% of control households engaged compared to 38.5% for interventions. Across the region, control households averaged 23.1% participation, while intervention households saw a mere 15.6%. These findings emphasize the necessity for localized extension strategies that build farmer trust and foundational extension structures, especially in low-participation woredas. Farmer-led and community-based platforms may offer a more sustainable pathway for promoting soil fertility management than solely relying on top-down interventions.

In the Central Ethiopia Region, Weira Woreda indicated 34.6% engagement for control households and 32.1% for intervention households. Overall, the total engagement across all regions revealed that only 20.7% of intervention-priority households participated in inclusive and participatory extension services.
This highlights a critical need for targeted strategies to enhance accessibility and inclusivity in extension programs, particularly for vulnerable groups. Scaling context-specific Integrated Soil Fertility Management (ISFM), which combines mineral and organic fertilizers (Doldt et al., 2023; Tamene et al., 2017), requires trained extension staff, decentralized soil testing (Hougni, 2023; Vanlauwe et al., 2023), and responsive input supply chains. Multi-channel delivery systems such as farmer field schools and SMS advisories (Alemayehu et al., 2025; IFDC, 2025) can also increase adoption when paired with hands-on follow-up. Strong linkages between woreda offices, research centers, and private suppliers ensure that recommendations match available inputs (LETA et al., 2020; Kansiime et al., 2022; Hörner et al., 2019; Berhane et al., 2018).

Table 16: Respondents Engagement in Household Inclusive and Participatory Extension Services

Region	Woreda	Control		Intervention	
		n	%	n	%
Amhara	Kalu	7	26.9	23	29.5
	Albuko	12	46.2	21	26.9
	Desse Zuria	9	34.6	13	16.7
	Tehuledere	3	11.5	13	16.7
	Basona Worena	12	46.2	39	50.0
	Total	43	33.1	96	24.6
Oromia	Sire	0	0.0	0	0.0
	Tiyo	0	0.0	2	2.6
	Digelu Tijo	10	38.5	4	5.1
	Omo Nada	11	42.3	30	38.5
	Gera	5	19.2	11	14.1
	Abaya	10	38.5	26	33.3
	Total	36	23.1	73	15.6
CER	Weira	9	34.6	25	32.1
Overall Total		**88**	**28.2**	**194**	**20.7**

3.3.3 Agronomic Management and Crop Production Practices

Diverse types of agronomic management and crop production are widely practices across the study areas. Overall, 91.9% of intervention kebeles' households reported practicing agronomic management, with slightly higher adoption among female-headed households (92.7%) compared to male-headed (92.0%). Youth participation was also strong at 90.1% (Table 17).

The use of agronomic practices was widespread in several woredas, including Albuko, Basona Worena, and Omo Nada, where all surveyed households practiced agronomic management. High but slightly lower rates were observed in Kalu (88.5%), Dessie Zuria (92.3%), Tehuledere (94.9%), Sire (94.9%), Tiyo (93.6%), and Abaya (94.9%). Digelu Tijo (89.7%) and Gera (85.9%) recorded somewhat weaker adoption, particularly among youth. The lowest coverage was found in Weira, where only 67.9% of households reported practicing agronomic management, with both youth and adults showing relatively limited participation.

In summary, adoption is nearly universal across most woredas, but important gaps remain in areas such as Weira and Gera, especially among younger farmers, underscoring the need for targeted extension efforts.

Table 17: Farmers' experiences in practicing agronomic and crop production practices

Regions	Woredas	Intervention		HH nature				Age Categories			
				Male		Female		Youth		Adult	
		N	%	N	%	N	%	N	%	N	%
Amhara	Kalu	69	88.5	50	92.6	19	79.2	23	92.0	46	86.8
	Albuko	78	100	53	100	25	100	29	100	49	100
	Desse Zuria	72	92.3	50	90.9	22	95.7	26	92.9	46	92.0
	Tehuledere	74	94.9	51	94.4	23	95.8	25	89.3	49	98.0
	Basona Worena	78	100	48	100	30	100	27	100	51	100
Oromia	Sire	74	94.9	50	94.3	24	96.0	25	96.2	49	94.2
	Tiyo	73	93.6	53	96.4	20	87.0	24	92.3	49	94.2
	Digelu Tijo	70	89.7	49	90.7	21	87.5	24	88.9	46	90.2
	Omo Nada	78	100	54	100	24	100	28	100	50	100
	Gera	67	85.9	51	89.5	16	76.2	29	87.9	38	84.4
	Abaya	74	94.9	51	92.7	23	100	25	96.2	49	94.2
CER	Weira	53	67.9	37	71.2	16	61.5	15	65.2	38	69.1
Overall Total		860	91.9	597	92.7	263	90.1	300	92.0	560	91.8

Cropping systems are diverse, influenced by factors such as land availability, cultural practices, and technical knowledge. In the baseline study areas, the most perceived agronomic management and crop production practices were Intercropping, crop rotation, relay and alley cropping, and fallowing.

Intercropping: Intercropping adoption varied widely across woredas. In Amhara, rates among intervention kebeles were generally high, ranging from 66.7% in Dessie Zuria to full coverage (100%) in Basona Worena. Kalu (81.2%), Albuko (79.5%), and Tehuledere (82.4%) also showed strong adoption, with both male- and female-headed households actively engaged.

In Oromia, adoption was highly uneven. Abaya (97.3%) and Omo Nada (83.3%) reported near-universal engagement, while Gera (76.1%) and Digelu Tijo (21.4%) showed moderate uptake. By contrast, Sire (4.1%) and Tiyo (5.5%) had almost no adoption, reflecting critical gaps in intercropping practices.

In Central Ethiopia, Weira recorded 69.8% adoption, with higher engagement among youth (81.3%) than adults (64.9%). Overall, adoption was strongest in Basona Worena, Abaya, and Omo Nada, while Sire and Tiyo highlighted severe gaps in practice (Figure 3, Appendix 1.A).

Crop rotation: Crop rotation was the most widely practiced system across surveyed woredas, with 89.4% of intervention kebeles kebele households engaged overall. Adoption was consistently high in most areas, reaching 100% in Sire and Digelu Tijo, and near-universal in Basona Worena (98.7%), Tiyo (98.6%), Tehuledere (94.6%), Albuko (94.9%), and Weira (94.3%). Kalu (89.9%), Gera (89.6%), and Omo Nada (87.2%) also showed strong participation. By contrast, Dessie Zuria (79.2%) and especially Abaya (47.3%) recorded lower adoption, with Abaya showing very limited participation among female-headed households.

Disaggregated results indicate male-headed (82.4%) and adult-headed households (88.6%) were slightly more engaged than female-headed (73.4%) and youth-headed (89.8%)

households. Overall, crop rotation is a dominant practice, though significant gaps remain in a few woredas, particularly Abaya (Figure 3, Appendix 1.B**)**.

Alley cropping: Alley cropping was adopted at relatively low levels across surveyed woredas, with considerable variation. In Amhara, adoption ranged from 10.3% in Basona Worena to 23.0% in Tehuledere, while Kalu (20.3%), Albuko (19.2%), and Dessie Zuria (16.7%) showed modest uptake. In Oromia, adoption was higher in some areas, reaching 31.3% in Gera and 28.2% in Omo Nada, while Sire (25.7%) and Digelu Tijo (22.9%) also reported notable engagement. Lower rates were observed in Tiyo (16.4%) and Abaya (10.8%). The highest adoption overall was recorded in Weira (56.6%), where more than half of the intervention kebeles' households practiced alley cropping. Across regions, adoption was more common among male-headed and youth households, though female and adult-headed households also participated to varying degrees (Figure 3; Appendix 1.C).

Fallowing practices: Fallowing was the least adopted practice overall, reported by only 20.1% of intervention kebeles households across regions. In Amhara, adoption was very low, ranging from 2.9% in Kalu to 9.7% in Dessie Zuria. By contrast, Oromia showed higher uptake, with Digelu Tijo (45.7%), Sire (43.2%), and Tiyo (41.1%) recording the strongest adoption. Gera (37.3%) and Weira (24.5%) also reported moderate levels, while Omo Nada and Abaya reported a 19.2% and 6.8% adoption of fallowing practices.

Male-headed youth households were the most likely adopters (20.9%), followed by adult male-headed households (18.3%). Female-headed households participated less, though youth and adult groups showed some engagement. Overall, fallowing remained a minority practice, with adoption concentrated in a few Oromia woredas (Figure 3; Appendix 1.D).



Figure 3: Agronomic Practices concerning the study Woredas (Cropping system)

3.3.4 Farm-level cost of production

Across the control households, average labor costs per hectare for crop production varied among regions and woredas. In Amhara, the highest cost was recorded in Kalu, where control households invested 43,329 Birr/ha, indicating a relatively strong labor commitment to soil fertility activities. Tehuledere and Basona Worena followed, with 30,320 Birr/ha and 21,808

Birr/ha, respectively, suggesting moderate levels of investment. By contrast, Albuko (17,711 Birr/ha) and Dessie Zuria (14,421 Birr/ha) recorded comparatively lower costs, reflecting more constrained household labor inputs.

In Oromia, control households showed mixed patterns. Tiyo (16,452 Birr/ha) and Sire (11,972 Birr/ha) demonstrated relatively higher labor allocations, while Digelu Tijo registered an exceptionally high but unusual figure (126,576 Birr/ha) that may reflect unique localized conditions of intensive labor demand. Conversely, Omo Nada (6,483 Birr/ha), Gera (8,615 Birr/ha), and Abaya (2,995 Birr/ha) reported significantly low expenditure, suggesting limited application of labor-intensive practices. In the Central Ethiopia Region (CER), Weira control households reported 14,612 Birr/ha, a relatively modest level of spending. The control baseline reflects that many households, particularly in Amhara woredas like Kalu and Tehuledere, are already committing substantial labor to soil fertility management, while others especially in Oromia low-cost areas face constraints that may undermine long-term soil productivity.

Among intervention priority households, labor costs per hectare were generally higher than in control areas, indicating stronger engagement with labor-intensive soil fertility measures. In Amhara, intervention households in Kalu spent the most, averaging 66,215 Birr/ha, nearly 53% higher than control households. This was followed by Dessie Zuria (34,375 Birr/ha) and Albuko (27,609 Birr/ha), where labor commitments more than doubled relative to control households, reflecting relatively strong adoption of fertility practices under intervention households. Tehuledere households reported 29,016 Birr/ha, while Basona Worena showed 18,866 Birr/ha (Table 18), suggesting that interventions were yet to translate into labor increases in these woredas.

In Oromia, intervention priority households in Tiyo (17,750 Birr/ha) and Sire (14,924 Birr/ha) continued to show strong labor allocations. Digelu Tijo households reported 19,759 Birr/ha, significantly lower than the control anomaly but still high compared to most woredas, indicating consistent investment in fertility-enhancing practices. In contrast, intervention households in Omo Nada (8,765 Birr/ha), Gera (13,766 Birr/ha), and Abaya (11,448 Birr/ha) remained at low-to-moderate levels. In CER, Weira's intervention households reported only 3,904 Birr/ha, pointing to severe underinvestment and possibly limited labor capacity among intervention groups (Table 18).

Table 18: Estimated average labor cost per hectare for crop production (hired & imputed family labor)

Region	Woreda	Interventions Type		Intervention Priority households			
				Nature of household		Age category of the HH heads	
		Control	Interventions	Male headed	Female headed	Youth	Adult
Amhara	Kalu	43329	66215	64853	70591	76745	60177
	Albuko	17711	27609	28306	25919	30127	26207
	Desse Zuria	14421	34375	31369	42839	35195	33916
	Tehuledere	30320	29016	27562	32909	27263	30117
	Basona Worena	21808	18866	19963	16655	21553	17290
Oromia	Sire	11972	14924	14612	15624	13582	15595
	Tiyo	16452	17750	16316	22257	17174	18045
	Digelu Tijo	126576	19759	18622	22689	11085	23246
	Omo Nada	6483	8765	10017	6156	11345	7432
	Gera	8615	13766	14132	12321	15201	12594
	Abaya	2995	11448	11919	10609	12029	11051
CER	Weira	14612	3904	3937	3867	3636	3919

The data reveal clear patterns: intervention households in woredas like Kalu, Albuko, and Dessie Zuria are increasing labor inputs, which supports integrated soil fertility management practices such as compost preparation, deep tillage, and erosion control. These areas show promising potential for long-term soil health improvement. However, in woredas with persistently low labor allocations particularly in Oromia (Omo Nada, Gera, Abaya) and CER (Weira) soil fertility risks may be high. These findings highlight the importance of targeted support to ensure equitable labor mobilization, especially for female- and youth-headed households who often face capacity constraints. Without such tailored interventions, disparities in labor investment could deepen, threatening the sustainability of soil fertility and crop productivity across regions.

3.3.5 Awareness and Adoption of Sustainable Land Management

The baseline survey results indicate substantial yet uneven adoption of Sustainable Land Management (SLM) practices across various woredas in Amhara, Oromia, and the Central Ethiopia Region (CER). The most prevalent practices included a combination of organic soil fertility management such as compost, vermicompost, household wastes, manure, biochar, and mulching and mineral fertilizer application (N, P, K, and NPS). These were complemented by structural and biological interventions including soil and water conservation, water harvesting, crop rotation, agroforestry, reforestation, and gully rehabilitation. The findings revealed significant disparities in SLM coverage between intervention priority households and control households.

In Kalu, intervention households managed an average of 0.38 ha under SLM, covering 57.4% of their land, while control households only covered 0.16 ha (36.5%). Albuko showed a similar trend, with intervention households covering 26% of their land with SLM practices compared to 33.4% for control households. Desse Zuria had intervention households managing 0.29 ha under SLM (36.0%), compared to control households at 0.28 ha (40.7%). Meanwhile, Tehuledere exhibited lower adoption rates, with intervention households covering only 27.7% of their land, while control households managed 32.0%.

In Basona Worena, SLM coverage was notably low, with only 12.6% of intervention land covered compared to 8.0% for control households. Sire demonstrated a slight edge, with intervention households managing 0.24 ha (17.5%) under SLM versus 0.35 ha (18.1%) for controls. Tiyo reported the lowest adoption, where control households covered just 5.0% of their land with SLM practices, while intervention households managed 18.0%. In Digelu Tijo, the intervention households achieved 27.9% coverage with an average of 0.43 ha, compared to control households at 26.9%. Omo Nada and Gera showed limited engagement with 16.6% and 8.6% coverage, respectively, among intervention households. In contrast, Abaya had a high adoption rate of 51.1% among intervention households, compared to 72.9% for controls.

Overall, while intervention households showed relatively high average land coverage of 25.8%, targeted efforts are crucial to enhance SLM practices effectively.

Table 19: Area of land covered by SLM practices in the 2016/17 E.C. (2024) cropping season (ha)

Woreda	Control				Intervention			
	n	Average land size (ha)	Average land covered by SLM (ha)	% land covered by SLM	n	Average land size (ha)	Average land covered by SLM (ha)	% land covered by SLM
Kalu	26	0.52	0.16	36.5	78	0.73	0.38	57.4
Albuko	26	1.11	0.32	33.4	78	0.78	0.2	26.0
Desse Zuria	26	0.75	0.28	40.7	78	0.9	0.29	36.0
Tehuledere	26	0.74	0.24	32.0	78	0.81	0.19	27.7
Basona Worena	26	1.47	0.11	8.0	78	1.49	0.16	12.6
Sire	26	1.98	0.35	18.1	78	1.49	0.24	17.5
Tiyo	26	1.6	0.06	5.0	78	1.69	0.27	18.0
Digelu Tijo	26	1.67	0.37	26.9	78	1.64	0.43	27.9

Omo Nada	26	1.22	0.14	8.3	78	1.42	0.16	16.6
Gera	26	0.97	0.09	19.5	78	1.36	0.09	8.6
Abaya	26	0.56	0.37	72.9	78	1.14	0.49	51.1
Weira	26	1.28	0.16	15.4	78	1.03	0.09	10.5
Total	312	1.16	0.22	26.4	936	1.21	0.25	25.8

At baseline, recorded willingness to invest in SLM was near-universal among control households across Kalu, Albuko, Dessie Zuria, Tehuledere, Basona Worena, Sire, Digelu Tijo, Abaya, Gera, and Weira, with limited reluctance in Omo Nada and Tiyo. Among households in intervention kebeles, willingness was also high; Kalu, Albuko, and Basona Worena recorded complete willingness, while Dessie Zuria, Tehuledere, Omo Nada, Gera, and Tiyo showed some reluctance. Sex- and age-disaggregated results are presented in Table 20.

FGDs in Chefa Gugesa (Digelu Tijo) noted fragmented land management efforts, with individual measures such as terraces and bunds often implemented without coordination, sometimes creating conflicts between farmers. The absence of agroforestry and limited watershed management highlight the need for more systematic interventions. Willingness also varied by type of SLM practice. Soil and Water Conservation (SWC) structures dominated, covering 64 ha, but only 51.4% were willing to invest due to high labor demands. By contrast, lime application had the highest willingness (66.7%), followed by manure application (61.5%), composting (59.2%), organic fertilizer (59.5%), and agroforestry (58.4%). Crop residue management (56.6%) and cover cropping (55.2%) also attracted moderate interest, while biochar (54.8%) showed potential due to its recognized soil fertility benefits.

In Debele Kebele (Bosana Worena Woreda) intervention kebele, FGD and KIIs participants reported SWC activities in about seven watersheds, including terracing, tree planting, reforestation, agroforestry, and community-based watershed management. These interventions have improved soil conditions and restored fertility in some areas. However, gully erosion linked to poorly constructed or maintained structures remains a major problem. Participants expressed readiness to address this issue if provided with adequate support.

Overall, the baseline reveals overwhelming readiness among both control and intervention households to adopt SLM, with only localized resistance. This provides fertile ground for scaling up interventions, shifting the focus from persuasion to ensuring access to inputs, training, and incentives, while targeting hesitant groups with tailored support.

Table 20: Farmers' willing to invest in SLM practice in the Amhara, Oromia, and central Ethiopia regional States

Region	Woreda	Intervention Status		Control Households				Intervention Households			
				Nature of household		Age category		Nature of household		Age category	
		C	T	M	F	Youth	Adult	M	F	Youth	Adult
		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		N	N	N	N	N	N	N	N	N	N
Amhara	Kalu	90	410	67	23	35	55	294	116	138	272
	Albuko	128	344	88	40	35	93	242	102	127	217
	Desse Zuria	88	380	69	19	27	61	272	108	151	229
	Tehuledere	125	340	92	33	33	92	243	97	116	224
	Basona Worena	100	337	68	32	35	65	213	124	114	223
	Sire	73	206	52	21	33	40	146	60	70	136

Region	Woreda	Intervention Status		Control Households				Intervention Households			
				Nature of household		Age category		Nature of household		Age category	
		C	T	M	F	Youth	Adult	M	F	Youth	Adult
		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		N	N	N	N	N	N	N	N	N	N
Oromia	Tiyo	52	231	39	13	18	34	160	71	71	160
	Digelu Tijo	90	285	69	21	42	48	201	84	91	194
	Omo Nada	56	185	40	16	15	41	127	58	58	127
	Gera	48	188	33	15	12	36	139	49	79	109
	Abaya	72	459	51	21	45	27	346	113	144	315
CER	Weira	78	176	52	26	28	50	118	58	47	129
Overall Total		1000	3541	720	280	358	642	2501	1040	1206	2335

Note: *C-Control, T-treatment, M-Male, F-Female, N indicates response of HHHs (Multiple's responses for all/ partial SLM practices listed under table 18); C-Control, T-treatment, M-Male, F-Female*

Overall, SWC structures, biochar, crop residue management, and agroforestry dominate in terms of land coverage, while lime application, reforestation, manure use, and agroforestry rank highest in terms of investment willingness. These findings underscore the need for region-specific, gender and youth-inclusive strategies that combine the scaling of dominant practices with targeted support for emerging techniques to achieve sustainable, farmer-driven land management.

Strengthening awareness and adoption of SLM is vital for achieving land degradation neutrality and sustainable rural development. A key milestone in this effort is the TRANSFORM Project, which envisions a significant shift toward inclusive and participatory approaches. By addressing long-standing socio-institutional gaps, the project will enable communities to co-develop soil fertility solutions, enhancing adaptive land management capacities.

3.3.6 Farmers' Perceptions on Soil Degradation

The perception of soil degradation as a critical issue varies considerably across regions and woredas, with the Amhara region consistently demonstrating greater awareness compared to Oromia and the Central Ethiopia Region (CER). This increased awareness in Amhara is reflected in both control (88.5%) and intervention (78.7%) kebeles. Within the region, certain farmer subgroups in Albuko and Tehuledere reported complete agreement (100%), indicating a profound understanding of the issue, likely driven by noticeable erosion and decreasing crop yields. In Dessie Zuria, the area with the lowest reported awareness in the region, 78.2%.

Focus group discussants in the 019/Asgedo Kebele, an intervention kebele within Dessie Zuria Woreda, reported experiencing "very severe" soil degradation. They indicated that erosion is continuously degrading their land, reducing its productivity, and causing the loss of valuable topsoil. Additionally, they noted that local water sources have dried up and that land fragmentation is an ongoing challenge, further exacerbating the decline in agricultural potential.

In contrast, Oromia displayed much lower concern, with only 48.1% of control and 46.6% of intervention households perceiving degradation as a problem. Tiyo and Sire reported extremely low concern—down to 11.5% in some subgroups—indicating either limited awareness, differing land-use pressures, or comparatively resilient soils. However, the exception of Abaya woreda, which reported 100% agreement, suggests that where degradation is severe or awareness is high, farmers' perceptions can align with those in Amhara (Table 21).

The focus group discussion (FGD) results obtained from male-headed households in the Debele kebele, Shamba village, of Bosana Worena outlined that farmers' land was seriously degraded due to a lack of proper and integrated soil and water conservation measures. Findings from the FGDs indicate that a major challenge was the uncontrolled flow of water in multiple directions, with no established land management system in place. The discussants also outlined the primary soil degradation and soil fertility problems, including soil erosion (particularly gully formation), declining soil fertility due to acidity, flood damage, and lack of proper drainage. This unmanaged runoff is contributing to soil degradation, highlighting an urgent need for appropriate treatment and conservation interventions. Farmers use terraces to control soil erosion, but much of the land remains degraded. According to FGD, fertilizers are essential for maintaining productivity, with no recent new interventions introduced. They obtain fertilizers through cooperatives at fixed prices. Regional disparities reflect both environmental realities and differences in exposure to land management interventions. The high concern in Amhara suggests either more severe visible land degradation or effective historical outreach programs (UNCCD, 2017).

Conversely, Oromia's low awareness levels—despite evidence of environmental stress—highlight the need for targeted awareness campaigns and participatory diagnostics to confirm whether the issue is underestimated or genuinely less severe. Findings from FGDs and KIIs indicated that the watersheds in Chefa Gugesa of Digalu Tijo are experiencing severe soil degradation, largely due to the absence of sustainable land management and protection measures. Although previous community-led initiatives, such as terracing and reforestation, had contributed to improving soil fertility, the current situation shows significant degradation of the soil resource. These findings align with studies indicating that awareness of soil degradation is often linked to visible erosion, declining yields, and historical extension activities (FAO, 2021; Teklewold et al., 2019).

At baseline, 66.7% of households in control areas and 63.5% of households in intervention kebeles reported soil degradation. In Amhara, reported levels were higher, with 88.5% of control households and 78.7% of intervention households identifying degradation, while in Oromia the proportions were lower but followed a similar pattern. Across all regions, 64.9% of male-headed households and 62.9% of female-headed households reported soil degradation; in Amhara, concern among female-headed households reached 93.9% in Albuko, whereas in Oromia, female-headed households in Tiyo reported 12.9%. By age group, 66.0% of adult-headed households and 61.3% of youth-headed households reported soil degradation nationally, with the lowest youth figure recorded in Digelu Tijo at 25.6%. The lowest youth perception occurred in Digelu Tijo (25.6%), consistent with research indicating that youth are less engaged in SLM due to limited farming experience (Nkonya et al., 2016).

Degaga Kebele (Control) of Albuko – FGD participants reported that soil erosion and declining soil fertility—linked to the area's topography, land location, and land fragmentation —are the primary soil degradation problems. Despite having water-abundant areas, agricultural productivity has declined. Additionally, waterlogged conditions lead to soil saturation, creating challenges for cultivation and land use. The discussants indicated that Degaga Kebele encompasses four distinct watersheds, in which the Tere watershed has received targeted interventions, including area closures, tree planting, and soil bund construction. These efforts aim to improve soil and water management, reduce erosion, and enhance the overall productivity of the watershed. Overall, 66.7% of all respondents recognized soil degradation as a significant issue, but perception varied by region, gender, and age. The high awareness in Amhara versus the lower awareness in Oromia—except Abaya—underscores the need for region-specific awareness enhancement strategies. In Chefa Gugesa of Digalu Tijo, the major land degradation challenges affecting watersheds and surrounding farmlands include soil erosion, road cavity formation, gully and streambank erosion, waterlogging, intrusion of new weed species, and a gradual decline in soil fertility. Continuous soil nutrient loss driven by erosion

and natural soil aging processes has led to declining agricultural productivity over time (FGD, KIIs).

Table 21: Farmers' perception of the soil degradation problem in the study woredas

Regions	Woreda	Intervention Status				Nature of household				Age category of the HH			
		Control		Intervention		Male		Female		Youth		Adults	
		Yes		Yes		Yes		Yes		Yes		Yes	
		N	%	N	%	N	%	N	%	N	%	N	%
Amhara	Kalu	23	88.5	59	75.6	55	76.4	27	84.4	28	77.8	54	79.4
	Albuko	26	100	71	91	66	93	31	93.9	32	88.9	65	95.6
	Desse Zuria	16	61.5	61	78.2	55	74.3	22	73.3	26	65	51	79.7
	Tehuledere	26	100	54	69.2	57	78.1	23	74.2	30	83.3	50	73.5
	Basona Worena	24	92.3	62	79.5	53	81.5	33	84.6	29	78.4	57	85.1
	Total	115	88.5	307	78.7	286	80.6	136	82.4	145	78.4	277	82.7
Oromia	Sire	9	34.6	18	23.1	20	28.2	7	21.2	9	23.1	18	27.7
	Tiyo	3	11.5	24	30.8	23	31.5	4	12.9	8	22.2	19	27.9
	Digelu Tijo	10	38.5	25	32.1	23	31.5	12	38.7	10	25.6	25	38.5
	Omo Nada	16	61.5	40	51.3	44	61.1	12	37.5	20	54.1	36	53.7
	Gera	11	42.3	33	42.3	31	41.3	13	44.8	17	40.5	27	43.5
	Abaya	26	100	78	100	71	100	33	100	42	100	62	100
	Total	75	48.1	218	46.6	212	48.7	81	42.9	106	45.1	187	48.1
CER	Weira	18	69.2	69	88.5	60	85.7	27	79.4	26	81.3	61	84.7
Overall Total		208	66.7	594	63.5	558	64.9	244	62.9	277	61.3	525	66

3.3.7 The root causes of soil degradation

The analysis of soil and land degradation across the surveyed woredas reveals a persistent and complex challenge, with degradation rates, spatial scope, and severity remaining high. Over 60% of households in control kebeles of Kalu, Albuko, and Tehuledere, and 50% in intervention kebeles, state that soil degradation problems occur "always" during the season (Figure 4). The degradation is not only frequent but also spatially extensive. A significant proportion of respondents reported that degradation affects large portions of their farmland. In the intervention kebeles, over 50% of household's report that the problem is "always affecting their land," despite the application of sustainable land management practices intended to curb broad-scale degradation (Appendix 6).

Moreover, FGD results revealed that, in Albuko Woreda, Dindin (04) Kebele, based on the landscape's topography, the main challenges include soil erosion caused by rainfall, declining soil fertility, and reduced agricultural productivity. To address these issues, farmers apply compost, practice fallowing, and implement crop rotation. While the use of mineral fertilizers on black soils or other lands can provide temporary improvements, traditional practices such as compost application, crop rotation, and fallowing contribute to long-term soil health, enhance fertility, and improve crop yields.

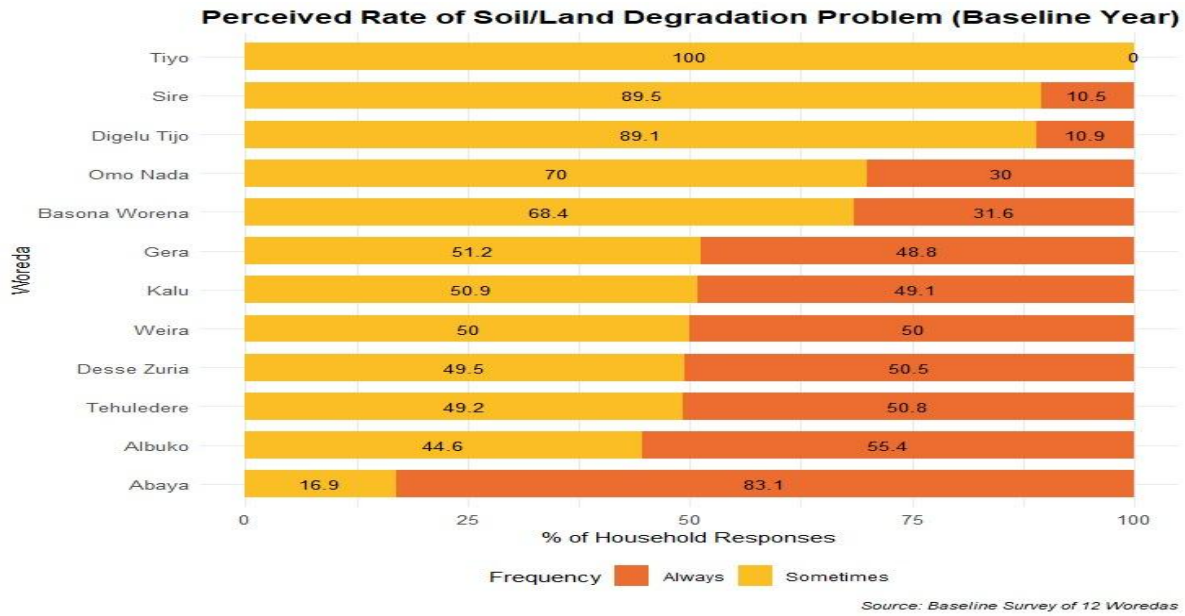


Figure 4: Rate of soil degradation problem occurrence for the baseline year/season

The situation is further exacerbated when examining the current degree of degradation. In several woredas, a substantial share of household's report that degradation has either "increased" or "highly increased" in recent seasons. For example, in Albuko (intervention kebeles), 70% of respondents fall into these categories, reflecting a concerning trend (Appendix 7). This is likely linked to structural drivers such as population pressure, shortened fallow periods, and incomplete adoption of soil fertility practices. Disaggregated results reveal that adult-headed households report higher degradation levels than youth-led households, possibly due to longer-term land tenure and agricultural practices. However, youth respondents show low engagement in addressing degradation, underscoring the urgent need for youth-focused land conservation strategies.

According to the FGD findings in Albuko Woreda, Dindin (04) Kebele, which encompasses three watersheds—Kilekili, Geshe, and Karahada, the hilly topography makes the area highly susceptible to soil erosion, particularly during rainfall and windy conditions, leading to noticeable soil degradation. Among these, the Karahada watershed has been the focus of green development initiatives, including the planting of exotic tree species such as Sesbania, Shiwshwe, and Leucaena. In addition, SWC measures have been implemented to mitigate erosion and improve land productivity.

However, the findings indicated that degradation remains a persistent and potentially worsening issue in many woredas, posing long-term risks to agricultural productivity and food security. Addressing this challenge requires scaling up landscape-level planning, aligning interventions with local socio-environmental dynamics, and actively engaging youth to ensure sustainable land stewardship.

3.3.8 Farmers' participation in Biophysical Land Management (BLM)

The Amhara region exhibits the highest participation rate, with 86.9% of respondents actively engaged in BLM initiatives (Table 22). This strong performance suggests either historically entrenched community-based natural resource management systems or more effective institutional frameworks, including extension services, proactive local governance, or active involvement from development partners (FAO, 2021). Conversely, Oromia records a much lower participation rate of only 36.5%, indicating systemic challenges such as limited access to extension services, weaker community mobilization, or pressing livelihood constraints that disincentivize long-term land management (World Bank, 2022). The Central Ethiopia Region (CER), represented by Weira woreda, showed a moderate participation rate of 61.5%, closely

aligning with the overall sample average. These regional disparities underscore the need for tailored, context-specific strategies rather than standardized approaches. Lessons from Amhara's success could provide replicable best practices for underperforming areas such as Oromia (UNCCD, 2020).

At the woreda level, more granular patterns emerge. Albuko and Basona Worena woredas report 100% participation in control areas, a remarkable achievement likely reflecting strong local traditions of sustainable land use or the long-term impacts of previous interventions that have shaped community behavior (MoA, 2023). The presence of high-functioning local institutions or customary land management systems could also account for this success. In contrast, woredas such as Tiyo in Oromia report extremely low participation levels—just 3.8%. The significant variation between woredas signals the importance of conducting localized diagnostics to design interventions that align with unique socio-cultural and institutional realities. High-performing woredas like Albuko could serve as learning sites for scaling best practices regionally (FAO, 2020).

Table 22: Farmers' participation in Biophysical land management practices at the regional and woreda levels

Woredas	Intervention Status				Nature of household				Age category of the HH			
	Control		Treatment		Male		Female		Youth		Adults	
	Yes		Yes		Yes		Yes		Yes		Yes	
	N	%	N	%	N	%	N	%	N	%	N	%
Amhara Region												
Kalu	15	57.7	61	78.2	55	76.4	21	65.6	24	66.7	52	76.5
Albuko	26	100	73	93.6	67	94.4	32	97	32	88.9	67	98.5
Desse Zuria	21	80.8	57	73.1	58	78.4	20	66.7	28	70.0	50	78.1
Tehuledere	25	96.2	62	79.5	61	83.6	26	83.9	30	83.3	57	83.8
Basona Worena	26	100	76	97.4	63	96.9	39	100	36	97.3	66	98.5
Total	113	86.9	329	84.4	304	85.6	138	83.6	150	81.1	292	87.2
Oromia Region												
Sire	6	23.1	20	25.6	20	28.2	6	18.2	10	25.6	16	24.6
Tiyo	1	3.8	23	29.5	17	23.3	7	22.6	9	25.0	15	22.1
Digelu Tijo	5	19.2	19	24.4	20	27.4	4	12.9	8	20.5	16	24.6
Omo Nada	19	73.1	51	65.4	51	70.8	19	59.4	22	59.5	48	71.6
Gera	9	34.6	41	52.6	37	49.3	13	44.8	19	45.2	31	50.0
Abaya	17	65.4	56	71.8	44	62.0	29	87.9	31	73.8	42	67.7
Total	57	36.5	210	44.9	189	43.4	78	41.3	99	42.1	168	43.2
Central Ethiopia Region												
Weira	22	84.6	37	47.4	46	65.7	13	38.2	18	56.3	41	56.9
Overall Total	192	61.5	576	61.5	539	62.7	229	59.0	267	59.1	501	62.9

N = Number of respondents; % = Percent of the total respondents; HH = Household

Gender differences in participation are modest but noteworthy. Male-headed households report slightly higher engagement (62.7%) than female-headed households (59.0%). This disparity may arise from structural inequalities, such as unequal access to land, extension services, or inputs. Yet, Albuko demonstrates exceptional female participation at 97.0% (Table 21), suggesting that enabling conditions—such as gender-sensitive programs or inclusive cultural norms—can significantly empower women (UN Women, 2021). Likewise, adult-headed households (62.9%) participate more than youth-headed households (59.1%), reflecting adults' stronger land tenure security and experience.

In Albuko, focus group discussants indicated that the variation in soil fertility improvement measures across households is largely influenced by differences in capacity and knowledge. Some model farmers have successfully enhanced their practices through diligent effort, leading to improved soil fertility and higher productivity. In contrast, other households, constrained by limited capacity, resources, and technical knowledge, have shown little improvement in soil fertility or productivity. Nonetheless, the small gap suggests that youth, if given resources and opportunities, can contribute meaningfully to sustainable land management. Targeted youth programs integrating conservation with income-generation activities (e.g., agroforestry and climate-smart agriculture) could enhance their participation further (MoA, 2023).

3.3.9 Adoption of Biophysical Land Management (BLM) Practices

Participation of farmers in BLM practices exhibits considerable variation across households, depending on the household headship, and age category (Table 21). The most widely adopted practices include soil and water conservation structures such as terracing, trenches, check dams, micro basins, gabions—and tillage methods. These practices are central to addressing erosion, runoff, and other soil health and fertility challenges.

Among all the BLM methods, terracing, particularly Soil/Stone Bunds and Trenches, emerged as the most widely perceived and implemented practice (Appendix 9). These structures are highly valued for their effectiveness in controlling erosion and improving water retention on sloped farmlands. Tillage practices—both conventional and improved—also rank among the most common measures, emphasizing their role in enhancing soil looseness and maintaining land productivity. In contrast, more labor- and resource-intensive techniques, such as gabions and micro-basins, showed moderate adoption levels, likely due to material or financial constraints. Meanwhile, biological and ecological approaches—such as mulching, cover cropping, and gully rehabilitation—are gaining traction, reflecting an increased awareness of sustainable land management.

Improved tillage (defined as tillage conducted more than three times per year) was the single most frequently adopted practice, with 193 households (20.6%). Conventional tillage (typically performed twice a year) and trench-based terracing were reported by 252 (26.9%) and 292 (31.2%) households, respectively. Other significant practices include check dams (149 households, 15.9%), micro-basins (135 households, 14.4%), and biological land and water management measures such as grass strips or shrubs (76 households, 8.1%). Additional practices like Fanya Juu (78 households, 8.3%), mulching/cover cropping (58 households, 6.2%), and gabions (40 households, 4.3%) were less commonly adopted. Soil/Stone Bunds stand out as the most dominant technique, with 501 households (53.5%) practicing them (Appendix 9). Interestingly, female-headed households reported higher adoption rates for several practices. Improved tillage was adopted by 38.9 female-headed households, compared to 10 male-headed households. Similarly, trench terracing was adopted by 33.3% of female-headed households, compared to 9% of male-headed ones. This trend likely reflects targeted interventions and heightened vulnerability to soil degradation among female-headed households, driving proactive participation in land management.

Age also influenced adoption. Adult-headed households dominated BLM adoption, with 59 and 53.8 adopters for improved and conventional tillage, respectively, compared to 19 and 17 among youth. However, youth participation was notable in trench terracing (22 households), nearly matching the adoption levels of adults. This suggests that with accessible opportunities and manageable labor requirements, youth can play an active role in land restoration. Overall, terracing—especially soil/stone bunds—remains the cornerstone of BLM, aligning with government and development efforts to mitigate erosion on sloped lands. The FGD conducted in Degaga Kebele of Albuko Woreda indicated that farmers are engaged in various SLM practices. These include area enclosures on sloping lands, terracing, water harvesting, and the planting of vetiver grass. However, participants emphasized that the scale and extent of these activities remain insufficient to adequately address soil degradation challenges. However, lower adoption of techniques like Fanya Juu, gabions, and mulching indicates barriers such as limited

technical knowledge, high labor requirements, or inadequate extension support. Moreover, biological practices, although limited in scale, reflect a growing shift towards integrated, sustainable approaches that enhance soil fertility and ecosystem resilience when combined with physical conservation structures.

3.3.10 Adoption of Soil Health and Fertility Management (SHFM) Practices

Our analysis of soil health and fertility management (SHFM) practices shows a mix of successes and challenges. We found that awareness and adoption of SHFM practices vary across districts, local communities, and different types of households and age groups. While some groups are embracing these practices, there are still significant gaps, especially when it comes to more advanced soil fertility strategies (Appendices 10 – 14). Across the surveyed woredas, farmers demonstrated relatively high levels of awareness and engagement with traditional SFM practices such as soil and water conservation (SWC), composting, and in-situ moisture management. However, some kebeles reported a higher level of adoption of a broader range of practices, including ISFM and site-specific nutrient management.

Farmers in intervention kebeles consistently reported higher percentages of positive responses across nearly all knowledge and practice indicators. For example, 90% of respondents in intervention kebeles affirmed both knowledge and application of in-situ moisture conservation and SWC techniques. Male-headed households (MHHs) exhibited slightly higher awareness of advanced SFM practices (Appendix 10). FHHs demonstrated strong engagement in core practices like composting and moisture retention, with adoption rates frequently exceeding 70%.

Age-based trends also emerged. Younger respondents—often more literate and exposed to recent training—reported higher awareness of technical practices such as the 4Rs of nutrient stewardship and Vertisol management. Conversely, older farmers exhibited greater experience in traditional methods, including composting, contour farming, and tied ridging. Encouragingly, across all age categories, the adoption of SWC and in-situ moisture management remained consistently high, exceeding 90%. This widespread uptake likely reflects both the visible short-term benefits of these practices and their consistent promotion through extension services and farmer field schools. However, advanced, knowledge-intensive techniques such as biochar application, lime use, and precise fertilizer application had adoption rates below 40% across all groups, pointing to areas in need of targeted education and field demonstrations.

In Degaga Kebele, Albuko, FGD participants also outlined that current mitigation measures include terracing, hillside plowing, traditional plowing, application of dry manure, and compost preparation from animal manure. While both traditional and improved practices are applied, participants noted that improved methods offer substantially greater long-term benefits. FGD in Asgedo Kebele of Dessie Zuriya revealed that variations among farmers in their soil fertility improvement practices are primarily influenced by differences in their capacity, availability of labor, and access to necessary tools and materials. Additionally, improper water diversion and poorly constructed soil bunds contribute to these disparities.

Farmers' Knowledge of In-Situ Moisture Conservation: In contrast, in-situ soil moisture conservation emerged as the most widely adopted SFM practice. In Amhara, over 93% of intervention kebeles' HHs reported active use of techniques like tie ridging and mulching, with control groups only slightly behind (Appendix 13). Central Ethiopia's Weira woreda recorded an even higher adoption rate of 98.1%. Gender differences in this practice were minimal, with female-headed households performing almost on par with male-headed ones. Adults exhibited slightly higher participation rates than youth, likely due to their greater experience and labor availability. This success suggests that simple, labor-based practices have strong potential for scaling up and can serve as entry points for introducing more complex conservation techniques.

Farmers' Practice of Soil and Water Conservation: Soil and water conservation (SWC) practices were also well-adapted. In Amhara, 100% of households in Albuko and over 90% in Dessie Zuria and Tehuledere (both intervention and control) reported active SWC engagement (Appendix

14). Oromia, however, lagged, with adoption rates ranging from 30–60%, depending on the woreda. Notably, gender disparities were minimal in Amhara, with female-headed HHs reaching 100% adoption in Albuko. However, youth participation in Oromia was significantly lower, indicating untapped potential for engagement. Expanding SWC in Oromia through incentive-based youth programs could enhance both labor availability and long-term sustainability of these practices.

3.3.11 Climate Change and Adaptation

Climate change compounds Ethiopia's soil fertility challenges, with rising temperatures, erratic rainfall, and increased erosion rates threatening long-term agricultural productivity (Niang et al., 2014). The government's Climate-Resilient Green Economy (CRGE) Strategy (2011) highlights the need for soil conservation and climate-smart agricultural techniques.

The Sustainable Land Management Program (SLMP) has implemented soil and water conservation measures—including terracing and reforestation—across over 1 million hectares, reducing erosion by up to 80% in some highland areas (World Bank, 2022). ISFM, agroforestry, biochar application, and lime treatment for acidic soils are promoted as climate-resilient soil practices (Amede et al., 2021). Plans involve scaling up climate-smart agriculture and integrating soil carbon sequestration into national soil health programs, linking soil improvement with global carbon reduction goals (FAO, 2020). A key gap is the absence of a national soil health monitoring system. Integrating soil health indicators into Ethiopia's agricultural statistics and aligning with SDG 2.4 and AU soil initiatives would enhance evidence-based policymaking (Wiese, 2024; AU, 2021). FGD Insights from Albuko: Participants were asked about the capability and effectiveness of their Kebele in coping with environmental shocks over the past three years, specifically referring to climate events and adaptive responses (e.g., drought-resistant crop varieties, livelihood diversification). Discussants reported that climate change has negatively impacted agricultural activities, noting that areas which should be green have become increasingly dry. They highlighted that the kebele's topography limits extensive environmental disturbances. Despite these challenges, community members are actively engaging in adaptation measures, including soil and water conservation practices and the cultivation of early-maturing crop varieties to sustain their livelihoods.

In Degaga Kebele, Albuko Woreda, FGD participants reported that climate change has increasingly constrained the community's capacity to cope with environmental shocks. Rainfall has become delayed or absent, disrupting Belg-season planting, while higher temperatures and intense sunlight limit livestock grazing and fieldwork, and mornings are unusually cold. Households have adapted by cultivating drought-resistant and early-maturing crops, practicing terracing, and implementing soil conservation measures; however, variable soil conditions and seed performance sometimes delay crop maturation. Support for smallholders has included occasional government training on soil fertility and natural resource management, complemented by farmer-to-farmer knowledge sharing. During the FGD, Asgedo Kebele, Dessie Zuriya, participants under intervention kebele indicated that climate change has increasingly resulted in prolonged droughts, gradually converting their area into dryland. This trend has adversely affected rainfed agricultural activities, with erratic and inadequate rainfall posing significant challenges. To cope with these impacts, the community has adopted various adaptive strategies, including rainwater harvesting and storage, construction of water points for livestock, cultivation of drought-resistant crops, and the use of improved seed varieties better suited to dry conditions during the rainy season.

In Chefa Gugesa (Digalu Tijo), respondents reported low capacity to cope with environmental shocks over the past three years. Heavy rainfall during harvest destroyed crops and left households without production or inputs. Farmers relied on short-maturing crops such as beans and peas, but options for livelihood diversification and access to resilient varieties were lacking. Food shortages forced households to purchase crops from the market, while delayed rains

continue to threaten production in the absence of drought-resistant wheat. Limited institutional support was also noted, as government resources were directed to administrative projects rather than agricultural assistance. Overall, the kebele shows weak adaptive mechanisms and high vulnerability to climate shocks (FGD and KIIs).

The impact of SLM practices on soil erosion in Ethiopia varies across regions, slope classes, and intervention types, reflecting both environmental conditions and the adoption of specific interventions. In the Amhara Region, highland woredas such as Basona Worena and Dessie Zuria have implemented bench terraces, fanya juu/fanya chini terraces, reforestation, and grass strips. Field measurements using runoff plots and sediment traps revealed substantial reductions in soil loss: upper slopes in Basona Worena decreased from 23 $t \cdot ha^{-1} \cdot yr^{-1}$ to 5 $t \cdot ha^{-1} \cdot yr^{-1}$, representing a 78% reduction, while middle slopes in Dessie Zuria declined from 20 $t \cdot ha^{-1} \cdot yr^{-1}$ to 4 $t \cdot ha^{-1} \cdot yr^{-1}$, equivalent to 80% erosion control (Amede, Haile, & Yitaferu, 2021; Hurni et al., 2015; World Bank, 2022). These outcomes demonstrate that carefully designed physical interventions can dramatically stabilize soils on steep terrain.

Similarly, in the Oromia Region, woredas such as Ada'a and Boset combined terracing with agroforestry and integrated soil fertility management (ISFM), yielding significant erosion reductions. Upper slopes saw soil loss decrease from 18 to 8 $t \cdot ha^{-1} \cdot yr^{-1}$ (56%), while middle slopes declined from 16 to 6 $t \cdot ha^{-1} \cdot yr^{-1}$ (63%), highlighting the complementary effects of combining physical and biological soil conservation measures (Amede et al., 2021). In the Central Ethiopia Region, a multi-pronged approach involving ISFM, lime treatment, biochar application, and terracing led to reductions in upper and middle slope erosion from 19 to 5 $t \cdot ha^{-1} \cdot yr^{-1}$ (74%). Lower slopes, which are less inherently prone to erosion, also benefited from organic amendments and agroforestry, with soil loss declining from 12 to 5 $t \cdot ha^{-1} \cdot yr^{-1}$ (58%) (FAO, 2020; Wiese, 2024). Across these regions, sediment traps, runoff plot monitoring, and topsoil loss assessment consistently verified the effectiveness of integrated SLM approaches in highland agricultural landscapes. Importantly, these field-based measurements align with community-reported adaptation efforts: focus group discussions in Albuko Kebele revealed that farmers actively implement terracing, reforestation, early-maturing crop varieties, and livelihood diversification strategies, demonstrating the link between local engagement and measurable erosion reduction (AU, 2021).

Building on these regional successes, the SLMP has implemented a comprehensive range of soil and water conservation interventions across Ethiopia's highland and erosion-prone landscapes. In the Amhara Region, stone and trench terraces, gully stabilization, and reforestation were promoted across more than 400,000 hectares, achieving 60–80% reductions in soil erosion, as verified through repeated plot-scale erosion assessments and sediment yield monitoring (World Bank, 2022; Hurni et al., 2015). In Oromia, ISFM, agroforestry, biochar application, and hillside bunds were implemented over roughly 350,000 hectares, resulting in 35–65% reductions in soil loss, measured through paired-plot field trials and soil depth monitoring over multiple cropping seasons (Amede et al., 2021). Likewise, in the Halaba Zone of the Central Ethiopia Region, small-scale bench terraces, water harvesting structures, and reforestation initiatives reduced runoff and topsoil loss by 40–70%, as assessed using sediment traps, runoff measurements, and soil depth monitoring (FAO, 2020; Wiese, 2024). These interventions illustrate that SLM strategies, when integrated and scaled appropriately, are highly effective across diverse ecological contexts.

At the national level, SLMP has also promoted climate-resilient soil practices—including ISFM, lime application for acidic soils, agroforestry, and biochar use—effectively integrating soil fertility improvement with carbon sequestration objectives. Monitoring combines empirical field measurements with remote sensing and GIS analyses, enabling spatial tracking of land cover changes, slope stability, and vegetation recovery over time (World Bank, 2022; FAO, 2020). Despite these achievements, a critical gap remains: the absence of a national soil health

monitoring system limits the systematic assessment of soil quality and the long-term sustainability of conservation interventions (AU, 2021; Wiese, 2024).

Finally, insights from focus group discussions in Albuko Kebele emphasize the adaptive role of local communities in response to climate variability. While formerly green areas have become increasingly dry, community members actively engage in soil and water conservation practices, including terracing, mulching, and cultivation of early-maturing crop varieties, contributing to improved resilience and erosion control. Participants noted that although the kebele's topography inherently limits large-scale environmental disturbances, proactive adoption of SLM practices has strengthened local adaptive capacity, mitigating the impacts of climate shocks and supporting sustainable agricultural productivity.

3.3.12 Household Food Security Measures

This section provides a baseline overview of household food security across key regions in Ethiopia, using two widely recognized tools: the Food Consumption Score (FCS) and the Household Dietary Diversity Score (HDDS). Food security is central to rural livelihoods and is shaped by access to resources, income, and the ability to withstand environmental and economic shocks. Recent evidence, including Headey et al. (2022) and FAO's RIMA-III (2021), highlights the persistence of food insecurity driven by undernutrition, seasonal gaps, and recurring crises such as droughts, inflation, and conflict. These stressors compound household vulnerability and disrupt sustainable food access.

The FCS was computed from 16 different food items, which were then grouped into eight categories: staples, pulses, vegetables, fruits, meat and fish, dairy, oil, and sugar, each with an assigned weight. Households scoring below 21 were categorized as experiencing Severe Food Insecurity, those scoring between 21 and 28 as Moderate Food Insecurity, scores from 29 to 42 as Mild Food Insecurity, and scores above 42 as Food Secure (WFP, 2008).

The CFS-based food security assessment revealed pronounced regional and the intervention-level disparities in household food security status, indicating the need for region-specific and targeted interventions. More than two-thirds of respondents in the Amhara region (71.2%) and nearly three-fifths in Oromia (58.3%) were food secure, reflecting relatively better food access and stability, whereas only about one-fifth of households in the Central Ethiopia Region (19.2%) achieved food security, underscoring substantial vulnerability in that area (Figure 5). The share of severely food-insecure households was notably higher in Central Ethiopia (15%) and Oromia (13%), compared to just 4% in Amhara, demonstrating the uneven distribution of food insecurity intensity across regions. At the intervention-level, 62% of households in the control group and 60% in the intervention group were food secure, while 10% and 7%, respectively, were categorized as severely food insecure at the time of the baseline survey, collectively illustrating

persistent regional and programmatic disparities that warrant focused policy and programmatic responses to bridge the food security gap (Table, 23).

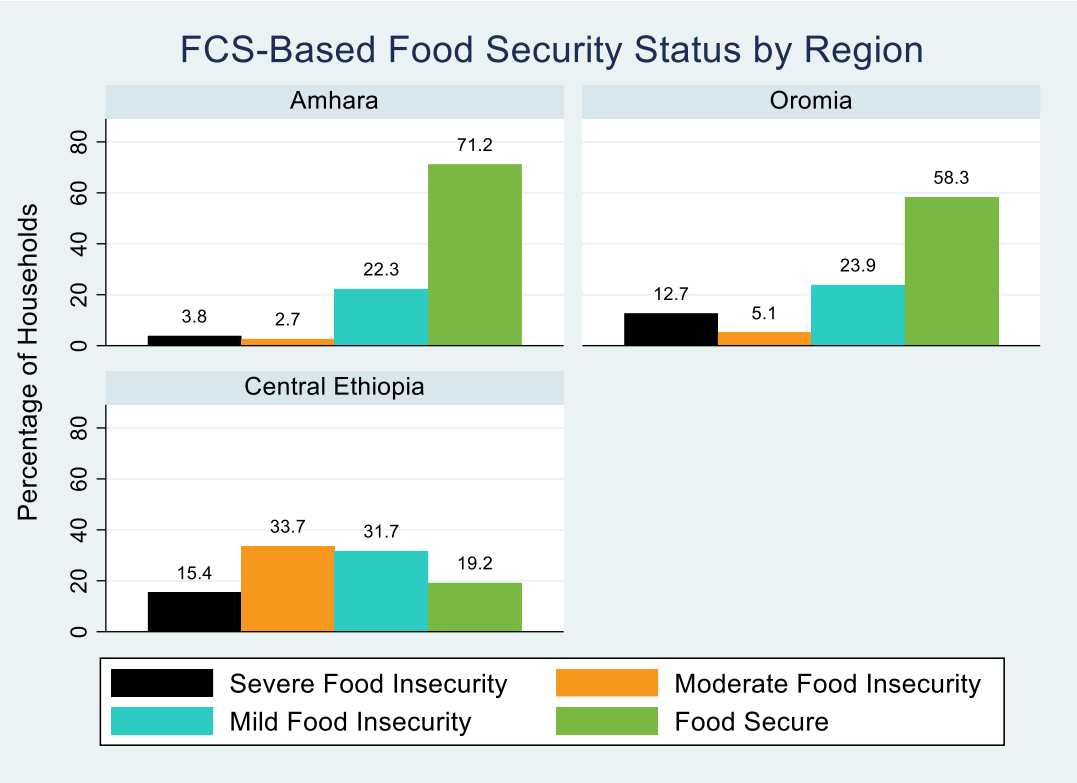


Figure 5 Proportion of Household Food Security Status Based on FCS across Target Regions, 2025

Table 23 Proportion of household Food security status based on the FCS in the target woredas, 2025

Region	Woreda	Intervention type									
		Control					Treatment				
		(1) (%)	(2) (%)	(3) (%)	(4) (%)	N	(1) (%)	(2) (%)	(3) (%)	(4) (%)	N
Amhara	Kalu	7.7	7.7	50.0	34.6	26	11.5	3.8	25.6	59.0	78
	Albuko	0.0	0.0	15.4	84.6	26	1.3	5.1	25.6	67.9	78
	Desse Zuria	0.0	0.0	19.2	80.8	26	7.7	3.8	20.5	67.9	78
	Tehuledere	3.8	0.0	15.4	80.8	26	1.3	2.6	24.4	71.8	78
	Basona Worena	0.0	0.0	26.9	73.1	26	0.0	0.0	10.3	89.7	78
	Total	2.3	1.5	25.4	70.8	130	4.4	3.1	21.3	71.3	390
Oromia	Sire	0.0	0.0	19.2	80.8	26	3.8	2.6	34.6	59.0	78
	Tiyo	3.8	0.0	15.4	80.8	26	0.0	5.1	17.9	76.9	78
	Digelu Tijo	3.8	11.5	7.7	76.9	26	7.7	3.8	21.8	66.7	78
	Omo Nada	3.8	3.8	50.0	42.3	26	5.1	5.1	35.9	53.8	78
	Gera	0.0	0.0	38.5	61.5	26	1.3	2.6	15.4	80.8	78
	Abaya	84.6	7.7	7.7	0.0	26	51.3	14.1	19.2	15.4	78
	Total	16.0	3.8	23.1	57.1	156	11.5	5.6	24.1	58.8	468
CER	Weira	11.5	19.2	19.2	50.0	26	16.7	38.5	35.9	9.0	78
Overall Total		9.9	4.2	23.7	62.2	312	9.0	7.3	23.9	59.8	936

Note: (1) Severely Food Insecure, (2) Moderately Food Insecure, (3) Mildly Food Insecure, and (4) Food secure

Likewise, the HDDS was calculated based on 12 food groups, with a minimum possible score of 0 and a maximum of 12. Households scoring below 3 were categorized as Severely Food Insecure, those scoring between 3 and 4 as Moderately Food Insecure, scores from 5 to 7 as Mildly Food Insecure, and scores above 7 as Food Secure (FANTA, 2006).

The HDDS based food security assessment revealed that the majority of respondents across all regions were classified as mildly food insecure, indicating that while most households were not in immediate crisis, they still faced challenges in maintaining adequate dietary diversity. Regional variations were observed in the level of food security. The highest proportion of food secure households was found in the Oromia region, where 31.4% of respondents achieved adequate dietary diversity and food security. In comparison, the proportion of food secure households was much lower in the Central Ethiopia Region and Amhara, where only 13% and 9% of respondents was food secure, respectively (Figure 6). This shows notable regional differences in household access to sufficient and diverse food.

When comparing intervention and control groups, food security status appeared nearly similar across all categories including severely food insecure, moderately food insecure, mildly food insecure, and food secure households (Table 24). This indicates that at the time of the baseline assessment, the effect of program interventions had not yet resulted in a measurable difference in household food security outcomes. The findings highlight the need to strengthen program efforts that enhance household dietary diversity and food access, especially in the Amhara and Central Ethiopia regions where the share of food secure households remains low.

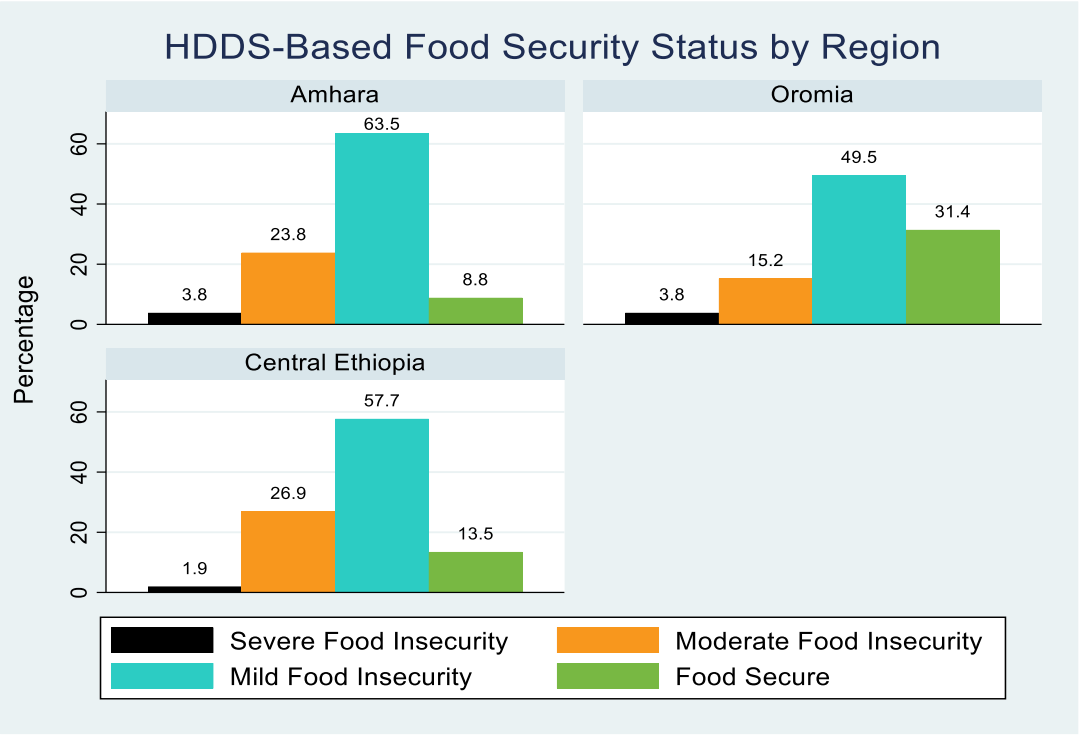


Figure 6 Proportion of Household Food Security Status Based on HDDS across Target Regions, 2025

Table 24: Proportion of household Food security status based on the HDDS in the target woredas, 2025

Region	Woreda	Intervention type									
		Control					Treatment				
		(1) (%)	(2) (%)	(3) (%)	(4) (%)	N	(1) (%)	(2) (%)	(3) (%)	(4) (%)	N

Amhara	Kalu	3.8	46.2	46.2	3.8	26	15.4	26.9	41.0	16.7	78
	Albuko	0.0	15.4	80.8	3.8	26	3.8	28.2	61.5	6.4	78
	Desse Zuria	0.0	34.6	57.7	7.7	26	3.8	20.5	65.4	10.3	78
	Tehuledere	0.0	34.6	61.5	3.8	26	1.3	19.2	66.7	12.8	78
	Basona Worena	0.0	0.0	96.2	3.8	26	0.0	20.5	74.4	5.1	78
	Total	0.8	26.2	68.5	4.6	130	4.9	23.1	61.8	10.3	390
Oromia	Sire	0.0	3.8	76.9	19.2	26	1.3	3.8	74.4	20.5	78
	Tiyo	0.0	3.8	61.5	34.6	26	0.0	3.8	67.9	28.2	78
	Digelu Tijo	0.0	23.1	46.2	30.8	26	3.8	9.0	60.3	26.9	78
	Omo Nada	0.0	7.7	53.8	38.5	26	2.6	9.0	44.9	43.6	78
	Gera	0.0	3.8	26.9	69.2	26	2.6	9.0	26.9	61.5	78
	Abaya	23.1	69.2	7.7	0.0	26	12.8	50.0	30.8	6.4	78
	Total	3.8	18.6	45.5	32.1	156	3.8	14.1	50.9	31.2	468
CER	Weira	0.0	7.7	65.4	26.9	26	2.6	33.3	55.1	9.0	78
Overall Total		2.2	20.8	56.7	20.2	312	4.2	19.4	55.8	20.6	936

Note: (1) Severely Food Insecure, (2) Moderately Food Insecure, (3) Mildly Food Insecure, and (4) Food secure

Since variation was observed between the two tools (FCS and HDDS), combining them provides a more comprehensive and holistic assessment of household food security. Accordingly, a combined food security indicator with four levels was developed, as recommended in the WFP Consolidated Approach to Reporting Indicators of Food Security (CARI) framework (WFP, 2015).

The combined food security measurement revealed that nearly two-thirds of respondents in Amhara (62%) and Oromia (61%) regions were food secure, whereas only one-fourth of respondents in Central Ethiopia achieved food security status (Figure 8). Almost 10% of respondents in Oromia and Central Ethiopia were severely food insecure, while in the Amhara region, only 4% were classified as severely food insecure. Overall, 7% of respondents were severely food insecure, and 58% were food secure at the time of the baseline assessment. The current assessment indicates a lower level of food security compared to the national average reported by the WFP (WFP, 2024), which was 18% food insecurity (mild to severe food insecurity). This implies that interventions that enhance the productivity of households are very important to transition from severely food insecure to moderately, from moderately to mild, and from mild to food secure.

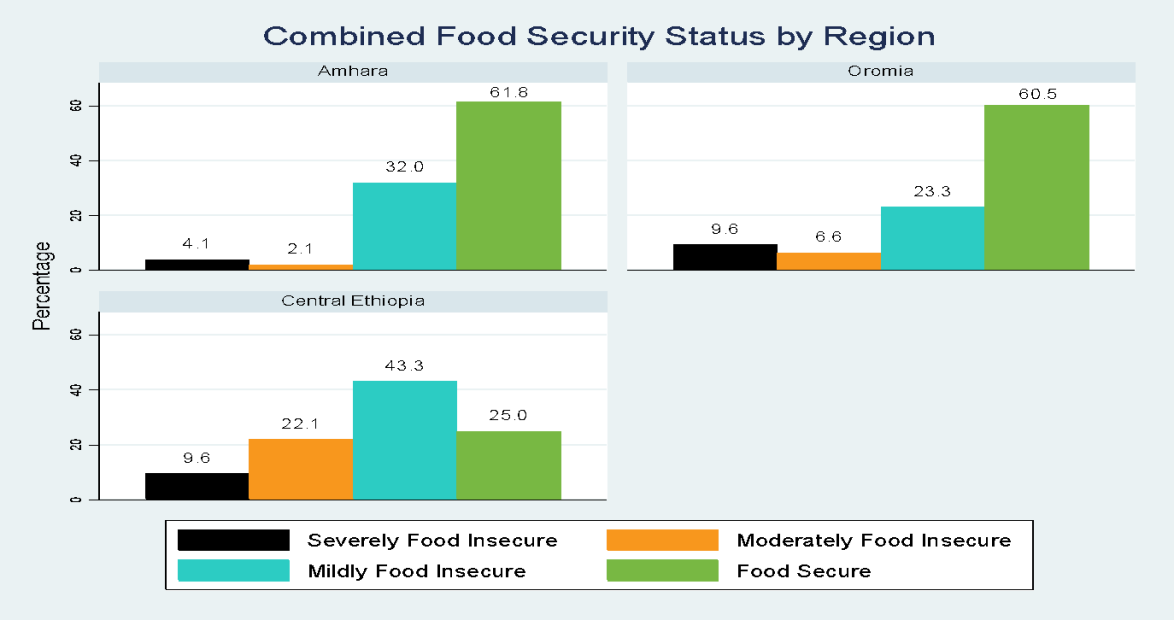


Figure 7: Proportion of Household Food Security Status (Combined FCS and HDDS) across Target Regions, 2025

Table 25 also presents the food security status by region, woreda, and intervention group, revealing that overall, 61% of households in the control group and 57% in the intervention group were food secure. Within regions at the woreda level, there is a huge variation in the proportion of food-secure and severely food-insecure households. For instance, Abaya Woreda in Oromia had the lowest food security status across all dimensions (Table 25). This implies that the intervention packages to enhance the livelihoods of communities should be context-specific and identify the specific gaps across woredas and regions.

Table 25: Proportion of household Food security status based on the combined score in the target woredas, 2025

Region	Woreda	Intervention type									
		Control					Treatment				
		(1) (%)	(2) (%)	(3) (%)	(4) (%)	N	(1) (%)	(2) (%)	(3) (%)	(4) (%)	N
Amhara	Kalu	7.7	7.7	57.7	26.9	26	12.8	5.1	34.6	47.4	78
	Albuko	0	0	19.2	80.8	26	3.8	1.3	35.9	59	78
	Desse Zuria	0	0	42.3	57.7	26	6.5	2.6	29.9	61	78
	Tehuledere	3.8	0	34.6	61.5	26	0	2.6	27.3	70.1	78
	Basona Worena	0	0	23.1	76.9	26	0	0	26.9	73.1	78
	Total	2.3	1.5	35.4	60.8	130	4.6	2.3	30.9	62.1	390
Oromia	Sire	0	0	19.2	80.8	26	2.6	2.6	33.3	61.5	78
	Tiyo	3.8	0	11.5	84.6	26	0	2.6	17.9	79.5	78
	Digelu Tijo	0	11.5	23.1	65.4	26	2.6	6.4	26.9	64.1	78
	Omo Nada	0	3.8	46.2	50	26	5.1	1.3	32.1	61.5	78
	Gera	0	0	11.5	88.5	26	0	1.3	18.2	80.5	78
	Abaya	84.6	11.5	3.8	0	26	37.7	29.9	19.5	13	78
	Total	14.7	4.5	19.2	61.5	156	7.9	7.3	24.7	60.1	468
CER	Weira	3.8	11.5	26.9	57.7	26	11.5	25.6	48.7	14.1	78
Overall Total		8.7	3.8	26.6	60.9	312	6.9	6.8	29.3	57.1	936

Note: (1) Severely Food Insecure, (2) Moderately Food Insecure, (3) Mildly Food Insecure, and (4) Food secure

3.4 Building a Vibrant Sector for Soil Inputs

Collecting data on soil input sector is aimed at establishing baseline values on availability, access, diversity, quality, and affordability of soil inputs. It also gathered data and information on the orientation and operational status of farmer-cantered soil inputs delivery systems that impact soil health and productivity. Information on the status of key stakeholders of the input sector emphasizing farmers' cooperatives and private sector entrepreneurs (agro-dealers, one stop shops, input voucher system, etc) would also be displayed and analysed tailored to building a vibrant soil input sector.
This baseline study revealed that soil inputs in the target woredas of Amhara, Oromia, and the Central Ethiopia region are generally constrained by limited access to a variety, quality, and quantity of mineral and organic fertilizers, soil amendments, and technical knowledge. Both the quantitative (household survey) and qualitative (KII and FGD) findings examined the current landscape of soil inputs, farmer practices, supply chains, and awareness levels, aiming to build a vibrant, accessible, and sustainable soil input sector.

3.4.1 Input Supply System and Value Chain Actors Analysis

The findings of baseline analysis revealed a fragmented input supply system across the 12 targeted woredas of Amhara, Oromia, and Central Ethiopia, marked by inconsistent availability, high prices, and limited private sector engagement. The main value chain actors are cooperatives, public, and a few private suppliers (one-stop shops, formal and informal agro-dealers, MSMEs), and exhibit weak coordination, linkage, and limited investment in last-mile delivery (Figure 7). The solid lines and broken lines of Fig. 7 depicts major and minor suppliers of soil inputs to farmers. The value chain challenges affecting farmers in accessing soil inputs include price fluctuation, poor credit access, transportation, timely arrival, and quality of soil inputs.

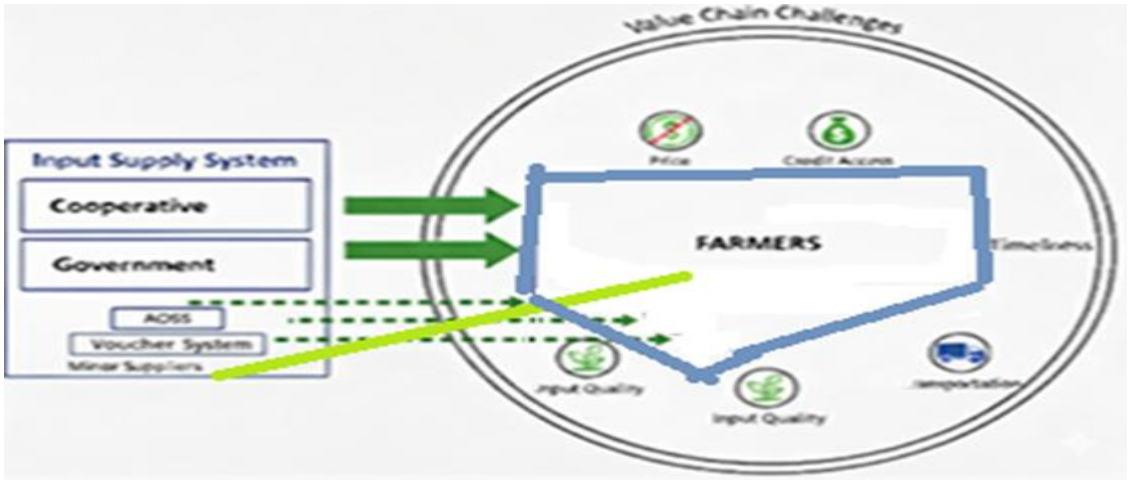


Figure 8: Soil Inputs Value Chain Map outlining suppliers and challenges of farmers

3.4.1.1 Types of soil inputs made available to the smallholder farmers

Urea fertilizer was most used ($\bar{x}$=67%) among the 13 types of soil inputs under consideration in many woredas, for instance, at 99% Omo Nada, 91% in Basona Worana, and 87% in Albuko and Tehuledere woredaswhile their use is notably low in Kalu and Gera (Table 25 and Appendix 18). Although both Urea and NPS were supplied to the kebeles, the lower household responses to NPS, particularly zero values in three woredas (Kalu, B/Worana and Abaya), mayn't be only due to its less demand than Urea but might be due to farmers' assumptions of NPS as DAP - the latter wasn't supplied in the baseline year. Among organic fertilizers, HH waste ($\bar{x}$=45%),

compost ($\bar{x}$=43%) and farmyard manure ($\bar{x}$=42%) use are reported to be common in some woredas, for instance, 67%, 81%, and 60% in Kalu, 46%, 82%, and 28% in Albuko and 62%, 74%, and 30% in Dessie Zuria. HH use of bio-fertilizer widely varied between 80% (Abaya) and 0% (O/Nada) with an average share of 18%, which is same rate in Albuko and close use rates in other four woredas. In contrary, soil inputs like lime, green manure, and vermicomposting are used sporadically, with zero values of gypsum and biochar, implying either no demand or unavailability of both soil inputs. This can be also a signal for dominancy of non-sodic non-clay soils and high organic matter contents, respectively. The overall use of these soil inputs by the woredas showed diversified use of soil inputs, with very limited use of bio-fertilizers, lime, and source of fertilizers for micronutrients. The findings highlight uneven use pattern highlighting the need for location-specific strategies that respond to local practices, input availability, and capacity gaps. The adoption of soil inputs like bio-fertilizers and lime is particularly low among youth farmers. Traditional organic inputs, such as compost and farmyard manure, show variable usage, with male farmers typically reporting higher innovation rates than female farmers.

Table 26: Baseline values (% HH responses) on soil inputs used by smallholder farmers in intervention woredas

Type of soil inputs	Kalu	Albuko	Dessee Zuria	Tehuledere	Basona Worena	Sire	Tiyo	Digelu Tijo	Omo Nada	Gera	Abaya	Weira	$\bar{x}$
Urea	10	87	71	87	91	68	76	86	99	28	83	23	67
NPS	0	15	14	15	0	41	37	37	6	1	0	10	15
Bio-fertilizers	19	18	17	15	21	4	19	17	0	6	1	80	18
Lime*	0	0	0	0	3	0	6	14	4	0	0	0	2
Gypsum	0	0	0	0	0	0	0	0	0	0	0	0	0
Compost	81	82	74	77	80	9	14	24	1	12	59	0	43
Vermicomposting*	1	0	3	5	1	3	1	0	1	0	4	0	2
Farmyard manure	60	28	30	27	17	32	42	47	26	49	73	68	42
Green manure*	5	0	0	5	8	0	3	0	1	24	13	1	5
Crop residues	28	5	5	9	6	9	6	18	23	37	19	0	14
HH Wastes*	67	46	62	49	1	32	50	65	41	50	33	44	45
Biochar	0	0	0	0	0	0	0	0	0	0	0	0	0
Ash*	36	15	18	24	3	13	23	13	0	13	9	0	14

3.4.1.2 Accessibility and Innovation of Soil Inputs

Next to the availability/types of soil inputs, key interconnected attributes that collectively determine farmers' accessibility and innovation for soil inputs include the source of input suppliers, affordability, timeliness, proximity to farm gates (in terms of distance), quality assurance, credit access, and other supply chain factors.

i. Source of Soil Inputs for Smallholder Farmers

The household responses of Table 27 indicate that public sector and cooperatives are the dominant channels of soil inputs, with a notable increase in reliance on cooperatives. Agro-dealers and ordinary shops serve as secondary sources, though their overall contribution remains modest and declines in intervention kebeles. Access through Agricultural One-Stop Shops (AOSS) remains negligible in both intervention and control kebels with highest baseline

values of only 3% in intervention kebels of Tiyo and Abaya and 8% in control kebeles of Gera Woreda. These findings partly align with the baseline community-level FGDs and KII reports of woreda and zonal levels. This qualitative report revealed that 5-6 soil input suppliers with cooperatives and public sources being the major input suppliers and distributors to smallholder farmers. Unlike, the low HH quantitative values for AOSS, the FGD and KII reported it as third source of soil inputs.

Table 27: HH responses (%) for sources of soil inputs across 12 Woredas in intervention and control kebeles

Woreda	Control (C) kebeles						Intervention (T) Kebebels					
	Gov	Coops	AOSS	Agro-dealers	Ordinary Shops	Others	Gov	Coop	AOSS	Agro-dealers	Ordinary Shops	Others
Kalu	54	4	4	15	62	0	56	17	1	12	38	3
Albuko	88	23	0	19	27	0	72	26	0	17	31	5
Desse Zuria	35	0	0	19	31	23	63	31	0	6	24	6
Tehuledere	38	0	0	23	65	23	63	37	1	14	46	3
Basona Worena	100	0	0	0	0	0	97	0	0	3	5	3
Sire	15	92	0	0	0	0	8	94	1	1	0	0
Tiyo	0	100	0	0	0	0	14	90	3	4	0	0
Digelu Tijo	19	81	4	12	4	0	6	96	0	1	5	0
Omo Nada	42	73	0	0	0	8	27	78	1	0	4	0
Gera	31	31	8	0	15	35	24	55	1	8	8	38
Abaya	15	23	0	0	73	4	88	91	3	12	0	1
Weira	35	54	0	8	35	4	3	68	0	19	1	12
Mean (x̄)	**39**	**40**	**1**	**8**	**26**	**8**	**43**	**57**	**1**	**8**	**14**	**6**

ii. Soil Inputs' Accessibility

Most respondents across all woredas in intervention kebeles (55%) reported that soil inputs are available within a 5 km radius (Table 28). However, about 21–25% of respondents experience medium accessibility (6–10 km), while 11–15% report having to travel farther (11–20 km), and 9–10% of the HHs faced travelling long distances exceeding 20 km. regional differences are evident in the data. Woredas in Oromia, such as Sire (97%), Tiyo (87%), and Digelu Tijo (83%), report exceptionally high proximity, with over 80% of farmers within 0–5 km of a supplier. In contrast, woredas in Amhara (Basona Worena) and Central Ethiopia (Weira) show a more dispersed pattern, with a significant portion of farmers having to travel medium to long distances. For instance, 49% of HHs in intervention kebels of Basona Worena travel more than 20 km, while in Weira, 45% of the HHs travel far but accessible distance (11–20 km). Disaggregated data by gender and age shows minimal variations, indicating that proximity challenges are largely uniform across demographic groups.

Table 28: HH responses (%) on accessibility of soil inputs in terms of proximity/distance (km)

Region	Woreda	Intervention (T) kebels				Control kebeles			
		1	2	3	4	1	2	3	4
Amhara	Kalu	59	36	3	1	54	31	15	0
	Albuko	55	42	0	3	92	8	0	0
	D/Zuria	68	26	3	4	54	23	0	19
	T/Dere	71	22	8	0	39	46	4	12
	B/Worena	10	9	32	49	8	54	8	31

Oromia	Sire	97	3	0	0	65	15	19	0
	Tiyo	87	13	0	0	81	15	4	0
	Digelu Tijo	83	14	3	0	85	15	0	0
	Omo Nada	83	15	1	0	81	19	0	0
	Gera	26	45	19	9	81	19	0	0
	Abaya	15	10	29	45	4	0	4	89
CER	Weira	4	49	45	3	46	31	23	0

Key (Distance from home/farm-gate): 1: Nearly good accessible distance (0-5kms).
2: Medium accessible distance (6-10 kms). 3: Far but still accessible distance (11-20 kms).
4: Relatively long distances (greater than 20 kms)

iii. Timeliness, affordability, quality, and credit access of major soil inputs

The quantitative household (HH) survey results (% of responses) for the above parameters are depicted in Figure 9 and Appendix 20. Descriptive analysis revealed significant limitations in accessibility for soil inputs across the 12 intervention woredas. Only 43% of households, on average, reported receiving mineral fertilizers at least one month in advance of the planting season, with wide variation across woredas—ranging from as low as 9% in Gera to as high as 91% in Omo Nada. A lower % of timing accessibility in Gera woreda may be attributed to the weaker soil input suppliers (e.g., Primary Cooperatives) in Gera compared to Omo Nada. Organic fertilizers (compost, manure, green manuring, etc) showed even lower timeliness, with just 27% of households accessing them early, indicating systemic delays in local production of input distribution. Price affordability remains a critical concern: only 17% of respondents found mineral fertilizers to be affordable, with particularly low responses in Kalu, Basona Worena, and Gera. Similarly, organic fertilizers were less affordable (17% on average). In terms of quality, 43% of households reported satisfaction with mineral fertilizers, but perceptions varied widely, with much lower confidence in woredas like Gera (5%) and Weira (5%). Lime inputs scored especially low in both quality (only 9% average) and credit access (2% average), suggesting minimal market development for this soil amendment. Credit access for mineral fertilizers was similarly constrained, with only 9% of households reporting any form of credit support, and almost no mechanisms (0-6%) in place for lime. Gender and age disaggregation revealed minimal differences, suggesting that the challenges of untimely delivery, high costs, low quality, and weak credit systems are broadly shared across demographics.

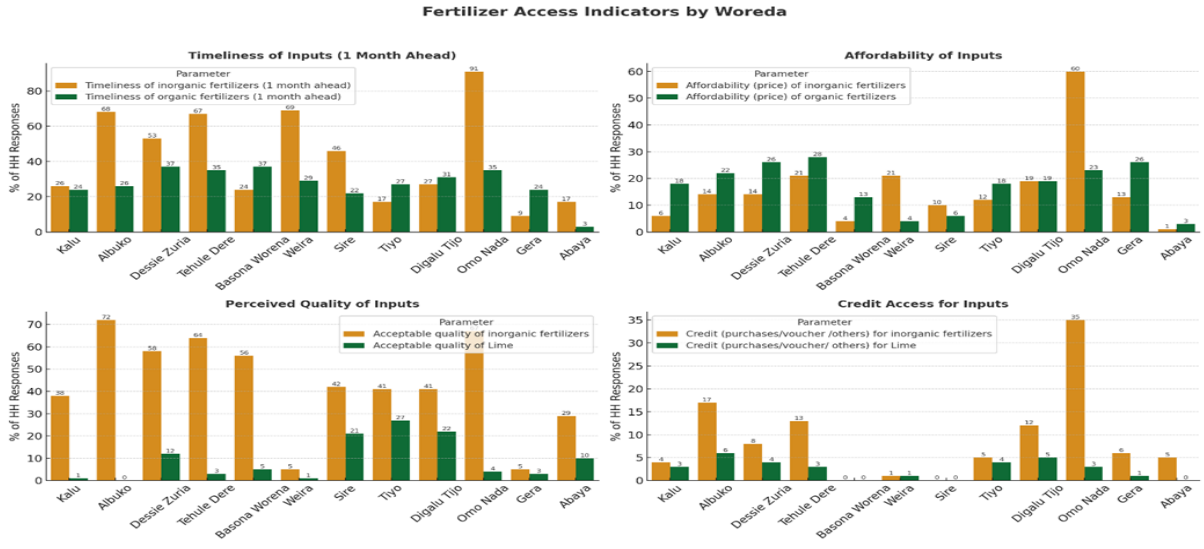


Figure 9: Timeliness, affordability, quality, and credit access of some soil inputs

Correlation Analysis: By deploying Pearson Correlation analysis, an examination of the interrelationships among timeliness, affordability, quality, and credit access reveals important patterns shaping household perceptions of soil inputs (Table 29).

Table 29: Correlation (r) values for four soil input parameters (timeliness, affordability, quality, and credit access)

Parameter	Timeliness	Affordability	Quality	Credit Access
Timeliness	1.00	0.42	0.58	0.33
Affordability	0.42	1.00	0.47	0.29
Quality	0.58	0.47	1.00	0.36
Credit Access	0.33	0.29	0.36	1.00

Among the four considered parameters of soil inputs (timeliness, affordability, quality, and credit access), timeliness emerges as a central factor with highest r value of 0.58 (Table 29). This implies the soil inputs delivered on time are more likely to be perceived as high quality, as evidenced by a moderately strong positive correlation of r = 0.58 between timeliness and quality. Affordability also plays a pivotal role, showing positive associations with both timeliness (r = 0.42) and quality (r = 0.47). However, the correlation (r) of credit access with the other parameters is relatively weaker (0.33 with timeliness, 0.29 with affordability, and 0.36 with quality). This implies that financial mechanisms like direct purchases, vouchers, and cash credit are not strongly linked to how timely, affordable, or high-quality the inputs are. Instead, credit access may be influenced by external factors like institutional support or local financial infrastructure.

3.4.1.3 Status of Lime Availability, Quantity, Innovation, and Usage

The fresh information in Table 30 is extracted from % HH responses on lime availability versus acidity levels of soils as reviewed from woreda-level soil maps of MoA and ATA (2016). The percent baseline values indicated extremely limited access to lime (0-4%) despite community-level FGDs' responses in Basona Worana and some woredas of Oromia for higher lime demand. Households in most woredas reported zero level lime availability, despite MoA and ATA (2016)'s report of moderately to strongly acidic soil levels, as seen in Gera, Albuko, Dessie Zuria, and Weira.

Table 30: Lime availability versus the reviewed status of soil acidity across the 12 woredas

Woreda	% HH responses on lime availability	Acidity Level (MoA & ATA, 2016)
Kalu	0	Neutral pH
Albuko	0	Moderately Acidic (part of the kebeles)
Dessie Zuria	0	Moderately Acidic (part of the kebeles)
Tehuledere	0	Neutral pH
Basoan Worana	2.6	Moderately Acidic (part of the kebeles)
Sire	0	Moderately Alkaline and Moderately Acidic
Tiyo	6.4	Neutral to Moderately Acidic
Digelu Tijo	14.1	No information
Omo Nada	3.8	Moderately-Strongly Acidic
Gera	0	Moderately-Strongly Acidic
Abaya	0	No information
Weira	0	Neutral to Moderately Acidic

National Context of Lime Potential and Production: Ethiopia has significant, though largely unquantified, potential for agricultural lime production due to its abundant limestone deposits (MoA, 2024a). A comprehensive national assessment of accessible and economically viable reserves is still lacking. However, government targets for lime distribution point to an underlying

capacity for supply, either through local production or imports (MoA, 2024c). One major challenge in setting a 2024 baseline is the lack of quantifiable data on actual lime production by commercial or local enterprises. This remains a key gap in understanding the development of the supply chain for this essential soil input (MoA, 2024a). Additionally, detailed data on production volumes and operational capacities are limited (MoA, 2024). While government-owned lime factories exist, some private cement factories (e.g., Dashen and Muger) have started producing agricultural lime (IF, 2023). There are also pilots of lime supply scattered across the country by small traditional producers and private agro-dealers (IF, 2023). However, the comprehensive quantity (MT) of lime was not nationally quantified (Ali et al, 2023).

Current Use of Lime by Smallholder Farmers (2024 Baseline): In 2024, the application of lime by smallholder farmers was linked to the government's strategic target of 900,000 tons of lime at the national level, through the subsidization of approximately 1.4 billion ETB (~ USD 12 million) (MoA, 2024c). This total amount is planned to be applied to 300,000 hectares of acidic soils. MoA (2024c) also reported that the regional states are planning more areas of acidic soils through the earmarking of additional budgets. Despite the bold national and regional targets and substantial budgetary allocations, the actual on-the-ground use of lime by smallholder farmers in 2024 was only 3.5% of the target, as depicted in Appendix 21. The universally recommended application rate for effective soil acidity treatment stands at 3 tons of lime per hectare (Tekalign & Haque, 1987). However, ongoing research and promotion of "lime micro-dosing" are underway, which involves applying smaller, more targeted quantities (MoA, 2024b).

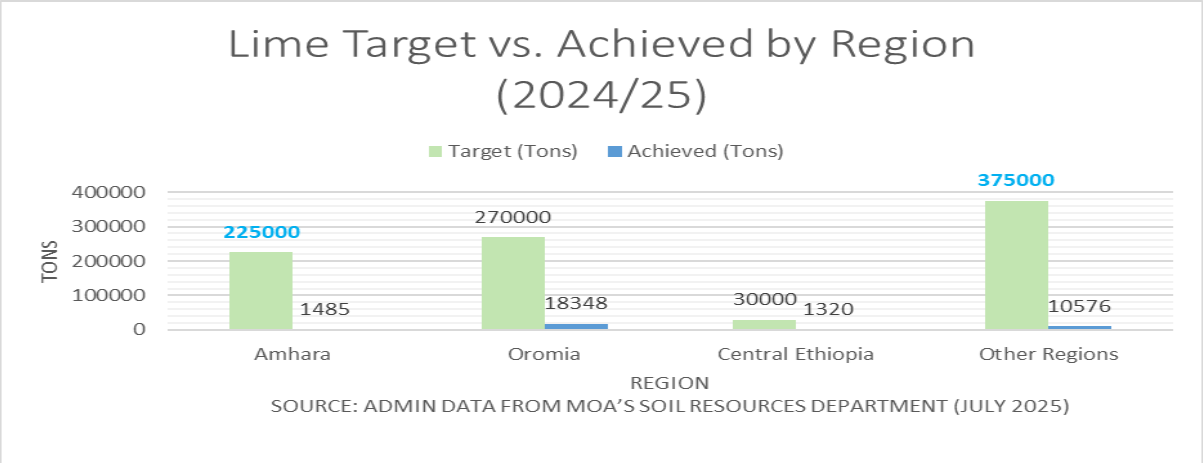


Figure 10: Volume of targeted versus applied lime in the 2024/25 production season

3.4.1.4 Private Sector and MSME Involvement in Input Production and Distribution

According to the ground-level information obtained through the household survey questionnaire, 114 household respondents (9.1%) reported the presence of small-scale soil input producers (MSMEs, cooperatives, individuals, etc.) who produce local soil inputs, such as compost, vermicompost, lime, and others (Table 30). Three among the 12 woredas (25%) and 8 of the control (C) kebeles (67%) have no local input producers/suppliers.

Table 31: The presence of local soil input producers (MSMEs) for the production and distribution of local soil inputs

No	Woreda	Control kebeles (C = 26)		Intervention kebeles (T= 78)		Total (N=104, K=4)	
		n	%	n	%	n	%
1	Kalu	0	0	6	7.7	6	5.8
2	Albuko	0	0	0	0	0	0
3	Desse Zuria	0	0	4	5.1	4	3.8

4	Tehuledere	0	0	0	0	0	0
5	Basona Worena	0	0	1	1.3	1	1.0
6	Sire	1	3.8	6	7.7	7	6.7
7	Tiyo	1	3.8	2	2.6	3	2.9
8	Digelu Tijo	7	26.9	5	6.4	12	11.5
9	Omo Nada	0	0	7	9.0	7	6.7
10	Gera	0	0	8	10.3	8	7.7
11	Abaya	19	73.1	47	60.3	66	63.5
12	Weira	0	0	0	0	0	0
	Total/Mean	28	9.0	86	9.2	114	9.1

In support of the limited availability of local soil input producers at the grassroots level, Ali et al. (2023) and IF (2023) reported that private sector and MSME engagement in soil inputs, including the lime value chain, is described as "minimal." Moreover, the types and precise number of products that are made available by private actors and MSMEs within the country were not counted (IF, 2023). It is also agreed that detailed statistics on the exact numbers, quantities, and investments for the specific areas are not consistently available (IF, 2023). However, Abate & Sheferaw (2023) reported that approximately 1.5 million MSMEs existed in 2020, employing around 4.5 million laborers nationally and generating a monthly income of 40.7 billion Birr; however, their specific involvement in organic input production and distribution is not disaggregated. ResearchGate (2019) and Abate & Sheferaw (2023) also reported that many MSMEs operate in local and regional markets, with limited vertical linkages to larger firms.

Pinning out the importance of 'Business Cases and Investments', there is a recognized need and ongoing discussions about increasing private sector participation and investment in various agricultural value chains, including fertilizer production (Munir, 2023). IF (2023) and Munir (2023) also predicted the existence of investment proposals for establishing new fertilizer factories (including organic fertilizer facilities). These would involve substantial capital, potentially through private or joint ventures. However, the specific number of developed "business cases" or concrete private sector investment figures that solely represent "soil health products" is either unquantified or unavailable (IF, 2023).

Table 32: Summary of soil inputs value chain gaps, opportunities and recommendations for Transform Program

Theme	Gaps	Opportunities to Fill Gaps	Recommendations
Major Value Chain Issues	Fragmented and uncoordinated supply system with limited private sector engagement. Inconsistent availability, high prices, and poor credit access for farmers. Weak last-mile delivery and transporta	**Leverage existing channels:** Strengthen the role of cooperatives and public suppliers. Engage the private sector: Capacitate and incentivize agro-dealers, one-stop shops, and MSMEs Operationalize AOSS: Expand Agricultural One-Sto as decentralized hubs.	**Improve Last-Mile Delivery:** Incentivize private partners and cooperatives to enhance logistics. Develop Integrated Credit Schemes: Pilot and scale-up credit access mechanisms linked to cooperatives or microfinance institutions. **Establish a Coordination Platform:** Create a platform for key improve coordination.
Use of Soil Inputs	Very low use of key inputs like lime, bio-fertilizers, and micronutrients. Uneven use patterns and low innovation among youth and female farmers. Lack of awareness about the benefits of non-traditional inputs.	**Promote location-specific inputs:** Tailor interventions to local soil needs (e.g., nutrient deficiencies). Leverage research: Promote new and efficient methods eg. 4Rs, lime micro-dosing. **Strengthen and Utilize extension services:** Use ex networks for targeted training and demonstrations.	Expand the Input Portfolio: Actively promote and make a wider range of inputs available. Tailor Interventions: Design location-specific strategies based on baseline data. **Enhance Extension Services:** Provide targeted training for youth the proper use of inputs. Eg. organic soil inputs and amendments.
Lime Availability & Usage	A massive gap exists between national targets and actual use (only 3.5% of the target was applied). Zero or near-zero use of lime despite soil acidity issues in many woredas. ·Lack of quantifiable data on actual lim	**Utilize policy support:** The government has high targets and substantial subsidies. Tap into domestic resources: Ethiopia has abundant limestone deposits for production. **Engage the private sector:** Partner with private c and small-scale producers to scale production.	**Quantify and Track Progress:** Establish a system with government agencies to track the volume of lime produced and distributed. **Formalize Partnerships:** Create formal partnerships with private producers to increase supply. **Enhance Knowledge Transfer:** Promote "lime micro-dosing" and application methods to farmers.
Quality & Credit Access	Low farmer satisfaction with the quality of certain inputs. Very limited credit access for purchasi	Implement quality assurance: A certification system could build farmer trust and confidence. Link credit to value chain: Integrate financial mech delivery of high-quality inputs.	**Establish Quality Assurance:** Implement a clear certification system for all inputs, with a focus on lime and bio-fertilizers. Strengthen Linkages: Explore ways to better link financial mechanism and quality delivery of inputs to farmers.
Private Sector & MSMEs•	Private suppliers are only a secondary source of inputs; declining contributions. Their overall engagement is limited. Lack of quantifiable data on their proc and operational capacities for inputs	**·Policy and financial incentives:** The government can offer incentives to attract private investment in the input sector. Existing initiations small traditional producers and private agro-dealers can be piloted and scaled-up.	**Formalize Partnerships:** Create formal partnerships between the Transform program and private agro-dealers and MSMEs. Provide Technical and Financial Support: Offer technical assistance and financial incentives to private sector actors and focus on MSMEs. **Promote AOSS:** Position Agricultural One-Stop Shops as a key channel for private sector engagement and expansion. Information sharing: Establish a system for data collection and sh private investment decisions.

3.4.2 Research and Innovation in Soil Inputs

Ethiopia, often dubbed the "Museum of Soils" due to its diverse soil resources, faces significant challenges related to soil degradation, nutrient depletion, and unsustainable farming practices, particularly by the smallholder farmers. In response, extensive research and innovation efforts are underway to enhance soil health and fertility, with notable initiatives in the key agricultural regions of Amhara, Oromia, and Central Ethiopia (MoANR, 2017).

Historically, soil fertility research in Ethiopia began in the 1960s, focusing on nitrogen (N) and phosphorus (P) deficiencies (Desta & Mitiku, 2014, and Tekalign & Haque, 1987). Subsequent soil surveys have consistently revealed widespread deficiencies of N, P, potassium (K), sulfur (S), zinc (Zn), and boron (B) across various regions (Abera et al, 2016, and Hailu et al, 2015). The alarmingly low soil organic matter content, particularly in the highlands, is also a critical research bottleneck (Nega et al, 2016). Soil acidity also poses a widespread problem, affecting approximately 41% of cultivated land, with 28% being highly acidic and severely limiting crop growth (Abegaz & Kebede, 2016). Furthermore, challenging terrain, intense rainfall, and unsustainable practices contribute to severe soil erosion and topsoil loss (Hurni, 1988). Smallholder farmers often apply fertilizers below recommended rates, and traditional practices (eg, land fallowing, dung application, and the use of crop residues) have declined due to competing demands (Regassa and Stroud, 2015, and Endalew, 2015).

Research and Innovation Approaches: Ethiopia's soil fertility research has significantly advanced from general surveys to detailed nutrient mapping and the use of diverse fertilizer blends (MoA & ATA, 2016; Tadesse & Gebre, 2020; Wassie et al, 2020). Current research and innovation in the three baseline regions pursue certain specificities:

Regional Specific Research Focuses: The Amhara region faces significant challenges in soil input due to degradation, erosion, and fertility loss, driven by unsustainable farming practices, population pressure, and climate change (Abera et al., 2018; Moges & Ambaw, 2017). Research promotes integrated soil fertility management (ISFM), which combines inorganic and organic inputs with legume-based nitrogen fixation (Hailu et al., 2015; Tadese & Bekele, 2014). It also addresses soil acidity through liming and the use of acid-tolerant crops (Tadese & Bekele, 2014; Yitaferu & Frankl, 2014). Innovations focus on sustainable practices, modernized research, site-specific fertilization, and blending indigenous with scientific knowledge (Abera et al., 2018; Hailu et al., 2015; Moges & Ambaw, 2017). Oromia's diverse soils, particularly Vertisols, face issues such as waterlogging, acidity, and low organic matter (Tolera et al., 2014; Negassa et al., 2015). Use of mineral fertilizers is limited to cereals, while organic inputs are only for crops like enset and coffee. Research focuses on soil-specific management and agro-ecological needs (Negassa et al., 2015). Inclusive, site-specific fertility strategies are recommended through the use of ISFM. Central Ethiopia likely faces soil acidity, nutrient depletion, and low organic matter (Negassa et al., 2015; Abegaz & Kebede, 2016). Strengthening extension services and participatory research can improve soil input use, supported by promoting ISFM, bio-fertilizers, and residue management (IFDC, 2024).

3.4.3 Indigenous and Innovative Knowledge Analysis of Soil Inputs

Indigenous knowledge: Across Amhara, Oromia, and Central Ethiopia, indigenous knowledge plays a vital role in managing soil health, often complementing or compensating for gaps in modern soil input systems. In Amhara, traditional practices such as fallowing, composting, and terracing are widely employed to restore soil fertility, conserve moisture, and mitigate erosion (Moges & Holden, 2008; Abera et al., 2018). Farmers also use indigenous indicators such as crop color, weed type, and soil texture to assess fertility levels and guide input

use. In Oromia, farmers integrate organic matter from crop residues, animal manure, and agroforestry species, particularly for high-value crops like coffee and enset. Knowledge of soil behavior especially of Vertisols is passed down inter-generationally to determine optimal tillage timing and avoid waterlogging (Lemma & Fantaw, 2017; Negassa et al., 2015). Customary practices, such as rotating legumes to enhance nitrogen fixation, reflect a deep-rooted ecological awareness. In central Ethiopia, where formal systems are still emerging, indigenous knowledge remains a central component. Practices like manure composting and soil-burning (ash application) are commonly used to improve nutrient availability and reduce acidity (Abegaz & Kebede, 2016). However, gaps persist in linking local practices with scientific innovations due to the limited availability of extension and research services.

Innovations in Soil Inputs: Innovative efforts across all three regions include the promotion of Integrated Soil Fertility Management (ISFM), site-specific fertilizer recommendations, and the use of lime to correct soil acidity. These and other innovative technologies shall be scaled up by incorporating both organic and inorganic inputs, as well as soil amendments tailored to local agro-ecologies. To maximize impact, bridging indigenous wisdom with scientific innovations is essential. This includes strengthening farmer-researcher partnerships, decentralizing soil testing, and enabling knowledge exchange platforms that validate and upscale locally adapted practices.

The most effective approach to soil management for farmers is to integrate indigenous knowledge with innovative scientific methods. The initial step would be validating and refining traditional practices with modern research and localizing innovations to fit specific agro-ecological conditions. By blending these two knowledge systems, farmers can improve soil health and productivity in a sustainable, cost-effective way. For instance, the traditional practice of fallowing can be enhanced by planting nitrogen-fixing cover crops, and the indigenous use of ash can be optimized by using simple soil pH testing kits to determine the correct application rate. Similarly, traditional terracing can be enhanced with climate-smart techniques.

3.4.4 Capacity Building for Soil Input Value Chains

The success of robust soil input innovations hinges on capacitating and empowering both the supply (soil input dealers) and demand sides (smallholder farmers). Preceded by knowledge gaps and need assessments, building the capacity of these actors is critical. During this baseline survey, the existing indigenous knowledge (IK) level of the smallholder farmers is assessed through a HH questionnaire survey and FGDs.

Table 32 recorded the baseline % responses of HHs across 12 woredas for intervention (T) kebeles who reported knowledge capacity on 16 aspects of IK levels including soil characteristics, soil inputs, soil health attributes, and 4Rs. Smallholder farmers showed relatively higher awareness in basic soil type identification (47%) and traditional soil and water conservation (SWC) practices, such as SWC techniques (55%). However, knowledge sharply declines for soil health attributes (8% for acid and 5% for saline). The latter coincides with neutral soil pH reports of Table 26, for instance, for Tehuledere (8%) and Weira (5%) woredas. Understanding of the use and 4R principles of organic fertilizers, bio-fertilizers, and soil amendments is also limited (Table 30), which implies the need for project intervention on 4Rs in both mineral and organic fertilizers' applications. The mean overall knowledge capacity ranges from 17% (Gera and Abaya) to 45% (B/Worana) (Table 30). Disaggregated by gender and age, the data reflect significant variability across woredas and demographic groups. However, the mean values for gender across the 16 knowledge attributes showed moderate variations, at 37% for male respondents and 29% for female respondents, while the adult and youth groups showed equivalent average knowledge levels of 35%. Such data are evident on the requirement of knowledge/practice-based interventions prioritizing female headed and both youth and adult headed HHs. Similar to intervention kebeles, baseline values (HH % responses) for control kebeles were recorded and depicted in Appendix 32 with a range of 0-26% knowledge/practice levels. This implies zero and generally low soil input knowledge and

practices of the smallholder farmers implying a need for training and knowledge sharing program. The highest record (26%) was obtained for the use of organic fertilizers in Basona Worana and soil and water conservation practices in Albuko woredas. Among 192 (12*16) records, 33 were obtained at 0% with most records being for use and practice of soil amendments, which is evident in all woredas except Digalu Tiju (9%) and Gera (1%), implying no or very little use of soil amendments.

Table 33: HH responses (5) on knowledge capacity of smallholder farmers on soil characteristics, soil health attributes, soil inputs, and 4Rs in the Intervention (T) kebeles

Types of knowledge/practices	Kalu	Albuko	Desse Zuria	T/Dere	B/Worena	Sire	Tiyo	Digelu Tijo	Omo Nada	Gera	Abaya	Weira	~X
I know soil types (clay, silt, sand)	64	56	57	61	73	20	17	20	41	26	53	78	*47*
Acid soils & management practices	12	5	10	8	10	3	7	14	10	8	3	5	*8*
Saline soils & management practices	8	1	2	3	12	5	6	11	7	6	1	3	*5*
Vertisol management practices	61	49	64	66	31	12	10	14	17	22	0	74	*35*
Recommended rates of IFs	5	58	48	53	61	30	33	25	54	12	46	45	*39*
Recommended type of IFs	5	62	50	60	69	29	30	21	54	13	12	18	*35*
Recommended method of IFs	5	64	50	59	69	30	33	23	66	20	12	35	*39*
Recommended times of IFs	5	64	49	61	69	29	33	25	66	26	11	27	*39*
Recommended rates of OFs	3	13	25	21	63	20	28	25	51	10	54	37	*29*
Recommended type of OFs	3	14	25	22	70	20	24	20	51	11	15	22	*25*
Recommended methods of OFs	4	14	26	27	70	20	26	23	71	26	16	39	*30*
Recommended times of OFs	4	14	26	28	70	20	28	24	71	29	16	31	*30*
Use of soil amendments & 4Rs	0	0	0	1	0	4	4	5	1	1	0	1	*1*
Use of Bio-fertilizers & 4Rs	0	2	0	1	10	4	6	6	0	0	0	14	*4*
Use of ISFMPs & 4Rs	0	1	3	1	0	2	3	5	0	1	1	18	*3*
Soil and water conservation practices	70	78	74	73	65	45	42	36	41	35	36	64	*55*

Types of knowledge/practices	Kalu	Albuko	Desse Zuria	T/Dere	B/Worena	Sire	Tiyo	Digelu Tijo	Omo Nada	Gera	Abaya	Weira	~X
MEAN	16	31	32	34	46	18	21	19	38	15	17	32	27

Abbreviations: IF – mineral fertilizers, OF – organic fertilizers, 4R – rate, type/source, method, and time of applications, ISFM – integrated soil fertility management

Pearson Correlation Analysis: Pearson correlation analysis was employed to examine the linear relationship among 16 types of soil-related knowledge and practices in intervention kebeles. The correlation analysis reveals strong positive relationships among farmers' knowledge of recommended mineral fertilizer practices, particularly between rate and time of application ($r = 0.94$, $p < 0.01$), suggesting that understanding in one domain often predicts familiarity with others (Appendix 33). Likewise, knowledge of in-situ soil moisture conservation is closely associated with soil and water conservation practices ($r = 0.87$, $p < 0.01$). In contrast, awareness of saline soil management and soil amendments shows weak correlations with other domains ($r < 0.3$, $p > 0.05$), indicating a low level of integration of these specific technical topics in local knowledge systems.

The community FGDs and KIIs conducted in the 12 woredas and kebeles also confirmed this variability in knowledge levels. The FDGs and KIIs also reported efforts in capacity-building training by public extension services (via DAs, Subject Matter Specialists, etc.) and other development partners (GIZ, FAO, CGIARs), as well as NGOs. For instance, CGIAR (2022), GIZ (2023), FAO (2022), and MoA (2024) variously reported on the periodical training programs by government agricultural bureaus/offices (MoA, BsOA, ATI), development partners (GIZ, FAO), and various research organizations. Most training programs often target district-level government staff and community leaders in a "Training of Trainers (ToT)" approach, aiming for a cascade effect (CGSpace, n.d.). It is also obvious that the successes of such trainings need to be complemented by demonstrations and adoption of multiple soil inputs at on-farm levels (KIIs and FGDs). Factors such as education level, family size, access to extension services, and credit access have a positive influence on farmers' decisions to use multiple land management technologies (EconStor, 2022; ResearchGate, 2017). Moreover, gender-disaggregated studies consistently highlight disparities in access to resources, information, and extension services, with female-headed households often having smaller farm sizes and limited access to critical inputs, such as manure (FAO, n.d.-a; CGSpace, n.d.-b; EEA, 2023).

3.4.5 Market Linkages and Commercial Viability of Organic Inputs

While Ethiopia has a long history of traditional farming practices that inherently utilize organic matter, the formal market for standardized, commercially viable organic inputs remains infant, insufficient, and less effective as compared to the established mineral fertilizer sector (federal KIIs). The regional, zonal, woreda, and kebele KIIs and community-level FGD respondents also proved to be consistent, as there were no exceptions in all project target woredas and kebeles. Moreover, there is an increasing recognition among stakeholders, including farmers and policymakers, about the benefits of organic inputs for soil health and long-term sustainability (ResearchGate, n.d.-a; UNCTAD, 2010).

A cost-benefit analysis of organic inputs showed that despite for higher initial costs and labor, organic farming can be as, or more, profitable than conventional farming. This is due to the significant premium price organic products command, which can offset potential yield gaps and increased expenses (Siddiqui & Hassan, 2021; Heinrichs et al., 2021). Furthermore, the substantial positive externalities of organic inputs, such as improved soil health and reduced environmental pollution would generate long-term societal benefits (Ng'ang'a et al., 2020). This integrated view, which considers both direct financial returns and broader ecological gains, affirms the economic feasibility and sustainability of organic inputs as a viable long-term agricultural strategy

However, the qualitative information of this baseline findings, as well as case-by-case cited authors, summarized the following challenges constraining the landscape of commercialization of the organic inputs in the country, including the project areas:

- **Limited Supply:** The organic inputs sector faces challenges in sourcing and consistent supply by private entities and MSMEs (Ali et al., 2023; IF, 2023).
- **Dominance of Mineral fertilizers:** Ethiopia's agricultural system has recently relied heavily on imported mineral fertilizers, with domestic demand largely met through imports (CABI Digital Library, 2024). This creates a significant structural challenge for the competitive entry and scale-up of organic alternatives.
- **Fragmented Supply Chains:** The supply chain for agricultural inputs, including organic materials, is often fragmented, with smallholder farmers relying on cooperatives and informal markets. The informal markets, while accessible, often expose farmers to poor-quality products (BEAM Exchange, n.d.-a).
- **Quality Control and Standardization:** A lack of clear quality standards and legal definitions for organic fertilizers can hinder their commercialization and farmer trust (Semantic Scholar, 2021).
- **Infrastructure and Logistical Constraints:** Transport infrastructure and efficient distribution networks remain a challenge, particularly for bulky organic inputs, impacting market access for both producers and consumers (Biovision Africa Trust, n.d.).
- **Cost Perceptions:** While organic farming can be less costly in terms of purchased inputs compared to inorganic methods (ResearchGate, n.d.-b), the initial investment in establishing organic production processes or the perceived effort for farmers to produce their own compost can be a barrier (federal, zonal and woreda KIIs).

Emerging Opportunities for Commercial Viability of Organic Inputs:

Despite the challenges, the commercial viability of organic inputs is gaining traction with opportunities. The following summaries are significant opportunities as expressed by the various KIIs (federal and zonal) as well as reviewed literature. These, *inter alia*, include:

- **Increasing Demand for Sustainable Practices:** Global and national pushes for sustainable agriculture, climate-smart practices, and soil health improvement are creating a favorable environment for organic input market development (KIIs; Biovision Africa Trust, n.d.).
- **Local Production Initiatives:** Investment proposals exist for establishing new organic fertilizer factories, often leveraging locally available raw materials like straw (KIIs; Scribd, n.d.). Various project-based interventions also simulate and attract internal investments through suggesting potential commercial viability for local entrepreneurs (KIIs; FGDs; Scribd, n.d).
- **Market Linkage Facilitation:** Programs such as the Agricultural Commercialization Cluster (ACC), Farmers Production Clusters (FPCs), and other similar projects are actively working to strengthen market systems for agricultural inputs by supporting input cooperatives and private agro-dealers, diversifying products, and improving the timely supply of quality inputs (KIIs; FGDs; Farm Africa, n.d.). Initiatives are also linking organic producers directly with consumers and supermarkets in urban centers like Addis Ababa, demonstrating a strong demand for organic produce (KIIs; Personal communications with MoA and ATI; Biovision Africa Trust, n.d.).
- **Policy Support:** The Ethiopian government has recognized organic agriculture through enforcing relevant policy such as the Agricultural and Rural Development Policy (MoA, 2025) and developing relevant strategies and guidelines (eg. MoA's Fertilizer and Soil Health Inputs Strategy, Agroecology Proclamation, etc) to support its development and facilitate access to new markets (KIIs; Individual Communications with MoA, EIAR and ATI; UNCTAD, 2010; Louis Bolk Instituut, n.d.).

- **Diversification of Income Streams:** For small-scale producers (MSMEs, Coops, AOSS, etc), engaging in the production of organic inputs (e.g., compost, vermicomposting, etc) can offer additional income streams and enhance farm resilience (KIIs; FGDs).

In summary, three major gaps and resultant recommendations are presented as follows

Findings (Gaps)	Recommendations
Limited Supply & Fragmented Chains: The formal market for organic inputs is underdeveloped and fragmented, with a heavy reliance on imported mineral fertilizers.	**Supply-Chain Development:** Support the establishment of local organic fertilizer factories and small-scale production initiatives (e.g., compost, vermicomposting) for efficient supply
Lack of Quality Standards: The absence of clear quality standards and legal definitions for organic inputs hinders commercialization and farmer trust.	**Standardization & Policy Support:** Advocate for the development and enforcement of clear quality standards and policies for organic inputs to build market trust and facilitate commercialization.
Marketing Infrastructure & Logistics: Transporting bulky organic inputs is challenging, impacting market access for producers and consumers.	Market & **Logistic Improvements:** Facilitate market linkages through existing and new initiatives to streamline distribution and connect producers with urban markets.

3.4.6 Knowledge Transfer and Linkages for a Vibrant Soil Input Sector

According to reviewed literature and KIIs' information collected from multiple stakeholders, Ethiopia is attempting multiple approaches to enhance knowledge transfer and linkages within the whole agriculture and its soil input sectors through an online directory and digital platforms.

Online Directory and Digital Platforms:
Aiming at providing services across the country (including target regions and woredas), Ethiopia has been developing and implementing online directories and digital platforms related to agricultural inputs, which is part of a broader "Digital Agriculture Roadmap" of the country (KII respondents; ATI, 2025; 2MC, 2025; AF, 2025; EHPEA, 2025; MoA, 2024; GAS, 2024; and DG 2023). These, inter alia, are summarized in the following Table 30.

Table 34: Tabulated overview of Ethiopia's digital agricultural initiatives.

Initiative/Platform	Description	Initiator/Actor
Digital Agriculture Roadmap	A comprehensive framework to integrate digital tools across the agricultural value chain to boost productivity and resilience.	ATI
Ethiopian Digital Input Tracking System (EDITS)	Tracks fertilizer distribution from ports to farms using QR codes and NFC tags, with plans to expand to other inputs.	ATI
Nationwide Digital Database for Farmers	Connects farmers directly with financial institutions, input suppliers, buyers, and advisory services.	MoA, ATI
Agricultural One Stop Shops (AOSS)	A project that uses physical one-stop shops supported by digitalization to improve farmers' access to inputs and services.	ATI
Lersha Application	A one-stop-shop app for smallholder farmers providing access to inputs, mechanization, and financial services.	Green Agro Solution
Digital Projects	Specific initiatives to streamline agricultural processes, including a platform for market linkage, an e-voucher system for inputs, and a farmer hotline for advisory services.	ATI, Digital Green
Supplier Directories	Online platforms that list various importers and suppliers of agricultural inputs, including those for soil.	EHPEA, 2merkato.com

Despite these efforts, the KIIs respondents and IFDC (2025), AF (2025), MoA (2025), MoA (2024), and IISTE (n.d) variously reported several challenges that hinder the effective knowledge transfer and strong linkages for a vibrant soil input sector. The major bottlenecks include poor digital infrastructure, capacity gaps, fragmented data, uncoordinated efforts, limited demand-driven research, weak research-extension-farmer linkages, and unsustainability of initiatives.

3.4.7 Challenges and Opportunities of the Soil Input Sector

The soil input sector faces a complex interplay of challenges and opportunities, largely driven by reliance on smallholder farming systems. The following findings are summarized from KIIs' responses of federal (MoA & EIAR), regional (RARIs & research Centers), and zonal/woreda/kebele levels and published/unpublished literature reviews.

Challenges: The overarching challenges of the soil input sector could be widespread land degradation, severe soil erosion, and declining soil fertility (primarily due to intensive cropping systems, limited biomass recycling, and inadequate replenishment of nutrients) (KII responses; Abera et al, 2018; DBFZ, n.d.). Most Ethiopian soils are deficient in essential plant nutrients like nitrogen (N) and phosphorus (P), with emerging deficiencies in macro and micronutrients such as potassium (K), sulfur (S), zinc (Zn), and copper (Cu) (Hailu et al, 2025; DBFZ, n.d; MoA & ATA, 2016). Soil acidity is a significant constraint, affecting an estimated 40-41% of arable lands, particularly in the highlands (EIAR & MoA's KII; Fenta et al, 2024). From soil inputs side, low availability of organic inputs and soil amendments, high cost of fertilizers, limited access to credit, insufficient infrastructure for transport and market access, limited capacity of smallholder farmers, and poor implementation of fertilizer and soil health strategies, and weak policy monitoring would be the major ones (KIIs and FGDs; Abera et al, 2018; ARARI, 2025; IQQO, 2024). Climate change, with its increased frequency of extreme weather events, further exacerbates these problems (Abera et al, 2018). Furthermore, a disparity exists between farmers' knowledge of good practices and their capacity to implement them due to resource limitations.

Opportunities: Despite these challenges, Ethiopia possesses significant opportunities. The country has a large agricultural labor force and abundant water resources, with potential for irrigation development (KII responses; Abera et al, 2018). There's a growing recognition of the need for integrated soil fertility management approaches, combining inorganic and organic inputs, and promoting practices like agroforestry and conservation agriculture (KII responses; IQQO, 2024; ARARI, 2025). Government and non-governmental organizations are increasingly focusing on improving living conditions through new technologies, including the application of combined organic fertilizers and biochar for soil amendment (NGOs & GOs' KIIs; SOS, 2025; DBFZ, n.d.). There's also potential to leverage indigenous knowledge alongside modern scientific approaches for sustainable soil management (DBFZ, n.d.) and incorporate available soil inputs research and related technologies by EIAR and RARIs (KIIs with EIAR).

Regional Specific Focuses on Challenges and Opportunities: In Amhara, land degradation, driven by erosion, acidity, and nutrient loss, is compounded by conflict-related disruptions in input supply. Yet, opportunities exist in advancing crop-specific fertilizer research, scaling up ISFM and SLM practices, and promoting acid-tolerant varieties and liming. Oromia's declining fertility and traditional farming practices hinder productivity; however, participatory research, slope-specific fertility management, and support for cooperatives offer potential solutions. Central Ethiopia suffers from poor soil conditions and limited community awareness, although transformative gains could be achieved through climate-smart agriculture, organic input development, and participatory soil health initiatives.

3.5 Strengthening Linkages between Research and Extension through Farmer-Led Action Research

The main goal of Component 3 is to enhance the link between agricultural research and extension, thereby improving practical farming. It does this by directly involving farmers in the research process through an approach known as '**farmer-led action research**', which empowers farmers to identify their own challenges and co-create solutions with researchers and extension agents. However, this section examined and reported the tripartite linkage among research, extension, and education, particularly the ATVET system. While significant progress has been made, addressing persistent gaps in research-extension-farmer linkages, ensuring demand-driven research, and strengthening infrastructure and capacity will be crucial for achieving a truly vibrant and sustainable soil input sector.

3.5.1 Analysis of Research-Extension-Education Linkage in Ethiopia

One of the key factors limiting the contribution of Ethiopian agriculture is the weak linkage among the three pillars of the agricultural knowledge system: research, extension, and education. The responses from KIIs disclosed the major cause of such weak linkage to be the institutional fragmentation and weak bondage among institutions that are responsible for separately administering these three agricultural systems (EIAR/RARIs, MoA/BoA, Agricultural Universities, and ATVET Colleges). The major obstacles to strong linkages include a lack of institutional collaboration, insufficient funding, and a "top-down" mind-set that marginalizes farmer input (S. Kebede, 2017). The linkage between higher education institutions, research centers, and extension services is often informal and depends on individual initiatives rather than a structured, systemic collaboration (Huluka, 2017). The lack of a strong, unified platform for these three pillars to interact leads to duplication of efforts, disconnect between technology generation and adoption, and ultimately, low agricultural productivity. The system is also hindered by inadequate infrastructure, limited use of digital information dissemination, and a general lack of a coordinated monitoring and evaluation framework.

Regarding research and extension linkage, the system is characterized by a top-down, "pipeline" model where research institutions, primarily the EIAR and RARIs, develop technologies which are then passed on to the MoA and BoA and their extension system for dissemination (KIIs; Belay, nd; Debelo, 2020). While EIAR and RARIs are responsible for coordinating federal and regional agricultural research and advising the federal and regional governments on policy, these structures, however, often lead to technologies that are not well-suited to the diverse needs and conditions of smallholder farmers at ground levels (Belay, nd; PSI, 2025). However, the KIIs responses from EIAR, RARIs and two research centres (Debre Birhan and Haik) reported the pursuance of bottom-up approach during research problem identification through deploying the federal and regional research and sub-research centres and DAs of the MoA despite the limited scale of released technologies and farmers' reached innovations. According to PSI (2025) and federal and regional/zonal KIIs' responses, a significant challenge both at federal and regional levels is the institutional separation between research (EIAR/RARIs) and extension (MoA/BoA), which is considered as a 'blame game' due to their operation under different administrative and budgetary frameworks. The research feel their technologies are not being adopted while extension services argue on practicalities and affordability's of released technologies.

Higher Learning Institutions: According to the responses of KIIs and earlier report by Huluka (2017), agricultural universities and vocational training centers produce graduates who should, in theory, form the backbone of the research and extension workforce. They are crucial for producing the next generation of researchers and extension professionals. Despite their mandates on research and community outreaches, the relevance of their curricula may not be fully aligned with the practical needs and current realities. They have a limited and often fragmented connection to both research and extension (Demissie, 2016). The curriculum can be overly theoretical and not aligned with practical, field-based challenges (M. Ayele, 2019).

This disconnect means new DAs and researchers may lack the practical skills needed to work directly with farmers or to adapt new technologies to diverse agro-ecological zones.

Local Contexts: Despite Ethiopia has one of the densest agricultural extension systems in the world (PSI, 2025) with massive number of DAs stationed at kebeles and FTCs levels, the linkage at the local level remains weak. The system is largely driven by a top-down approach, with farmers often viewed as passive recipients of technology rather than active participants [Belay, n.d.]. Although there have been efforts to introduce more participatory approaches at grassroots' level, the old models persists and DAs often face challenges like high turnover, low motivation, and a lack of resources and training, which further weakens their ability to effectively link farmers with research findings (Tesfaye, 2023; Belay, n.d.).

While efforts in establishing platforms such as the current Agricultural Development Partnership Liaison and Advisory Council (ADPLAC), the former Research, Extension and Farmers Advisory Council (REFAC), and the pioneer Research and Extension Liaison Committee (RELC) were apparent since the age of RELC in 1990s, results were inconsistent in fully reversing the poor linkage. Owing to the facts that ADPLAC evolved from its two predecessors and it's still the present platform since its formulation in the 2008, the following baseline information is presented on its strength, weakens and opportunities (Table 34).

Table 35: Strengths, weaknesses, and opportunities on the current platform of research-extension-education linkage, the ADPLAC.

Strength	Weakness	Opportunities
Established Platform: ADPLAC provides an existing multi-stakeholder platform to strengthen research-extension linkages for farmer-led action research.	Limited Farmer Voice: Despite its advisory role, ADPLAC has historically struggled with meaningful farmer representation, which is a core tenet of farmer-led action research	Leveraging a Pre-existing Structure: ADPLAC would be a primary vehicle to implement its research-extension activities on soil health and fertility instead of thinking to build a new institutional framework from scratch.
Built-in Collaboration: The council's core purpose is to foster collaboration among researchers and extension agents, which is essential for successful joint research projects with farmers.	Lack of Funding and Mandate: ADPLAC's lack of a dedicated budget and its limited legal authority hindering its ability to coordinate linkages including farmer-led research initiatives.	Enhancing the Existing System: ADPLAC's is existing platform to build upon. Its weaknesses can be addressed through introducing new funds and a more structured mandate to improve feedback loops. It can support genuine farmer-led research and outreach activities.
Decentralized Structure: The presence of ADPLAC at regional and woreda levels, which are existing local councils to facilitate activities at ground level, including farmer-led action research and demo plots.	"Top-Down" Mindset: A prevailing "top-down" approach within the existing institutional culture. This is a barrier to participatory approaches like genuine farmer-led action projects, which requires a bottom-up and facilitative approach.	Introducing a New Methodology: ADPLAC can serve as a platform to introduce and mainstream the concept of farmer-led action research, which empowers farmers as co-researchers and innovators within the national agricultural system.

In summary, while there have been attempts to improve the research-extension-education linkage in Ethiopia, it remains largely weak due to historical institutional fragmentation and a top-down approach. Compounded by institutional fragmentation, there is weak farmer

involvement in the research process, which ultimately leads to low adoption rates of new technologies. Therefore, either modifying ADPLAC or establishing new platform for participatory and inclusive research-extension linkage is recommended where strengthening such linkage requires a fundamental shift towards a more demand-driven, participatory, or well-resourced system that fully integrates farmers, researchers, and educators at all levels. To build a strong research-extension-ATVET linkage in Ethiopia, a fundamental shift is needed from fragmented, top-down approaches to a collaborative, demand-driven system. This requires systemic collaboration, including the creation of a national-level "Knowledge Hub" and local "innovation platforms" to jointly set research priorities and co-design relevant curricula. Simultaneously, it is crucial to leverage digital platforms by developing a centralized, multi-channel system (e.g., a mobile app, call centers, and SMS services) that provides farmers with timely information, facilitates two-way communication, and uses data to inform research and extension efforts. By integrating these institutional and technological strategies, the gap between agricultural theory and practice can be bridged, ensuring that research directly translates into on-farm impact and improved livelihoods.

3.5.2 Participatory Research Mechanisms and Good Practices

According to KIIs' respondents of the EIAR, RARIs, and interviewed agricultural research centers, the concepts of Participatory Research (PR) and Farmer Research Groups (FRGs) were formally introduced in Ethiopia in the late 1990s by the EIAR with technical and financial support from the Japan International Cooperation Agency (JICA). This idea is also evident in EIAR & JICA (2008). The KIIs also reported that in PR and FRGs, smallholder farmers lead problem identification and technology testing. In support of the PR and FRGs' initiation and implementations in Ethiopia, the KIIs report from MoA and SOS Sahel mentioned the introduction of Participatory Rural Appraisals (PRA) and the existence of farmers' Training Centers (FTCs), while FAO (2025) reported the importance of Farmer Field Schools (FFS) for Ethiopian smallholder farmers. From an international research linkage perspective, the KII's discussion with ISRIC disclosed that Ethiopia is one of the African countries where ISRIC joined hands with EIAR, MoA, IFDC, and ATI on soil PR, soil information sharing, and research-extension linkages. This KII also reported the motivation of ISRIC to support Ethiopia in capacity building, soil mapping, soil data quality, Decision Support Tool (DST) engagements, and other interrelated activities.

Good practices in Ethiopian PR emphasize farmer empowerment and ownership, ensuring solutions are context-specific and locally adapted by integrating indigenous knowledge with scientific approaches (Adamo, 2001; Taylor & Francis Online, 2018). Effective PR relies on strong multi-stakeholder collaboration, bringing together researchers, extension agents, NGOs, and communities, complemented by continuous capacity building and robust feedback mechanisms (Taylor & Francis Online, 2018; SOS Sahel Ethiopia, 2025). Leveraging farmers' existing social networks has also proven vital for efficient knowledge sharing and the diffusion of technology (Adamo, 2001).

Regionally, these approaches are tailored to specific needs. In Oromia, the good practice of PR is well-institutionalized, with regional institutes actively conducting on-farm research and promoting FRGs for integrated soil fertility management and water-saving techniques (KII with IQQO; JICA, n.d.a; IQQO, 2024). PR and FRGs in the Amhara region focus on addressing severe land degradation and soil erosion through participatory sustainable land management practices and watershed initiatives that harness local knowledge (KIIs with D/Birhan and Haik Research Centers; Abera et al., 2018; African Research Nexus, n.d.). Central Ethiopia tackles challenges like soil acidity and erosion through nature-based, climate-smart agriculture, where NGOs were facilitating participatory action research and the development of organic input production (KII with CEARI; Fenta et al., 2024; SOS Sahel Ethiopia, 2025). Despite these advances, resource limitations, institutional capacity, and ensuring long-term sustainability remain ongoing challenges (KIIs with EIAR, RARIs, and Research Centers; ResearchGate, 2021).

In summary, formalizing and scaling-up of PR and FRGs is recommended as primary mechanism for a demand-driven agricultural system. This can be achieved by establishing formal partnerships and agreements between the EIAR, RARIs, and the MoA or BoAs to integrate PR and FRGs into their regular operational plans. This also require rapid capacity building through targeted training for extension agents and researchers on participatory methodologies and the integration of indigenous knowledge. It's also important to expand successful regional models and sharing context-specific knowledge, for instance, ISFMPs in Oromia and SLM techniques in Amhara.

3.5.3 Status of Farmer-led Action Research Practices

Based on the household (HH) questionnaire, a household survey is conducted to learn the presence of soil input trials and demonstrations at the farm level. Table 35 presents the baseline values in percentage of household responses. In the five woredas of the Amhara region, the descriptive analysis revealed a near-total absence of farmer-led soil input trials, with a mean value of nearly 0. This is true across all demographic groups, with very minimal participation of adult males. Despite KIIs' positive responses for the presence of DST plots, trial-based research works were either unrecognized or excluded at the sampled HH level. In contrast, Oromia woredas showed relatively higher trial engagement with a regional mean of **17.3%** (vs. **0.13%** in Amhara), and notably higher awareness among adult males in the intervention kebeles. Unfortunately, HHs in Weira responded at 0% in intervention kebeles, while 33% responded in control kebeles. Across all regions, adult males reported the highest trial participation, but overall awareness remained low (**10.6%**), underscoring limited baseline exposure to participatory soil input research.

The near zero in CER & Amhara and minimal baseline responses in Oromia are not due to less interest of the farmers rather lesser capacities of the research and extension to conduct on-farm trial sites and demo plots in the baseline year, respectively. Expressing their interest to conduct on-farm trial sites and demo plots on their farms, the community groups of the FGDs also confirmed minimal presence of on-farm research trials and demonstrations at kebele levels, including the DSTs. On the other hand, research informants of the KIIs reported the presence of a few DST plots in the baseline year, although they were minimally distributed among the 12 target woredas. Zonal, Woreda, and Kebele levels KIIs' responses also supported the minimal presence of DST and other fertilizer demo plots across the 12 woredas.

Table 36: HH responses (%) on the presence of farm trials and research in soil inputs during the 2024

	Region /Woreda	Cont. kebeles	Trt kebeles	MEAN	Male		Female		Youth		Adult	
					Con	Trt	Con	Trt	Con	Trt.	Con	Trt
1.	Kalu	0	1	1	0	2	0	0	0	4	0	0
2.	Albuko	0	0	0	0	0	0	0	0	0	0	0
3.	Desse Zuria	0	0	0	0	0	0	0	0	0	0	0
4.	Tehuledere	0	0	0	0	0	0	0	0	0	0	0
5.	B/Worena	0	0	0	0	0	0	0	0	0	0	0
	Amhara $\bar{x}$	0	0	0	0	0.4	0	0	0	0.8	0	0
6.	Sire	12	8	10	6	8	25	8	15	8	8	8
7.	Tiyo	15	6	11	17	6	13	9	20	0	13	10
8.	Digelu Tijo	23	8	15	26	7	14	8	25	4	21	10
9.	Omo Nada	38	28	33	44	33	25	17	33	32	41	26
10	Gera	27	19	23	22	25	38	5	0	27	41	13
11	Abaya	0	23	12	0	26	0	17	0	15	0	27

	Region /Woreda	Cont. kebeles	Trt kebeles	MEAN	Male		Female		Youth		Adult	
					Con	Trt	Con	Trt	Con	Trt.	Con	Trt
	Oromia $\bar{x}$	19	15	17	19	17	19	11	16	14	21	16
12	CER: Weira	31	0	15	33	0	25	0	22	0	35	0
	GRAND $\bar{x}$	11	7	9	12	9	12	5	10	8	13	8

3.5.4 Current Landscape of Soil Health and Fertility Research in Ethiopia

According to the KIIs conducted with EIAR, RARI, and Research centers, the current landscape of soil health and fertility research in Ethiopia has attempted to address the widespread land degradation, nutrient deficiencies, soil acidity, and IFSM practices, though limited in scope and scale. Supporting such research agendas, Erkossa et al. (2022), Hailu et al. (2015), and Fenta et al. (2024) reported the growing emphasis on integrated and site-specific solutions. Historically, the previous soil research landscape focused on the prevalent deficiencies of two macronutrients (N and P), leading to blanket fertilizer recommendations (Hailu et al., 2015). However, recent national soil fertility surveys and mapping, such as the EthioSIS program (MoA & ATA, 2016), reported the nutrient deficiencies to broaden to other essential macro and micronutrients, prompting a shift towards more balanced nutrient management (MoA & ATA, 2016; Erkossa et al., 2022; Hailu et al., 2015). Currently, however, the KII with EIAR disclosed that the motive of importing and locally manufacturing blended fertilizer has been replaced by importing DAP and Urea fertilizers. To stop fertilizer importation, the GoE has recently committed to establishing a fertilizer manufacturing industry through a partnership with international companies, with the motto: "self-reliance in fertilizer supply" (Federal KIIs, MoI, 2023).

Current Regional Landscapes in Soil Health and Fertility Research: In **Amhara**, current research targets severe land degradation and nutrient depletion through ISFM and SLM practices like terracing and agroforestry, alongside studies on optimal N and P use for crops like barley (KIIs with two Amhara Ag. Research Centers; ARARI, 2025; Addis Standard, 2025). In **Oromia**, focus areas include soil test-based fertilizer recommendations, acid soil reclamation, and participatory on-farm trials to address nutrient imbalances and erosion (KIIs with IQQO; Hailu et al., 2015; Nekemte Soil Research Center, 2023). In **Central Ethiopia**, efforts focus on climate-smart practices, organic input production, and balanced fertilization to mitigate soil acidity and erosion (KIIs with CEARI; Fenta et al., 2024; SOS Sahel Ethiopia, 2025).

3.5.5 Academic Programs and Capacity Building in Soil Science

According to the KIIs' respondents of the sampled ATVET colleges (federal and regional), Ethiopia's commitment to addressing widespread land degradation, declining soil fertility, and soil acidity, particularly in key agricultural regions like Oromia, Amhara, and Central Ethiopia, is also underpinned by the ATVET's academic programs and capacity-building efforts. However, the KII respondents confirmed that such programs and capacity-building endeavors are more intensified in agricultural universities than ATVETs. Agricultural Universities across the country serve as vital hubs for developing the human capital necessary to understand, research, and implement sustainable soil management practices. The universities offer a range of postgraduate degrees, including MSc and PhD programs, in fields directly relevant to soil science and other pertinent fields of study, such as Agronomy, Natural Resource Management, Integrated Watershed Management, and specialized Soil Science programs. This academic pipeline is crucial for equipping professionals with evidence-based knowledge to tackle the complex soil health challenges facing Ethiopian agriculture (Haramaya University, n.d.b; Debre Tabor University, n.d.). Capacity building in soil science extends beyond formal degree programs, encompassing collaborative research initiatives and practical training. These academic endeavors are frequently conducted in partnership with national research bodies like the Ethiopian Institute of Agricultural Research (EIAR) and Regional Agricultural Research

Institutes (RARIs), ensuring that the research is relevant to local contexts and contributes to the knowledge base of the target regions (ICARDA, n.d.; ARARI, 2025).

3.5.6 Status of ATVET Colleges in Soil Health and Fertility Research and Outreach/Practices

According to ATVETs' KIIs responses, the ATVET colleges in Ethiopia play a critical, albeit indirect, role in advancing soil health and fertility practices, serving as a vital link between research and farmers. Their primary mandate is to train Development Agents (DAs), who are the frontline extension workers directly engaging with smallholder farmers across the country (KIIs). While ATVET colleges are not primary centers for generating soil research, their contribution lies significantly in outreach and practical application. The KIIs also confirmed that the ATVETs are serving as important demonstration sites for evidence-based soil health technologies and practices such as improved compost preparation, efficient fertilizer application methods, soil conservation techniques (e.g., terracing, bund construction), and integrated soil fertility management (ISFM) approaches, which can be showcased and taught practically.

Furthermore, the structure of the Ethiopian agricultural extension system emphasizes the crucial link between ATVETs and Farmer Training Centers (FTCs). ATVET graduates are assigned to work at FTCs, where they directly engage with farmers in demonstrating and advising on improved soil health and fertility research, and outreach practices (KIIs with ATVETs and MoA).

Challenges of ATVETs often include strengthening the practical skills of graduates and ensuring better linkages between ATVET curricula and the specific, evolving needs of farmers and agricultural programs, which require effective ground-level promotion and adoption of sustainable soil input practices.

Estimate for Number of ATVET Students: Although the actual figure could be computed by summing the anticipated graduating number of the baseline year from all ATVETs, these colleges produce approximately 50,000 trainees or graduates per annum. These are the graduates of various agricultural programs across federal and regional ATVET colleges (EJOL, n.d.).

3.5.7 Linkages and Collaboration between Research, Academia, and Other Stakeholders

The KII respondents and even the FGDs' female and male community groups of discussants witnessed that the effectiveness of agricultural development programs, such as the soil health and fertility agenda, relies heavily on robust linkages and collaboration among multiple stakeholders. Such linkage in the Ethiopian agricultural research, innovation, and extension system critically requires the liaison and close working relationship between the three research systems (federal and regional research institutes and universities) and the federal/regional agricultural extension service providers. This linkage also crucially demands the association and interactions by ATVETs, private sector actors, farmers and their cooperatives, development partners, NGOs, associations, professional societies, think-tanks, public/private enterprises, etc. During this baseline survey, the criticality of such a scenario and close linkage is proved by all contacted partners, including the international KII respondent of the ISRIC, lead, and local consortium partners, as well as all federal and regional respondents and discussants.

Such collaborations are designed to foster demand-driven research, ensure the relevance of academic outputs, and facilitate the efficient transfer and adoption of sustainable agricultural technologies, including integrated soil health and fertility management practices. As of the 2024 baseline, these linkages would be manifested in various forms across the target regions. Research institutes actively engage in participatory on-farm trials with farmers, ensuring technologies are adapted to local conditions, a practice common in all regions (IQQO, 2024; ResearchGate, 2024b). Universities contribute significantly through postgraduate research, often in collaboration with EIAR and RARIs, generating evidence-based solutions for regional challenges like soil acidity, salinity, degradation, waterlogging, etc (KIIs; FGDs; Fenta et al., 2024). ATVET colleges, in turn, train Development Agents who serve as the critical last-mile link,

disseminating practices learned from research and academia to farming communities (KIIs of ATVETs, EIAR, RARIs, MoA, and lead/consortium partners; EJOL, n.d.; FAO, n.d.). SOS (2025) also reported that NGOs, such as SOS Sahel Ethiopia, further bolster these efforts by supporting community-level implementation of soil health initiatives and fostering participatory action research. Establishing such a multi-stakeholder armed ecosystem would be fundamental for developing cohesive strategies and ensuring that the robust translations of soil health and fertility management strategies and interventions are implemented into improved practices on the ground.

While the assignment of providing precise, gender disaggregated numbers of researchers/experts for an inclusive, bottom-up, participatory, science-led research in soil health and fertility is temporarily difficult at once, this baseline survey can inform the requirements of enrolling these critical actors through knowledge bases and focuses. These include continuous capacity building, targeting the right audiences, gender and youth mainstreaming, and regional relevance.

Similarly, providing an exact, gender/youth disaggregated number of researchers specifically capacitated in "Standardizing Soil and Fertilizer Analysis, Soil Data Collection, and Management" in Ethiopia is still difficult unless systematically collected over time. However, this baseline study can infer significant interventions through mentioning evidence, yet not for this baseline year, but during the past decade. The Ethiopian Soil Information System (EthioSIS) program, which collected over 180,000 soil samples and established soil data management systems (AGRA, 2017; IFPRI, 2016; MoA & ATA, 2016), is a very good instance. Through EthioSIS, hundreds of laboratory technicians, soil scientists, and data managers across federal and regional levels were trained and up-skilled in these precise areas (IFPRI, 2016, and MoA, 2025). Another important stance is strengthening laboratory infrastructure and supporting postgraduate research through MSc and PhD students in soil science and related fields. Pursuing and enabling the continuity of certain ongoing programs would also be vital.

3.5.8 Status of Participatory Research and Outreach in Research and ATVETs in Ethiopia

According to KIIs' responses by EIAR and RARI, these research institutes have been at the forefront of research that has embraced participatory research (PR) as a fundamental methodology for decades. The PR evolved from actively engaging farmers through Farmer Research Groups (FRGs) and conducting on-farm trials to ensure that developed technologies, including improved soil management practices and nutrient solutions, are relevant, adaptable, and farmer-preferred (KIIs; JICA, n.d.a; IQQO, 2024). Their outreach efforts primarily involve the systematic dissemination of these validated research findings and improved technologies through various channels, often in close collaboration with the Ministry of Agriculture's extension services. This ensures that research outputs on soil health, soil inputs, and technologies reach the farming communities they are intended to serve.

ATVET colleges, as disclosed by ATVETs' KIIs, while not primary centers for initiating novel scientific research, play a crucial and distinct role in the ecosystem of participatory outreach. Their mandate is predominantly focused on training Development Agents (DAs), who are the frontline implementers of agricultural extension. ATVETs equip these DAs with practical, hands-on skills in various agricultural disciplines, including soil health and fertility management (EJOL, n.d.). Their "outreach" or "practice" is fundamentally about translating research-derived knowledge into actionable practices at the farmer level through demonstrations, farmer field days, and direct technical advice. Thus, while research institutes lead in participatory knowledge generation, ATVETs are instrumental in disseminating and promoting the practical adoption of knowledge, forming a vital bridge that ensures soil health and soil input technologies and innovations move from research plots to farmers' fields.

3.5.9 Identified Gaps and Priorities in Research and ATVETs in Ethiopia

Among the 64 KIIs' total informants, research and ATVET respondents were probed on existing gaps and priorities in research and ATVETs in the baseline year, though they responded for the last decade. According to them and available literature, the following are identified. A primary gap in research institutions (EIAR and RARIs) lies in translating research findings into widespread farmer adoption, often due to insufficient demand-driven research, limited adaptive trials, and resource constraints (KIIs; ARARI, 2025; IQQO, 2024; ATI, 2025; ResearchGate, 2021). In addition, insufficient capacity of MoA-NSIS, the MoAs and EIAR's KIIs reported the inexistence of a referral soil lab and weak operations of regional soil labs as a critical limiting bottleneck. Besides, resolving the bottlenecks and challenges of soil health and fertility outlined in the different sections of this baseline report should also be essential to mitigate research gaps. For ATVET colleges, key gaps include strengthening the practical skills of Development Agents (DAs) to diagnose and address complex soil issues on the ground effectively, ensuring curricula remain agile and responsive to evolving research and farmer needs, and bridging the often-present disconnect between academic theory and practical application in real farm settings (KIIs with ATVETs, EIAR & MoA; EJOL, n.d.).

According to KIIs, contacted scholars, and desk reviews, addressing these gaps and limitations necessitates strategic priorities for both research and ATVET systems. For research, a key priority is to deepen inclusive, bottom-up, and participatory research approaches in soil health and fertility, ensuring that studies are more directly aligned with farmers' felt needs and local conditions. For ATVETs, priorities revolve around strengthening hands-on, practical training for DAs in diversified soil input practices, ensuring they are proficient in demonstrating and guiding farmers on techniques like composting, integrated nutrient management, and soil conservation. Ultimately, a collective priority across all stakeholders is to foster stronger, more fluid linkages and collaboration between research, academia, extension (including DAs), and farmers, creating a cohesive innovation ecosystem that can effectively translate knowledge into sustainable soil health practices on a broader scale. To transform the relationship between research and ATVET, it's recommended to build human capital and revamp ATVET curricula to equip DAs in practical hands-on skills, thereby a cohesive innovation ecosystem would be created.

3.6 Promoting an Enabling Environment for Soil Health and Fertility in Ethiopia

Ethiopia's agricultural productivity relies heavily on its diverse soils; however, widespread land degradation and nutrient depletion have undermined long-term food security and rural livelihoods (Hurni et al., 2016). Since the early 2000s, the Ethiopian government has intensified efforts to restore and manage soil fertility, recognizing soil health as a cornerstone for achieving food security, rural development, and climate resilience. The Soil Health and Fertility Improvement Strategy (2017) set ambitious goals "to establish national and institutional capacities that improve, conserve, and enrich soil health and fertility" (MoA, 2017). Complementing this, the Growth and Transformation Plan II (GTP-II) aimed to achieve an 8% annual growth rate in agriculture through integrated soil fertility packages tailored to agro-ecological zones (MoFED, 2016). While these efforts have produced encouraging results, persistent challenges remain, including insufficient institutional coordination, weak enforcement of quality standards, limited farmer knowledge of soil constraints, and slow adoption of new technologies (IFDC, 2023).

To address these gaps, the Ethiopian government and regional states have established dedicated Soil Health and Fertility Directorates to guide policy and coordinate interventions from the federal to the grassroots level (MoA, 2017). Current initiatives, such as the IFDC-led TRANSFORM Project (2025–2028), aim to strengthen soil management for 100,000 smallholder farmers across 65,000 hectares (IFDC, 2024). This review critically assesses the national and

regional frameworks, governance mechanisms, and enabling environment for soil health, focusing on opportunities and challenges.

3.6.1 National and Regional Policy and Legal Frameworks

Ethiopia's legal and policy architecture for soil fertility management spans several decades of agricultural planning. The Ethiopian Constitution recognizes soil as a vital natural resource, and recent policy frameworks explicitly target soil health. The Soil Health and Fertility Improvement Strategy (2017) formalized a mission to "contribute significantly to the planned target of 8% agricultural production and productivity growth through integrated soil health and fertility packages" (MoA, 2017). This strategy complements broader initiatives such as the Agricultural Growth Program (AGP) and the GTP frameworks, which emphasize institutional strengthening and legislation to regulate soil management. Key elements of the policy framework include input access, financing schemes, and institutional mandates. Ethiopia, unlike many countries, does not operate a direct national fertilizer subsidy. Instead, fertilizer promotion relies on government-managed procurement and credit programs. For instance, under GTP-I and GTP-II, the government significantly increased fertilizer imports—from approximately 440,000 tons in 2008 to 890,000 tons by 2012—distributed primarily through cooperative unions (IFPRI, 2015). Although there is no official subsidy program, fertilizer promotion incurs an estimated annual fiscal cost of US$40 million since 2008 (Jayne & Rashid, 2013).

At the regional level, Ethiopia's nine regional states implement federal soil policies through their respective Bureaus of Agriculture (BoA). Regions adapt soil fertility packages to local agro-ecological conditions. For example, Oromia and Amhara have introduced regional soil fertility programs promoting balanced fertilization and lime application on acid soils, based on soil test-based recommendations (Amede et al., 2021). These regions collaborate closely with the federal Soil Health Directorate to harmonize efforts. Analysts stress the need for modernizing Ethiopia's fertilizer policy. Policy briefs recommend training certified fertilizer inspectors, upgrading soil testing laboratories, and integrating standards for organic and biofertilizers (AFAP, 2020). Experts also advocate for transitioning from cooperative monopolies to a competitive market system that allows private-sector importers and distributors (Jayne & Rashid, 2013).

3.6.2 Institutional Architecture and Governance Mechanisms

Ethiopia's institutional landscape for soil management is multi-layered, involving federal ministries, research institutions, and regional authorities. At the federal level, the Ministry of Agriculture (MoA) plays a central role. The former Agricultural Transformation Agency (ATA)—now reintegrated into the MoA—was instrumental in setting up fertilizer blending plants, quality control systems, and soil mapping initiatives (ATA, 2019). The MoA regulates fertilizer registration and quality standards in collaboration with the Quality and Standards Authority of Ethiopia (QSAE) and the National Soil Testing Laboratory (NSTL). However, regulatory oversight is often fragmented. A recent assessment highlighted that "Fertilizer production, importation, distribution, marketing, and trade are regulated by multiple institutions with overlapping mandates", leading to inefficiencies (AFAP, 2020).

At the regional level, BoAs house Soil Health and Fertility Directorates that oversee technical guidance and implementation. Research institutions, such as the Ethiopian Institute of Agricultural Research (EIAR) and various universities, contribute to soil science research, while the Environmental Protection Authority (EPA) enforces environmental regulations that indirectly affect soil health (Tesfaye et al., 2022). Ethiopia still lacks a dedicated National Soil Health Authority to coordinate among diverse stakeholders. Capacity constraints, including a shortage of trained soil analysts and inspectors, remain a significant bottleneck. Strengthening inter-

ministerial collaboration and expanding laboratory networks are critical recommendations (AFAP, 2020).

3.6.2.1 Proposed National Soil Health Coordination Body (NSHCB) for Ethiopia

Ethiopia should establish a National Soil Health Coordination Body (NSHCB) to address the persistent institutional fragmentation across the soil management sector, which currently involves the Ministry of Agriculture (MoA), the Quality and Standards Authority of Ethiopia (QSAE), the National Soil Testing Laboratory (NSTL), research organisations such as the Ethiopian Institute of Agricultural Research (EIAR) and universities, as well as regional Bureaux of Agriculture (BoAs) and environmental regulators. Independent assessments have documented overlapping mandates across fertilizer production, importation, distribution, and quality control that undermine regulatory efficiency and service delivery (African Fertilizer and Agribusiness Partnership [AFAP], 2020). A statutory NSHCB would act as the principal convening and stewardship body for soil information, laboratory accreditation, and fertilizer-quality assurance, while remaining operationally linked to the MoA to ensure policy coherence and rapid implementation (AFAP, 2020; Tesfaye et al., 2022).

The NSHCB's mandate should include: (a) harmonizing national soil-testing and fertilizer-quality standards and standard operating procedures (SOPs) across QSAE, NSTL, and regional laboratories; (b) accrediting and overseeing inter-laboratory proficiency testing for both public and private laboratories; (c) managing and safeguarding the National Soil Information System (NSIS)/Ethiopian Soil Information System (EthioSIS) and related Laboratory Information Management Systems (LIMS); (d) generating and updating site-specific, evidence-based fertilizer and soil amendment recommendations for blending plants and extension services; (e) providing a single-window interface for fertilizer regulatory processes and market surveillance; and (f) leading national capacity development for technicians, analysts, and extension staff (ATA, 2019; Ministry of Agriculture [MoA], 2020).

Institutionally, the NSHCB should be established as a statutory coordination authority hosted under the MoA, governed by a multi-stakeholder council and an Executive Secretariat. The Governing Council, chaired by a State or Deputy Minister of Agriculture, should include senior representatives from QSAE, NSTL, EIAR, the Environmental Protection Authority (EPA), two rotating regional BoA representatives, university soil science departments, private-sector actors (e.g., fertilizer blenders), and farmer organisations. The Executive Secretariat, led by a Director-General, would comprise five technical directorates: Standards & Accreditation, Data & NSIS, Fertility & Recommendations, Extension & Digital Advisory, and Market & Regulatory Liaison. Regional Soil Health Units embedded within BoAs would coordinate sampling, quality assurance, and data flows (MoA, 2020; Tesfaye et al., 2022).

The NSHCB should be resourced with a robust laboratory and digital infrastructure. This includes upgrading the NSTL as the National Reference Laboratory, accrediting 12–15 regional laboratories, deploying 20–30 mobile laboratories for rural outreach, and implementing a unified LIMS integrated with NSIS/EthioSIS. Human resources would include soil scientists, accreditation specialists, data engineers, and extension officers. Funding sources may comprise federal budget allocations, development partner support for capital investments, and medium-term cost recovery from laboratory accreditation fees and analytical services (AFAP, 2020; MoA, 2020).

Regional experiences provide valuable lessons for Ethiopia. Rwanda has centralized soil information management and fertilizer recommendation delivery under the Rwanda Agriculture and Animal Resources Development Board (RAB) and the Smart Nkunganire System (SNS), linking parcel-level identifiers with digital fertilizer recommendation services and mobile laboratory support (International Soil Reference and Information Centre [ISRIC], 2022;

MINAGRI, 2021). This demonstrates the value of a single-agency custodial model integrated with digital advisory systems. Kenya, through its Agricultural Soil Management Policy (2023) and the Kenya Soil Information System (KenSIS) under the Kenya Agricultural and Livestock Research Organization (KALRO), has established a policy-driven, research-backed platform for soil data and fertilizer quality management (Kenya Ministry of Agriculture, 2023; KALRO, 2023). These models highlight the importance of anchoring soil governance within a clear policy framework, designating roles among policy, research, and standards institutions, and investing in centralized, interoperable soil data platforms.

The establishment of an NSHCB—initially within the MoA but governed by a multi-stakeholder council, equipped with accredited laboratories, mobile units, and a nationally integrated NSIS—would address the documented regulatory overlaps, weak laboratory quality assurance, and fragmented data-to-advisory chains in Ethiopia. Lessons from Rwanda and Kenya underscore that central custodianship of soil information, paired with deliberate digital advisory systems and policy anchoring, can significantly enhance the translation of soil data into actionable farmer-level recommendations (AFAP, 2020; ISRIC, 2022; Kenya Ministry of Agriculture, 2023).

3.6.3 National and Regional Coordination Platforms

Ethiopia's soil health and fertility landscape is supported by a network of national and regional multi-stakeholder platforms that coordinate efforts to combat soil degradation and enhance agricultural productivity (Getahun, 2025).

At the national level, the National Soil Information System (NSIS), building on the EthioSIS project, provides comprehensive soil data to inform agricultural practices and policy decisions. The "Enhancement of the NSIS of Ethiopia" project, initiated in 2024 in collaboration with the Ministry of Agriculture and ISRIC – World Soil Information, aims to improve data quality, accessibility, and utilization to support sustainable soil management (ISRIC, 2025; CABI et al., 2024a,b; Beyene & Regassa, 2023). Complementing this, Ethiopia is advancing a national agroecology strategy to integrate biodiversity, soil health, and sustainable land-use principles into agricultural development (Getahun, 2025). A critical next step involves establishing sustainable domestic financing mechanisms for the NSIS to ensure its long-term operationalization beyond donor-supported phases. This includes integrating NSIS funding within Ethiopia's national agricultural budget lines, mobilizing private sector contributions (e.g., fertilizer companies, agri-tech firms), and leveraging climate finance and green bonds to maintain and expand soil data infrastructure. Complementing this, Ethiopia is advancing a national agroecology strategy to integrate biodiversity, soil health, and sustainable land-use principles into agricultural development (Getahun, 2025). Furthermore, to maximize the utility of soil data for agricultural transformation, it is recommended that the NSIS be aligned with Ethiopia's Digital Agriculture Roadmap (DAR) targets, consistent with the World Bank's 2025 digital agriculture vision, to enable interoperability between soil data platforms, digital advisory services, and precision agriculture tools (World Bank, 2025). Such integration would facilitate real-time decision-making for farmers, policymakers, and agribusiness stakeholders.

Regionally, Ethiopia participates in the African Soil Partnership (AfSP), established by the Food and Agriculture Organization (FAO) in 2015, which facilitates collaboration on soil-related challenges, knowledge exchange, and policy advocacy. In 2025, AfSP convened a continent-wide webinar to discuss the Soil Initiative for Africa. The EU-supported Soils4Africa project under Horizon 2020 has developed an open-access Soil Information System (SIS), improving the availability and quality of soil data for farmers, researchers, and policymakers.

The IFDC-led TRANSFORM program leverages these platforms to establish a comprehensive multi-stakeholder framework for soil health and fertility management. By coordinating government agencies, research institutions, farmers, and the private sector, TRANSFORM aims

to enhance soil management practices, promote sustainable agriculture, and advance Ethiopia's food security and environmental goals (IFDC, 2024).

The emerging National Soil Health & Fertility Platform will develop a 15-year Soil Health Vision aligned with Ethiopia's long-term agricultural plans. Activities include annual plenary sessions, technical workshops, policy discussion papers, and knowledge-sharing webinars. Regionally, Oromia and Amhara have operationalized multi-stakeholder committees focused on soil management and fertilizer use. Capacity-building is central, with plans to train hundreds of extension agents and agricultural officers in soil testing, fertilizer blending, and ISFM practices. By fostering dialogue, ensuring sustainable domestic financing, and aligning with digital agriculture transformation agendas, these platforms are positioned to institutionalize collaborative soil management strategies across Ethiopia (IFDC, 2024).

3.6.4 Soil Input Registration and Distribution

Ethiopia's fertilizer market remains highly regulated, with the EAA managing fertilizer registration and import licenses. Historically, all imports were handled by state-owned enterprises and cooperative unions, but recent reforms permit private-sector participation. Firms seeking to introduce new fertilizers must undergo multi-year efficacy trials before they can be registered. Currently, Ethiopia's market is dominated by mineral fertilizers, such as urea, NPS, and NPK blends (MoA, 2021). The number of registered fertilizer products in Ethiopia has historically been limited, primarily due to stringent regulatory requirements and centralized control. The Fertilizer Proclamation mandates that all fertilizers be registered before importation, a process that includes laboratory testing and sometimes field trials. These regulations, while ensuring product safety and quality, have inadvertently restricted the introduction of new and innovative fertilizers into the market (AGRA, 2018).

However, recent developments indicate a shift towards increased private-sector involvement and product diversification. The Ethiopian government has recognized the need to enhance fertilizer availability and has initiated reforms to encourage private sector participation. For instance, the establishment of fertilizer blending plants in partnership with donors aims to produce customized fertilizers tailored to Ethiopia's diverse agro-ecological zones. Additionally, the Agricultural Transformation Agency (ATA), in collaboration with the Ministry of Agriculture, has developed a new Draft Fertilizer Proclamation to facilitate greater private sector engagement in the fertilizer supply chain. The results of FGD in Degaga Kebele, farmers primarily rely on government-provided mineral fertilizers, supplemented by self-prepared organic inputs such as compost and vermicompost. Fertilizer distribution through cooperatives is functional but costly. Soil acidity is suspected but unassessed, resulting in no lime use and limited awareness of its application or cost. Key challenges include insufficient plowing, lack of water retention structures in waterlogged areas, and potential soil acidity, while existing plowing and some soil and water conservation practices represent positive aspects. According to FGDs conducted in 019/Asgedo Kebele (intervention) of Dessie Zuriya, farmers produce and apply compost and other organic fertilizers themselves, following guidance from agricultural experts. In contrast, mineral fertilizers are supplied through government channels. Consequently, there are currently no small-scale enterprises in the kebele involved in the production or distribution of soil amendments. Chemical fertilizers are mainly accessed through the Farmers' Cooperative Union in collaboration with the government and the Development Bank. Despite their high cost, demand for these fertilizers remains strong, and there are no reported issues regarding their supply or availability.

A notable gap is the lack of a formal registration system for biofertilizers and organic inputs. Plans are underway to integrate biofertilizer standards and quality control into the national framework, with TRANSFORM providing technical support (IFDC, 2024). The Quality and Standards Authority and NSTL are being upgraded to test both chemical and biological inputs.

To enhance the timely registration and availability of biofertilizers and blended fertilizers in Ethiopia, it is recommended that a dedicated regulatory framework be established to distinctly address biological and organic inputs separate from conventional mineral fertilizers. The current multi-year efficacy trials required for fertilizer registration, while essential for ensuring product safety and quality, have inadvertently delayed the introduction of innovative and environmentally sustainable soil inputs. It is therefore proposed that a risk-based, tiered registration system be adopted, whereby biofertilizers and blended products with proven efficacy in countries with comparable agro-ecological conditions undergo an abridged fast-track process involving dossier review and one-season verification trials, while novel or unproven products continue to follow the standard multi-season evaluation protocol. Institutional coordination among the Ethiopian Agricultural Authority, the Quality and Standards Authority, and the National Soil Testing Laboratory should be strengthened to eliminate duplication of functions and ensure efficient registration and quality control, including the accreditation of private laboratories, universities, and research centers to conduct efficacy and quality testing under government oversight. A transparent, digital, and time-bound registration platform should be established, setting clear procedural timelines (e.g., three to six months for proven products) and maintaining a centralized database of all registered fertilizers to facilitate access by manufacturers, importers, and farmers.

For blended fertilizers, it is recommended that regionally validated formulations (e.g., NPSB, NPSZn, NPSZnB) be formally recognized, and that licensed blending plants be permitted to undertake site-specific modifications within defined nutrient thresholds without the need for full re-registration. Furthermore, post-market surveillance mechanisms should be strengthened through the upgrading of the National Soil Testing Laboratory and regional laboratories to provide rapid microbial, nutrient, and contaminant analyses, thereby shifting regulatory emphasis from prolonged pre-market trials to active market monitoring and enforcement. Complementary measures, including structured farmer awareness campaigns on the use of biofertilizers, lime, and soil health restoration practices, should be implemented, particularly in areas affected by soil acidity. To stimulate private-sector participation, policy instruments such as matching grants, tax incentives, and import duty exemptions for biofertilizer and blended fertilizer production and distribution are recommended. Finally, it is imperative that the Draft Fertilizer Proclamation be finalized and enacted with explicit provisions for biofertilizers, organic amendments, and blended fertilizers, supported by technical assistance from initiatives such as TRANSFORM (IFDC, 2024).

Ethiopia currently lacks a formal regulatory framework for biofertilizers and organic soil amendments, which limits the development, registration, and availability of these environmentally sustainable inputs. While the national fertilizer system is highly regulated—with multi-year efficacy trials required for registration of conventional mineral fertilizers—biofertilizers remain largely unregulated, and their market entry is constrained. This regulatory gap has prevented the establishment of small-scale enterprises involved in the production and distribution of biological inputs, despite growing farmer interest in organic and blended fertilizers.

To address these gaps and promote private-sector participation while maintaining quality control, it is recommended that a dedicated regulatory framework for biofertilizers and blended fertilizers be established. A risk-based, tiered registration system should be adopted, enabling products with proven efficacy in comparable agro-ecological zones to undergo a fast-track review and one-season verification trial, while novel products continue with standard multi-season testing. Institutional coordination among the Ethiopian Agricultural Authority, Quality and Standards Authority, and National Soil Testing Laboratory should be strengthened, including accreditation of private laboratories, universities, and research centers to conduct efficacy and quality testing under government oversight. A transparent, digital registration

platform with clear procedural timelines and a centralized fertilizer database would further facilitate market entry.

Complementary policy reforms should incentivize private-sector involvement through matching grants, tax breaks, and import duty exemptions for biofertilizer and blended fertilizer production and distribution. At the same time, post-market surveillance mechanisms must be enhanced, shifting regulatory emphasis from prolonged pre-market trials to active market monitoring, and ensuring that quality, safety, and efficacy standards are met. Finally, the Draft Fertilizer Proclamation should be finalized and enacted with explicit provisions for biofertilizers, organic amendments, and blended fertilizers, supported by technical assistance from initiatives such as TRANSFORM.

3.6.5 Community Participation and Stakeholder Engagement

Community-driven approaches are at the heart of Ethiopia's soil fertility initiatives. Agricultural extension services—coordinated by the Agricultural Extension Directorate—are the primary channels for disseminating soil health knowledge at the grassroots level. Programs such as the 2015 Soil Campaign and Farmer Training Centers (FTCs) have raised awareness of soil fertility issues among rural communities (Gebremedhin & Jaleta, 2021). Cooperatives play a central role in fertilizer distribution, credit provision, and outreach to farmers. Farmer field schools and demonstration plots are widely used to promote ISFM practices, such as combining organic compost with mineral fertilizers. Inclusivity is a key principle of current programs. The TRANSFORM project emphasizes empowering women and youth farmers to become active stewards of the land, aligning with Ethiopia's gender and youth policies (IFDC, 2024). Knowledge-sharing events, including agricultural fairs, radio broadcasts, webinars, and field days, are increasingly being deployed to strengthen farmer feedback mechanisms.

3.6.6 Gaps, Challenges, and Opportunities

In Ethiopia, sustaining multi-stakeholder platforms (MSPs) for soil health and fertility management (SHFM) at both national and regional levels faces several persistent gaps. At the institutional level, mandates remain fragmented, and vertical coordination between the Ministry of Agriculture (MoA) and regional bureaus is weak, leading to inefficiencies in data exchange, reporting, and technology dissemination—core functions of MSPs (MoA, 2024). While the National Soil Information System (NSIS) serves as a backbone for SHFM coordination, its operational sustainability is threatened by reliance on short-term donor projects for platform enhancements, leaving critical functions vulnerable to funding interruptions (CABI & ISRIC, 2024). Data governance has improved following the introduction of Directive No. 974/2023, but the absence of a fully implemented spatial database schema, comprehensive metadata, and interactive geoportal features continues to limit interoperability and shared evidence use across actors (MoA, 2023; CABI & ISRIC, 2024). Capacity constraints, particularly the shortage and high turnover of specialists who can bridge soil science, spatial data infrastructure, and digital soil mapping, further undermine platform continuity (CABI & ISRIC, 2024). On the implementation side, MSPs struggle to effectively integrate private-sector actors and value-chain partners into SHFM activities, with persistent bottlenecks in lime, blended fertilizer, and biofertilizer production and delivery (MoA, 2024). Moreover, there is inconsistent participation from farmer organizations, women's groups, youth associations, and universities across regions, limiting inclusivity and local ownership (MoA, 2024; World Bank, 2025). Budgeting and program alignment issues—such as mismatched budget calendars, under-resourced environmental safeguards, and insufficient livelihood linkages—complicate the translation of MSP agreements into coordinated field-level action (World Bank, 2025). Finally, while Ethiopia's Digital Agriculture Roadmap (2025–2032) and continental commitments from the Africa Fertilizer and Soil Health Summit present new opportunities, MSPs have yet to fully align these initiatives with regional SHFM priorities to ensure sustained, integrated action from policy to practice (World Bank, 2025; African Union & IFAD, 2024).

Despite notable progress in soil management and policy development, Ethiopia continues to face persistent and complex challenges. Policy fragmentation remains a significant obstacle, as overlapping mandates among government agencies hinder the efficient implementation of soil-related policies and strategies, underscoring the need for a central coordinating authority (AFAP, 2020). Regulatory weaknesses further compound the problem, with outdated fertilizer laws and insufficient enforcement capacity—particularly in quality control—leading to inefficiencies and reduced farmer confidence. Additionally, knowledge and data gaps are evident due to the limited availability of localized soil testing and insufficient extension outreach, which collectively impede the widespread adoption of improved soil management practices (Amede et al., 2021). Economic constraints present another major barrier, as smallholder farmers face high fertilizer prices, limited access to credit facilities, and government-managed supply chains that restrict the diversity of agricultural inputs (Jayne & Rashid, 2013). Compounding these issues are environmental pressures, including soil erosion, deforestation, and the impacts of climate variability, all of which continue to degrade soil resources and reduce agricultural productivity (Hurni et al., 2016). The results of FGD in Degaga Kebele Key challenges include insufficient plowing, lack of water retention structures in waterlogged areas, and potential soil acidity, while existing plowing and some soil and water conservation practices represent positive aspects. In the 019/Asgedo Kebele (intervention) of Dessie Zuriya, FG discussants identified key challenges affecting agricultural practices, including the rising cost of mineral fertilizers, limited research on soil acidity, and inadequate provision of training.

Nevertheless, there are significant opportunities to address these challenges. Expanding private-sector participation in input supply and distribution, promoting organic and compost-based enterprises, and harnessing digital innovations such as soil information systems, digital soil maps, and machine-learning-based site-specific recommendations can greatly enhance soil management efforts. Moreover, international initiatives—such as the African Union Soil Health Action Plan provide both technical and financial support that can accelerate the implementation of reforms and promote sustainable soil health management (AU, 2021).

4. CONCLUSION AND RECOMMENDATION

4.1 Conclusion

Farm Household Analysis: The baseline findings reveal that farming households in the target woredas are predominantly smallholders, with an average landholding of 1.2 hectares and a family size of five. Household heads are generally experienced in farming activities, with an average age of 44 years. Despite an overall literacy rate of 69 percent among intervention households, gender disparities persist, with a lower literacy level among female-headed households than male-headed households. Crop production is the dominant farming system, with only 3 percent of land under irrigation. Farms are highly fragmented, averaging 2.8 plots per household. Annual household income stands at an average of Birr 43,836, primarily derived from cereal cultivation and mixed crop-livestock systems, with youth-headed households tending to have higher literacy and income levels. Although women are actively engaged in soil fertility management and household decision-making, they have limited access to inputs, constraining their productivity. Social networks and cooperative memberships are widespread, enabling both men and women to access information and agricultural inputs. However, the high average dependency ratio of 86 imposes economic pressure on working members. While only 5 percent of households include persons with disabilities, these individuals face significant barriers to agricultural participation and productivity. The findings portray a farming system shaped by a mix of demographic pressures, economic limitations, and social dynamics, offering both challenges and entry points for sustainable development.

Customizing Extension Services to Provide Context-Specific Advice to Farmers: Analytical review of EthioSIS woredas maps revealed generally favorable soil conditions (neutral pH, low salinity) but widespread nutrient deficiencies (particularly P, S, and B), significant soil acidity in parts of Oromia woredas, aggravated by nutrient imbalances. This underscores the urgent need for updated soil testing and localized fertility strategies. The baseline findings highlight significant but uneven adoption of soil health, fertility, and sustainable land management (SLM) practices across regions, woredas, kebees, and individual households. Farmer's engagement in household inclusive and participatory extension services showed significant variability. The overall engagement rate averaged 28.2% in control kebeles and 20.7% in intervention kebeles. Similarly, the adoption of specific cropping practices varied widely, with very low rates for intercropping (4%), fallowing (5%), and relay-alley cropping (10%), while crop rotation saw moderate adoption (47%). The report also highlights observable gaps in SLM coverage. Responses on willingness to invest in SLM were widespread ranging from 25 ha in Basona Worena to 61 ha in Digelu Tiju woreda for intervention kebeles and from 8ha to 28 ha for control kebeles households. A major gender disparity was also evident, with male-headed households managing significantly more land (up to 45.1 ha) than female-headed households (as little as 2.2 ha). While perception of soil degradation was high in Amhara (79-89%) and CER (89%), it was notably lower in Oromia (47-48%), despite some pockets of high awareness (100% in Abaya). The lowest participation in soil conservation practices was in Oromia (37%), while CER had a modest rate (62%). Soil/stone bunds were the most common practice (54%), followed by trench terracing (31%) and conventional tillage (27%). These findings signal lower adoptions and a need for project interventions.

Household Food Security and Resilience Measures: The study revealed that household food security levels are below the national average, with significant variation across woredas within the study regions. This indicates the need for geographically tailored interventions to improve household livelihoods.

Building Vibrant Soil Input Sector: Smallholder farmers in the baseline woredas faced a critical lack of access to diverse and affordable soil inputs, heavily relying on mineral fertilizers and traditional methods. Government initiatives to promote lime application have seen very low adoption, and the private sector's involvement in the soil input market, especially for organic options, remains largely untapped, with a significant missed opportunity given that only 9.1%

of households access these providers. Despite a rich history of soil research, persistent challenges like nutrient depletion, soil acidity, and erosion highlight the disconnection between research and practical application. The overall soil health landscape is fragile, marked by limited farmer knowledge, uneven access to quality inputs, and weak institutional support. While some progress has been made in Oromia regarding improved soil management, awareness, and implementation of ISFM and the 4R principles remain critically low, especially among women and youth. Despite the prevalence of indigenous knowledge, significant knowledge gaps persist, with very few farmers understanding soil acidity or saline soil management. Overall knowledge capacity varies widely, and female farmers consistently demonstrate lower knowledge levels than their male counterparts. Furthermore, the organic input market is severely underdeveloped, hampered by supply constraints, poor standardization, and infrastructure gaps, despite growing awareness and potential for digital innovation.

Strengthening Linkages between Research, Extension, and Education through Farmer-Led Action Research:- The virtual absence of farmer-led research trials in Amhara and limited participatory learning platforms across all regions underscores the lack of inclusive engagement in soil innovation processes. Key informant interviews and focus group discussions echoed these findings, pointing to institutional fragmentation, gaps in localized soil data, inadequate extension services, and limited access to credit and inputs as persistent bottlenecks. Research and innovation efforts are evolving towards more precise, data-driven, and integrated soil management solutions. However, a critical disconnect exists between research findings and widespread farmer adoption, compounded by limited farmer-led trials and persistent knowledge gaps, particularly in managing complex soil issues and applying modern nutrient management principles. The current linkages and collaborations among research, academia, extension, and farmers, while present, require strengthening to foster a truly cohesive and efficient agricultural innovation system.

Promoting an Enabling Environment for Soil Health and Fertility in Ethiopia:- The current policy and legal landscape governing soil health and fertilizer is significantly fragmented, characterized by outdated regulations and weak institutional coordination. This structural weakness acts as a major bottleneck, hindering progress in the agricultural sector. Despite existing frameworks, there's a clear and pressing need for comprehensive reform to modernize soil health and fertilizer legislation, strengthen governance mechanisms, and bolster national capacities in soil testing and research. The KIIs reported the presence of multi-stakeholder platforms (MSPs) though fragmented. These MSPs have gained traction at both national and regional levels as tools for collaborative problem-solving in agriculture and natural resource management. At the federal level, MSPs are often government-led and focus on policy coordination, while regional platforms in regional level like in CER addresses localized issues like biodiversity and food security (Seifu et al., 2022; Melaku & Minh, 2021). Despite their presence, the KIIs also disclosed that MSPs are facing challenges such as limited technical capacity and resource mobilization, which can hinder their effectiveness and sustainability.

4.2 Recommendation

Farm Household Analysis: To enhance the productivity and resilience of smallholder farming households, interventions should prioritize integrated support for land management, youth engagement, and climate-smart agriculture. Given the widespread plot fragmentation and limited use of irrigated land, efforts should focus on promoting cluster-based farming, improving soil fertility, and expanding access to water-efficient irrigation technologies. Youth-headed households, which demonstrate higher literacy and income potential, represent a critical entry point for innovation and should be supported through targeted access to extension services, digital tools, and agribusiness development opportunities. Additionally, enhancing productivity per unit of land through improved input access and capacity-building will be essential, particularly for households with high dependency ratios. Gender-responsive

programming is also vital, as women play an active role in farming decisions and soil fertility management but face persistent barriers to productivity due to limited access to resources. Expanding access to agricultural inputs, training, and cooperative membership for women and female-headed households will help close this gap. The well-established presence of social networks and cooperatives offers an effective platform for scaling improved technologies and practices, especially in areas like soil health, crop diversification, and market linkage. Furthermore, strengthening inclusive service delivery by incorporating disability-sensitive approaches will ensure that farmers with physical or cognitive impairments are not left behind. Tailoring interventions to these diverse needs will contribute to more equitable and sustainable rural development outcomes across the program areas.

Customizing Extension Services to Provide Context-Specific Advice to Farmers: Acquired from both quantitative and qualitative information, this baseline survey draws the following recommendations pertinent to extension services:

- **Updated soil testing:** is essential across all target woredas to guide effective interventions, with a focus on correcting deficiencies in P, S, and B, managing soil acidity and promoting balanced nutrient application through region-specific soil fertility packages.
- **Strengthen Context-Specific Extension Systems:** Expand successful multi-channel approaches (farmer field schools, SMS advisories, lead farmer networks) in underperforming woredas (Sire, Tiyo, Chefa Gugesa), while reinforcing strongholds like Basona Worena and Omo Nada with tailored crop- and soil-specific packages.
- **Enhance Inclusive Agronomic Adoption:** Target youth and female-headed households with capacity-building, labor support, and input credit schemes to close adoption gaps in relay cropping, fallowing, and intercropping. Promote integrated soil fertility management (ISFM) to balance mineral and organic inputs.
- **Address Input and Labor Disparities:** Provide subsidies or revolving funds for woredas with low labor investment (Weira, Omo Nada, and Abaya) and enhance fertilizer–organic integration in high-spending regions (Tiyo, Kalu) to prevent soil acidification and nutrient leaching.
- **Scale Sustainable Land Management (SLM):** Prioritize high-willingness regions (Kalu, Albuko, Digelu Tijo) for rapid scaling of SLM structures (terraces, agroforestry, lime application). Address fragmented or poorly maintained structures in hotspots (e.g., Debele, Asgedo) to reduce gully erosion and runoff.
- **Intensify Soil Degradation Awareness:** Develop region-specific campaigns in Oromia (Tiyo, Sire, and Digelu Tijo) using participatory watershed diagnostics and youth-focused land stewardship programs to bridge perception gaps and mobilize conservation.

This integrated approach will accelerate soil fertility restoration, enhance productivity, and reduce degradation risks while ensuring equitable participation across gender, age, and regional lines.

Household Food Security and Resilience Measures: Special attention is needed to strengthen household productivity and promote climate adaptation strategies. These two areas are particularly critical, as they directly influence a household's capacity to withstand shocks, maintain consistent food access, and recover from crises. Enhancing resilience through locally appropriate improved agricultural practices, sustainable resource management, and adaptive livelihood options will be essential for reducing food insecurity in the most affected woredas.

Building Vibrant Soil Input Sector: To address these multifaceted challenges, several key interventions are crucial. First, inclusive capacity building must be prioritized, targeting not only adult males but also women and youth with tailored training on soil characteristics, input use, and climate-smart agronomic practices. Second, to strengthen soil input systems, private sector and MSME involvement should be actively promoted through clear investment incentives and capacity development, particularly for organic and locally produced inputs. Third, research outputs must be better integrated with local knowledge to enable context-specific, sustainable

soil management practices, especially in response to widespread acidity, nutrient gaps, and declining organic matter. Finally, to close the knowledge gap, targeted training on 4R practices and ISFM should be scaled, prioritizing regions with the lowest awareness, and gender-responsive extension services must be strengthened to address the knowledge disparity between male and female farmers. Efforts should also focus on improving the commercial viability of organic inputs by supporting MSMEs, expanding quality control, and leveraging digital tools and policy implementation to encourage localized production and bridge smallholders with emerging market demand.

Strengthening Linkages between Research, Extension, and Education through Farmer-Led Action Research:- Revitalizing participatory approaches such as Farmer Research Groups (FRGs) and demonstration plots is essential for empowering farmers to co-generate and test locally relevant soil solutions. Strengthening institutional coordination across federal, regional, and woreda levels is vital to harmonize input supply chains, linakge and advisory systems. Expanding the reach of decision support tools (DSTs) and improving the availability of mineral and organic fertilizers adapted to local soil profiles will also be key. Finally, investment in local input production, improved extension linkages, and community-level innovation platforms can serve as catalytic levers for properly managing soil health and fertility agendas from fragmented and reactive to integrated, inclusive, and resilient.

Promoting an Enabling Environment for Soil Health and Fertility in Ethiopia:- To overcome the identified policy and regulatory challenges, it is imperative to undertake a strategic overhaul of the existing framework. This involves updating and integrating all relevant agricultural laws and regulations, while also developing new ones where gaps exist. Crucially, these revised policies must be prudently aligned with significant global initiatives, particularly the African Fertilizer and Soil Health (AFSH) Action Plan (2023-2033). Simultaneously, efforts must focus on policy monitoring and strengthening. Multi-stakeholder platforms should be better coordinated to reduce fragmentation and improve synergy across all levels while technical capacity must be strengthened through targeted training. Sustainable resource mobilization is essential to ensure long-term viability whereas inclusive participation should be prioritized to reflect diverse voices in decision-making. Regular monitoring and evaluation will help track progress and guide adaptive improvements at all levels.

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ANNEX

List of Appendices

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Data Collection Tools

A HOUSEHOLD SURVEY QUESTIONN

Baseline values

Baseline values and Target-TRANSFORM

Raw Data Sets

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Clean Data Sets

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