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Research Article

Determinants of soil and water conservation adoption and farmers' perceptions in the Shafe catchment, Southern Ethiopian Rift Valley

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Abstract

Soil degradation remains to be a substantial issue for subsistence agriculture in Ethiopia, particularly in higher and sloped areas where land burden and poor farming methods intensify soil destruction and nutrient loss. Though Soil and water conservation approaches were developed to tackle this issue, their success eventually trusts on farmers' views and readiness to implement them. Yet, there is a lack of empirical evidence connecting farmers' perceptions with adoption choices in different agro ecological and socioeconomic settings in South Ethiopian Rift Valley. This study is aimed at examining the perceptions of small-scale farmers towards soil degradation and identifying the most important socio-demographic, institutional, psychological, and physical determinants behind the adoption of soil and water conservation (SWC) technologies in the Shafe catchment area. A mixed method approach was employed where the data collection involved household survey from 185 households selected randomly in three kebeles combined with focus group discussion and key informant interviews. Farmers' attitudes and adoption behaviors were examined using descriptive statistics while multiple logistic regression analysis revealed the determinants causing disturbance of adoption of selected SWC technologies. It is found that agro-ecology plays a critical role in the adoption process, with households living in lowlands or kolla areas being more willing to adopt certain SWC practices such as avoidance of up and down ploughing and fallowing. Institutional factors, particularly the availability of training opportunities, played a positive role in adoption of SWC technologies. Other household characteristics, such as larger household sizes, participation in other economic activities apart from farming, for example, weaving, and larger sizes of homesteads were found to be significant drivers of the uptake of labor intensive SWC measures. The study indicates that efforts aimed at increasing the perception levels of farmers through training and extension are fundamental for increasing SWC uptake. There is an urgent need by regional, district agricultural offices, extension organizations, local authorities and development partners to increase and intensify their extension programs for households practicing agriculture on steep slopes and distant lands with high risk of land degradation. The priority is to improve the access of farmers to extension, technical training and supervision. It is urgent for intervention measures to be taken to enhance SWC adoption in Shafe catchment and similar agro ecological zones.

Keywords: Adoption; Perception; Shafe catchment; Soil and water conservation; South Ethiopian rift valley

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1. Introduction

Approximately, 40% of the planet's surface consists of agricultural land within various managed ecosystems facing numerous challenges, including soil deterioration (Chalise et al., 2019; He et al., 2017). Ineffective farming methods utilized by smallholder farmers cause soil loss and diminished farming output in Sub-Saharan Africa (Kabubo-Mariara et al., 2011; Okoba & de Graaff, 2005). Sustainable use of land assets, soil erosion control, soil and water conservation measures and proper cropping forms has the potential to advance soil efficiency, improve carbon sequestration and avoid land degradation in Sub-Saharan Africa (Gadisa, 2021; Goba et al., 2022; Moges & Taye, 2017).

Soil resource degradation, particularly in Ethiopia's highlands, remains a significant risk to subsistence agriculture, which is fundamental to the economy (AbdelRahman, 2023; Wordofa et al., 2020). It should be emphasized that about 90% of the population resides in the uplands, wherever land is regularly farmed and consequently is very susceptible to soil erosion and degradation (Belayneh, 2023; Maqsoom et al., 2020; Sileshi et al., 2019). In principle, soil and water conservation measures support decrease ecological weakening while conserving or improving farming output (Maniraho et al., 2023). Agriculturalists in many nations have constituted various soil and water conservation measures to diminish land degradation, including agroforestry, mulching, terracing, conservation tillage, and integrated nutrient management (Masha & Bojago, 2023; Mohawesh et al., 2015). Other practices include crop rotation, intercropping, fallowing, and water gathering possibilities such as tied ridges, pond creation, floodwalls, dams and clearing of irrigation channels (Kidane et al., 2019; Kouchaky et al., 2025).

In spite of its paybacks, the acceptance level of soil and water conservation strategies significantly differs in most unindustrialized countries (Ashuro & Takele, 2019; Sileshi et al., 2019). Poor implementation of soil and water conservation measures has been attributed to great communication breaks between scholars, extension workers, and farmers among other factors (Asfaw & Neka, 2017).

Several studies have been implemented in diverse parts of the world to decide factors that affect the acceptance of soil and water conservation methods amongst farmers (Gebresellassie Zelelew, 2017; Sileshi et al., 2019). These aspects can be assembled into five broad groups viz. demographic (age, sex, marital status, family size), socio-economic (education, income, job, skills), farm features (land tenure system, farm size, distance of farm from homestead, tropical livestock unit, awareness of soil loss), institutional aspects, (access to capital and labor, training and alertness, access to extension services, access to farm inputs, social group membership, access to information) and bio-physical factors (slope of cultivated land, agro-ecological zonation) (Assefa & Kefyalew, 2022; Telles et al., 2022).

Regardless of the fact that many scholarships have viewed at broad soil fertility management in Ethiopia, there is clearly not enough study that focuses on soil and water conservation techniques in the Shafe catchment. Existing literature offers broad perspectives on issues related to soil degradation and fertility, yet often fails to consider localized challenges, farmers' viewpoints, and the factors that affect the implementation of soil and water conservation in this specific area. Thus, the present study is crucial as it fills this gap by investigating not just the technical success of soil and water conservation techniques but also socio-economic and perceptual elements that shape farmers' choices, ultimately producing context-specific data to strengthen the Shafe watershed long-term land administration strategies. Matched with this, the current research was carried out to assess farmers' perspectives and the features that impact the implementation of soil and water management measures in the study area.

2. Materials and Method

2.1 Description of the study area

The Shafe catchment is located in the Mirab Abaya District of the Gamo Zone, Southern Ethiopia Regional State (Fig. 1). Geographically, it lies between 6°18′30″–6°22′00″ N latitude and 37°38′30″–37°45′30″ E longitude, covering an area of approximately 17,402.61 ha. The catchment ranges in elevation from 1,176 to 2,788 m above sea level and comprises three major agro-ecological zones: Dega, Woina Dega, and Kolla.

The area is characterized by diverse soil types and experiences a bimodal rainfall pattern, with a mean annual rainfall of 1,013.63 mm. The main rainy seasons occur during Belg (March–June) and Meher (September–November). Land use in the catchment is predominantly cultivated land, followed by grassland, forest, settlement areas, and barren land. Subsistence mixed farming constitutes the principal livelihood of the local community.

2.2 Sampling strategy

For this study, a multi-phase sampling approach was used, selecting individuals using both purposive and systematic sample strategies. In this investigation, Mirab Abaya area was primarily selected to represent Lake Abaya sub basin. The Shafe catchment was intentionally chosen because of its distinct agro-ecological zoning, varied topography, ease of access, established techniques for conserving water and soil, as well as susceptibility to erosion.

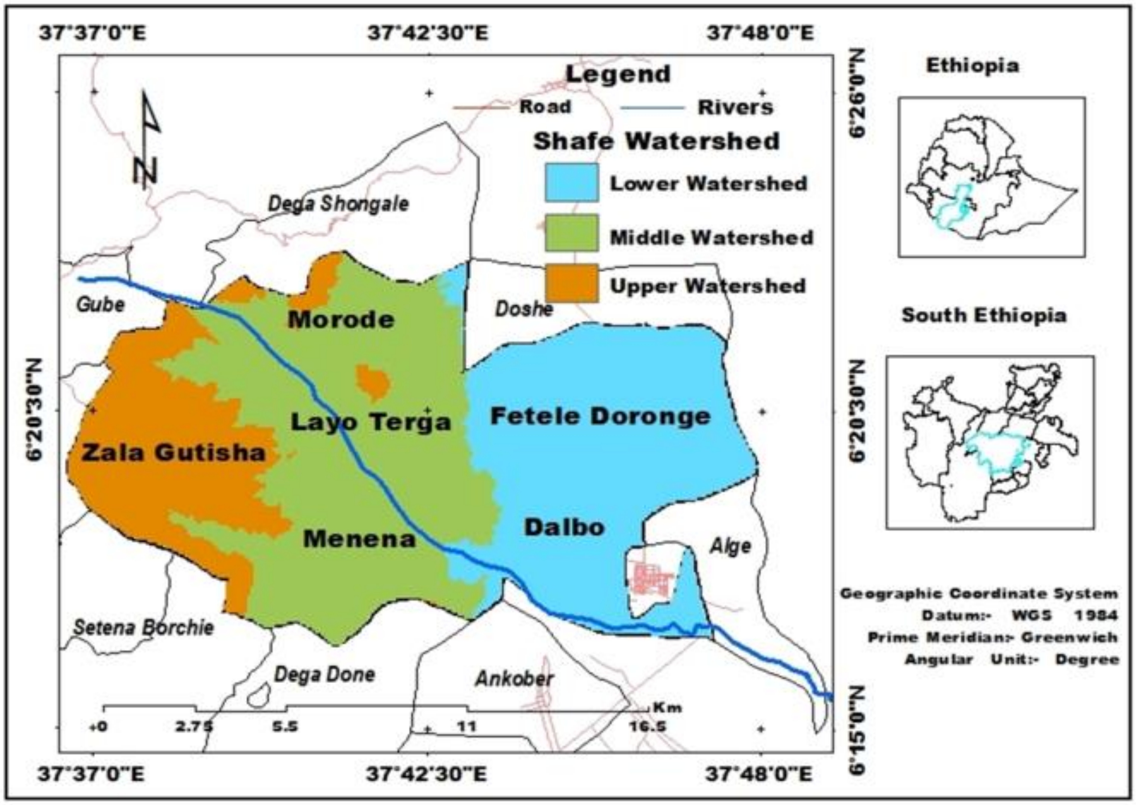

Figure 1. Map of the study area

In order to characterize the diverse AEZs and lands, the target population for the second stage was determined from three kebeles (the smallest administrative unit) in the high, middle, and bottom sections of the catchment. The target population comprised approximately 1955 active smallholder households from the study area. The local administrative officers' records provided this number of smallholder farmers, subsequently sample size of 185 households was determined using Equation (1) (Glenn.D, 2012).

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

Where, e= accuracy level (7%), n= sample size, and N= target population size

Accordingly, n= $\frac{1955}{1+1955(0.07^2)}$ =185

Thirdly, in order to make certain equal treatment, acceptable sampling was used to distribute the amount of responders within every kebele based on the precise number of agricultural households per kebele. In the end, data was collected via random sampling, where the sampling interval (K) was calculated by distributing the entire amount of farm households (N) in each kebele by the sample size (n) for that kebele.

Table1. Sample size distribution and sampling interval

Sample kebeles	N	n	%	K
Zala gutisha	1415	134	72	11
Morode	367	35	19	10
Fetele Doronje	173	16	9	11
Total	**1955**	**185**	**100**	**-**

2.3 Data sources and collection approaches

Primary data were gathered via a cross-sectional household survey employing semi-structured questionnaires, along with key informative discussions and field-work to obtain both quantitative and qualitative data. The survey was created utilizing Kobo Toolbox, a digital platform for data collection.

Agents involved in development from the chosen kebeles received training on digital data collection methods, and the tool was pre-tested on 10 farmers from the research area, leading to essential adjustments for improved clarity, relevance, and reliability. Data gathering was carried out by trained research assistants from every kebele under strict supervision. The survey aimed to identify practices for soil and water conservation (SWC), analyze socioeconomic and demographic factors affecting their adoption, and evaluate the challenges farmers encounter in applying SWC methods.

Key informer discussions were undertaken with agricultural extension officers& community leaders to enhance and confirm the household survey data, alongside field-level observations made during the survey period to corroborate reported practices and evaluate the real state of soil and water conservation efforts.

2.4 Data inquiry and presentation

Facts gathered through household survey questionnaires were downloaded from the Kobo Toolbox platform and examined by expressive and inferential statistical techniques. The socioeconomic and demographic features of farmers, as well as constraints related to soil and water protection strategies were examined by binary logistic regression model at 95% confidence level. Acceptance of soil and water management was considered as dependent variable with two possible outcomes, while a group of hypothesized socioeconomic, demographic, and institutional factors were included as explanatory variables.

Prior to administration of the regression model, all illustrative variables were tested on behalf of potential multicollinearity to ensure the robustness of the estimates and to minimize possible bias arising from household self-reported data. Using a threshold correlation coefficient of less than 0.8 to show lack of multicollinearity, Pearson correlation analysis was first used. All explanatory variables had correlation coefficients below this cutoff, indicating weak inter-variable relationships. In order to confirm these findings, the variance inflation factor (VIF) and tolerance values were also computed. Following standard econometric practice, multicollinearity was thought to be indicated by tolerance values less than 0.1 and VIF values larger than 5. In results showed that all variables fell within acceptable limits, confirming the absence of multicollinearity and supporting the suitability of the model for analyzing aspects manipulating the acceptance of soil and water conservation methods in the Shafe catchment (Sileshi et al., 2019).

2.5. Ethical consideration and clearance

This research was carried out following the ethical guidelines established by Arba Minch University. Ethical approval was secured from the post Graduate Studies, College of Agricultural Sciences, Arba Minch University, Ethiopia, before starting the research. Apart from this, a formal research permit was also obtained from the Department of Plant Science, which was then forwarded to the concerned local administrative authorities.

Verbal consent was received from the heads of households who participated in this study after explaining the objectives and nature of the study to them.

3. Results and Discussions

3.1 Traits of the respondents' demographics

Household survey included a total of 185 heads of households, with 169 (91.35%) being male and 16 (8.65%) being female. In terms of educational background, 66 participants (35.68%) were unable to read or write, while 56 (30.27%) had engaged in adult education programs. Additionally, 49 household heads (26.49%) had completed primary education, 9 (4.86%) had finished secondary education and only 5 respondents (2.70%) had education beyond grade 12 (Table 2). The data on marital status showed that a significant majority of respondents were married (168 households, or 90.81%). The other respondents included divorced individuals (10 households, 5.41%), widowed individuals (6 households, 3.24%), and single individuals (1 household, 0.54%).

Among the 185 sampled households, 115 (62.16%) accessed extension services regarding SWC practices, whereas other 70 households (37.84%) did not obtain these services. Generally, every Kebele had support from at least two to three development agents. Yet, when there are too few agents, they find it difficult to effectively tackle problems concerning crop and cattle production, resource management, irrigation, cooperatives, and land utilization. Joint training sessions were organized by both governmental and non-governmental organizations in the study area. Based on the survey findings, 99 households (53.51%) underwent training concerning SWC interventions, while 86 households (46.49%) did not (Table 2).

Moreover, most farmers had earlier engaged in soil and water conservation initiatives and exhibited a favorable view towards conservation activities. Table 2's descriptive statistics indicate that among the 185 respondents, 135 (73%) practiced SWC adoption, whereas the other 50 (27%) did not adopt these practices. This suggests a notably high degree of participation in conservation efforts among the households surveyed. Study made in Ethiopia by Sileshi et al. (2019) also stated that growers supposed soil erosion as a problem constraining crop production.

Table 2. Descriptive result for dummy and discrete variables

Items	Alternatives	Frequency	Percentage
Sex	Male	169	91.35
	Female	16	8.65
Educational level	Unable to write and read	66	35.68
	Adult education	56	30.27
	Primary education	49	26.49
	Secondary education	9	4.86
	Above grade 12	5	2.7
Family size	<4	13	7.0
	>12	20	10.8
	4-7	79	42.7
	8-12	73	39.5
Marital status	Married	168	90.81
	Divorced	10	5.41
	Widowed	6	3.24
	Single	1	0.54
Participation in Training	Yes	99	53.51
	No	86	46.49
Access to extension service	Yes	115	62.16
	No	70	37.84
Adoption status of farmers on SWCP	Adopter	135	73.0
	Non-adopter	50	27.0

The outcomes of multiple logistic regression analyses identifying socioeconomic and farm-related factors influencing the implementation of soil and water management strategies are shown in Table 3. The results are reported as odds ratios (OR), along with statistical significance levels ($p < 0.05$)

Table 3. The outcomes of multiple logistic regression analyses identifying socioeconomic and farm-related factors

Variables	Terracing	Fallowig	Contour plowing	Avoid ups down plowing	Intercropping	Manuring
Age of household head	0.36	1.03	0.94	0.96	1.10*	0.01
Agriculture	0.00	7,347.0	1.14e+09	195.22	1.94e+08	4.06e+31
Agro-ecology (kola)	1.72e+64	39.55*	5.20e+14	545.66**	6.86e+08	0.00
Agro-ecology (woynadega)	9.62e+21	0.31	1.28	0.44	1.75	0.00
Bush/tree land	0.00	1.77	1.13	0.23	1.13	4.47e+30
Daily laborer	0.00	4.17	0.16	5.32	0.90	5.58e+41
Eduhh (adult education)	1.14e+78	0.59	4.44	8.99e+05	1.35	5.78e+35
Eduhh (primary education)	6.98e+63	1.10	3.36	4.07e+06	1.21	5.33e+35
Eduhh (secdary education)	3.80e+70	19.19	2.57	1.00e+06	2.09e+09	1.40e+30
Eduhh (unable to read& rt.	7.97e+54	3.26	3.37	1.55e+06	1.36	1.61e+58
Extension (yes)	231.44	0.27	1.90	0.06**	0.20*	7.48e+10
Fallow land	0.00	1.62	1.98	4.18	0.26	0.00
Family size hh 47	0.00	0.58	0.35	4.09	18.35	0.00
Family size hh 8_12	0.00	0.63	1.56	93.39*	6.12	1.74e+08
Family size hh >12	0.00	0.17	0.40	95.36*	17.04	6.77e+97
Farm size hh	476.68	1.22	1.04	1.54	1.80	0.00
Grazing land	21,150.0	0.69	1.45	0.21	0.47	2.94e+27
Handicraft	4.54e+05	6.90e+07	4.61e+08	9.43e+07	1.70e+08	1.67e+29
Homestead area	2.62e+27	5.59	0.95	537.44**	2.30	3.29e+36
Perception on erosion (low)	3.03e+66	34.74**	0.39	15.04*	0.55	3.43e+31
Married hh	0.01	0.01	3.56e+08	0.46	10.33	0.04
Widowed hh	0.00	0.03	0.84	13.83	84.22	6.75e+11
Perception on ero (moderate)	0.00	4.71	0.52	26.82*	0.08**	1.45e+28
Own	4.60e+08	1.53e+06	2.84e+08	2.42e+09	1.50e+08	2.34e+06
Rented	4.04e+06	0.64	2.13e+08	2,563.0	2.00e+07	1.03e+65
Sex of hh (male)	1.33e+37	154.08	0.03	94.03	0.09	0.00
Small business	0.00	0.00	0.00	0.00	0.00	0.00
Training (yes)	0.00	1.72	0.26	20.61*	1.10	0.00
Perception on ero (very low)	0.00	0.46	0.25	38.47	0.16	1.59e+78
Weaving	0.00	5.46	1.38	61.16**	11.33	7.20e+57

hh= Household

3.2 Farmers' perception on SWC in the Shafe catchment

Soil erosion poses a serious threat to agriculture production and sustainability of the soil in the current research area. It was therefore necessary to understand the opinions and experiences of the farmers by asking them relevant questions. The first question about the knowledge of farmers concerning soil erosion in their farms (yes/no) is meant to measure the extent of awareness among the households. Measuring the extent of soil erosion (severe, moderate, mild, no erosion) will enable us understand the level of perception of the severity of the problem in the particular context. Understanding the possible impacts of soil erosion (loss of soil fertility, change of crop varieties, and low productivity) enables know the farmers' connection of erosion with their results.

In addition, understanding the identified causes of soil erosion (deforestation, runoff, sloping land cultivation) is helpful in appreciating how the farmers understand the causes of land degradation locally, which is vital in developing appropriate conservation measures. Asking farmers about their opinion regarding the severity and trend of erosion (becoming more severe, becoming moderate, becoming less, no erosion at all) and the trend of soil fertility (improving, moderate, becoming very poor) will be helpful in assessing how soils are changing over time from farmers' perspective. Furthermore, asking farmers about their expectations regarding the trend of future soil erosion (getting worse, getting better, staying the same, not sure) will be helpful in understanding local concerns and preparedness for implementation of conservation practices.

Ultimately, the issue of whether erosion can be managed (yes, no, uncertain) is essential for evaluating farmers' trust and eagerness to engage in topsoil and water management initiatives. Generally, the questions were relevant within the study area as they elicited vital insights into farmers' awareness, attitudes, and perceptions regarding soil erosion, which are important for effective land management planning and promoting the embrace of conservation practices. The findings showed that farmers view soil erosion as a significant issue that jeopardizes their quality of life and the output of their land. They believe that adopting effective soil and water management tactics are the best approach to decrease the negative effects of soil erosion and promise the sustainability of farming output.

3.3 Elements determining adoption of soil and water management measures

Multiple logistic regression models were used to test factors of implementation on the designated soil and water management approaches. Several aspects were considered to considerably affect the likelihood of adopting specific water and soil management methods. Model result revealed that, households residing in kolla agro-ecological zones (low land) were considerably more probable to accept soil and water management strategies such as Avoidance of up-and-down ploughing ($OR = 545.66$, $p < 0.01$) and fallowing ($OR = 39.55$, $p < 0.05$). Likewise, Training positively impacted the agreement of avoidance of up-and-down ploughing (OR = 20.61, $p < 0.05$), indicating the role of extension services and awareness in influencing conservation behavior. Larger family size was also positively associated with the implementation of certain labor-intensive approache. For example, families with more than 12 persons were significantly more likely to adopt avoidance of up-and-down ploughing (OR = 95.36, $p < 0.05$). Additionally, weaving as a livelihood activity and larger homestead area were strong predictors of adopting certain practices, such as avoidance of up-and-down ploughing (OR = 61.16 and OR = 537.44, respectively; $p < 0.01$ for both).

On the other hand, extension service access showed undesirable relationship with the implementation of avoidance of up-and-down ploughing (OR = 0.06, $p < 0.01$), possibly indicating barriers in implementation or targeting. Overall, the results highlight that implementation of water and soil management is influenced by combination of agro-ecological, demographic and institutional factors. Programs aiming to enhance sustainable land management should consider these multidimensional influences to effectively promote SWC methods.

The possibility of performing conservation tillage was comparatively low as related to the chance of practicing tree planting, intercropping, manuring, multiple cropping, fallowing and contour farming. This indicates, growers were not concerned to implement conservation tillage as per compared to other conservation structures because that might demand additional skill and awareness for practicing the technology. The outcomes of regression are similar with detected facts figured exhausting expressive statistics as designated in Table 2.

Observed influence of agro-ecological location on the implementation of water and soil management measures is reliable with discoveries from several empirical studies in Ethiopia and other parts of sub-Saharan Africa. Earlier studies have shown that farmers in lowland (kolla) areas are better probable to implement strategies such as contour-aligned ploughing, fallowing, and conservation tillage due to higher exposure to soil erosion risks, moisture stress, and land degradation (Mengistu et al., 2016). This suggests that perceived environmental vulnerability plays a critical role in shaping farmers' conservation decisions, aligning sound through the strong positive association observed in the Shafe catchment.

The positive effect of training on the adoption of avoidance of up-and-down ploughing corroborates earlier empirical evidence emphasizing the role of knowledge, awareness, and institutional support in conservation behavior. Secondly, empirical research carried out in the highland and Rift Valley areas of Ethiopia has proven that farmers with access to training or technical assistance are more prone to use SWC technologies owing to the fact that training improves knowledge of erosion dynamics and the long-term benefits of conservation methods (Belayneh et al., 2019; Moges & Taye, 2017).

In a similar fashion, the positive relationship between larger household sizes and the use of labor intensive SWC techniques has been widely supported by the existing literature. From an empirical point of view, larger families have higher chances of adopting and maintaining physically intensive conservation measures like contour farming and improved tillage (Miheretu & Yimer, 2017). The strong effect observed among households with more than 12 members in this study supports the labor-constraint hypothesis commonly highlighted in adoption studies. The significant role of livelihood diversification, particularly engagement in weaving, aligns with findings suggesting that non-farm income sources enhance farmers' ability to participate in sustainable land management strategies. Previous research has shown that households with diversified income streams are less constrained by short-term liquidity needs and are therefore more willing to adopt SWC practices that yield benefits over the long term (Hundera et al., 2019). Likewise, the optimistic effect of larger homestead size on adoption reflects consistent empirical evidence that land availability reduces opportunity costs associated with allocating land to conservation measures. In contrast, the negative association among contact to extension facilities and the implementation of avoidance of up-and-down ploughing diverges from many empirical studies but is not unprecedented. Similar counterintuitive findings have been reported in contexts where extension services are poorly targeted, emphasize blanket recommendations, or prioritize structural measures over indigenous and plot-specific practices (Belayneh, 2023). This may indicate gaps in extension quality, relevance, or follow-up support rather than a lack of farmer willingness to adopt conservation practices.

Overall, the descriptive adoption patterns observed in this study particularly the high prevalence of tree planting, intercropping, and manuring are consistent with empirical evidence suggesting that farmers tend to favor practices that provide immediate or multiple benefits, such as soil fertility improvement, fuel wood supply, and crop yield stabilization. In contrast, the relatively lower adoption of contour farming and conservation tillage mirrors findings from other studies that identify labor demands, technical complexity, and delayed benefits as key barriers to adoption.

Table 4 provides information on the adoption of various soil and water management techniques among the growers in the area. Among all the management practices, the highest level of adoption is noted for crop rotation (81.5%), followed by terracing (76.3%), and tree planting

(75.6%). This is because the growers understand the starring role of these techniques in maintaining topsoil fertility and preventing erosion. The moderate level of adoption has been noted for intercropping (66.7%) and manuring (62.2%), both of which can contribute to improved soil productivity and sustainability. However, multiple cropping (45.2%) and fallowing (40%) have also been found to have relatively higher levels of adoption because these are usually affected by land availability. Avoiding up-and-down ploughing (31.1%), cover cropping (27.4%), mulching (23%), furrowing (21.5%), and conservation tillage (20.7%) have relatively lower levels of adoption than other practices. However, all these practices play an important role in preventing soil erosion and preserving its fertility.

Table 4 .Water and soil management strategies (multiple responses)

SWC Practice	Frequency	Percentage
Crop rotation	110	81.5
Terracing	103	76.3
Tree planting	102	75.6
Intercropping	90	66.7
Manuring	84	62.2
Multiple cropping	61	45.2
Fallowing	54	40.0
Contour ploughing	49	36.3
Avoid ups and down ploughing	42	31.1
Cover cropping	37	27.4
Mulching	31	23.0
Furrowing	29	21.5
Conservation tillage	28	20.7

The Variance Inflation Factor and tolerance values designate that multicollinearity is not a serious problem among the explanatory variables included in the model (Table 5).

Table 5. Variance inflation factor (VIF) for continuous descriptive factors (Multicollinearity test)

Variables	VIF	Acceptance level
Agro-ecology	4.81	0.21
Sex of HH	1.86	0.54
Farm size of HH	2.14	0.47
Training	1.58	0.63
Grazing land	1.36	0.73
Fallow land	1.68	0.60
Own	1.00	1.00
Rented	1.39	0.72
Very low	1.49	0.67
Low	1.43	0.70
Moderately	1.69	0.59

Generally, a VIF value below 10 (or even below 5 in some standards) and a Tolerance value above 0.1 suggest acceptable levels. In this case, all variables have VIF values ranging from 1.00 to 4.81 and Tolerance levels between 0.21 and 1.00, showing that there is no severe multicollinearity. The variable Agro-ecology has the highest VIF (4.81), indicating relatively stronger association with other predictors, but still within acceptable limits. Therefore, all variables can be retained for further regression analysis.

As shown in Figure 2, the correlation matrix illustrates the relationships between household characteristics, land use patterns, and livelihood activities. As expected, the diagonal shows perfect positive correlations (r=1) of each variable with itself. Farm size exhibits a positive correlation with grazing land, homestead area, fallow land, and bush/tree land, indicating that households with larger farms tend to diversify their land use across multiple purposes

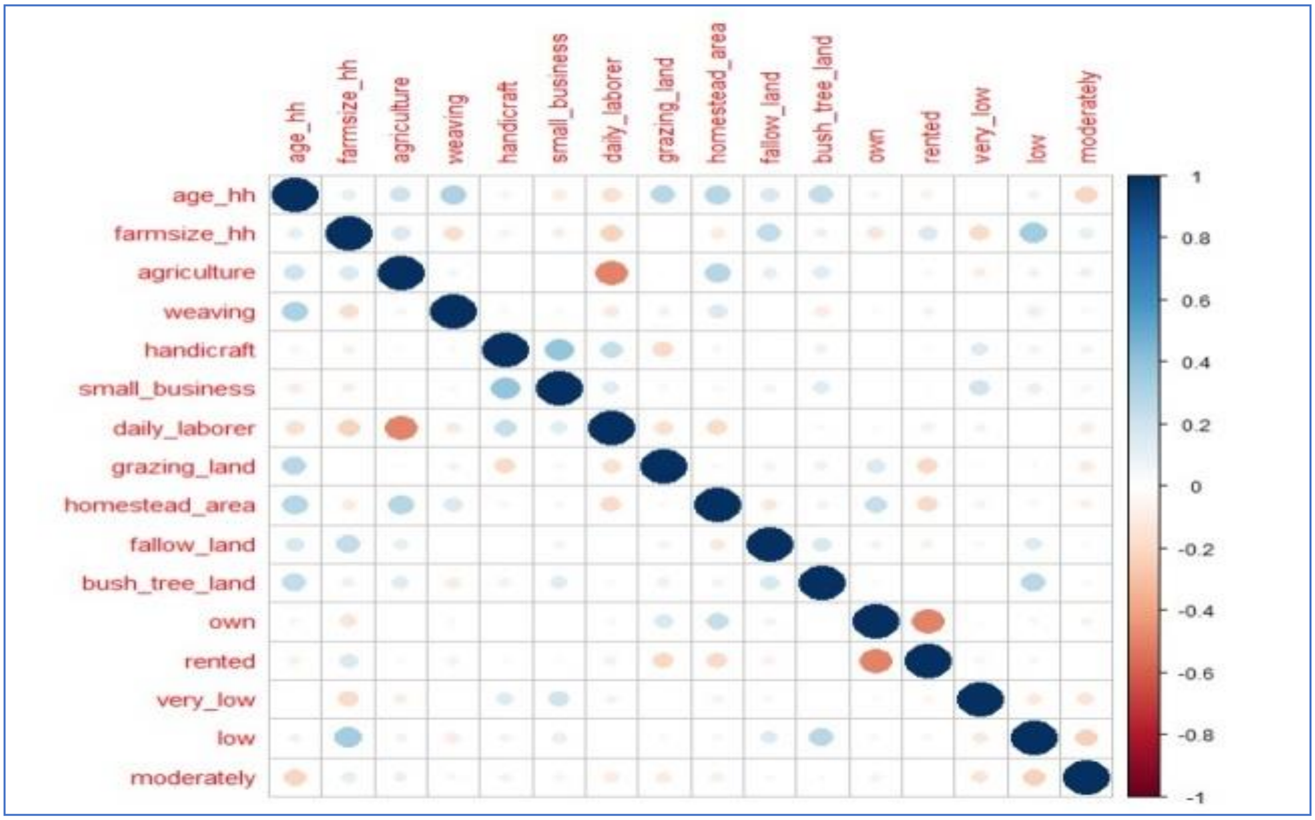

Figure 2. Correlation matrix heat map for model multicollinearity test

Ownership of the land (owned versus rented) is another example of different types of relationships where land ownership is positively related to farm size and land uses categories, whereas the rent has a negative relationship. Wealth categories (very low, low, moderately) have a positive relationship with the household resource land size indicating that richer people have more land size and diverse land uses. Overall, the above graph clearly indicates that farm size, land tenure, and diversification have an impact on the economic situation of the households.

Figure 3 illustrates extent of implementation of different soil and water management activities by farmers in the study area. Crop rotation (60%), earth bunds/terraces (56%), and tree establishing (55%) are the utmost widely adopted strategies, indicating farmers' strong preference for strategies that directly enhance soil fertility, reduce erosion, and sustain long-term productivity. Inter-cropping (49%) and manuring (45%) are also relatively high on the scale of adoption, indicating the significance of soil quality management through integration. On the other hand, methods such as multiple cropping (33%), fallowing (30%) are moderately adopted, possibly due to the problem of land scarcity and competition between the needs of the household. Methods such as contour ploughing (29%), avoidance of up-and-down ploughing (26%), and cover cropping (23%) have lower adoption levels, and it can be deduced from the fact that these methods require more effort or might not be well known. Mulching (19%), furrowing (16%), and conservation tillage (15%) have the lowest rates of adoption.

Overall, it is evident that farmers tend to adopt traditional and visibly soil conservation methods and modern techniques are not used.

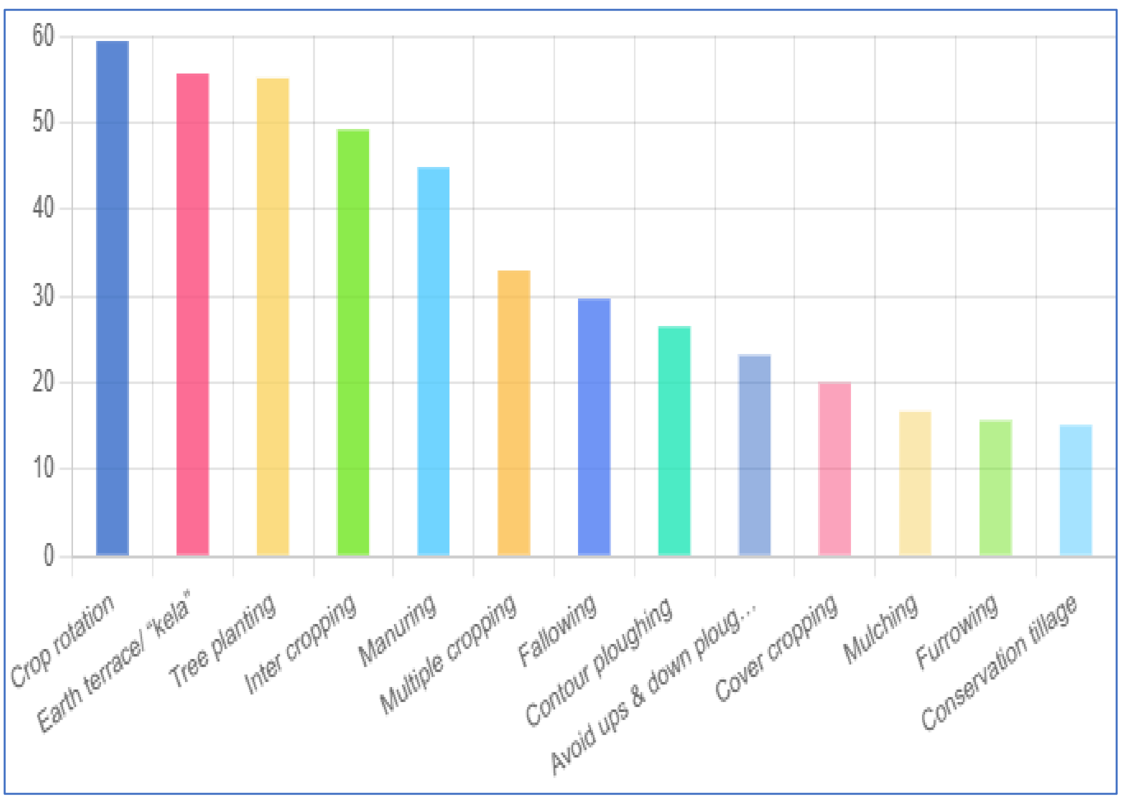

Figure 3. Indigenous soil and water management practice

3.4 Benefits of water and soil management strategies

The perceptions of farmers on the benefits of various approaches employed for water and soil conservation are depicted in Table 6. It is evident that the most significant number of the participants (over 90%) perceive SWC practices as essential in increasing agricultural productivity, whereas improving soil fertility came in second place (almost 85%). This finding coincides with the findings of the study done in the Lege-Lafto Watershed, Dessie Zuria District, South Wollo, Ethiopia (Yifru & Miheretu, 2022). Prevention of soil erosion is also one of the benefits that were identified by almost 80% of the respondents as highly important. In addition, about 75% of the participants believe that the mentioned practices are necessary for protection of plant roots from exposure and maintaining soil fertility. Thus, it may be stated that farmers are aware of the variety of benefits offered by such practices as SWC. However, the reduced perception of their importance in the process of roots protection and soil fertility is the reason for implementing new awareness programs.

Table 6. Benefits of soil and water management methods in the catchment as stated by the respondent farmers at the time of interview (multiple response).

Perceived Benefits	Frequency	Percentage
Improves agricultural productivity	179	96.76
Increases soil fertility	161	87.03
Prevents soil erosion and runoff	145	78.38
Prevents crop root exposure	138	74.59
Maintains soil fertility and moisture	135	72.97

As shown in Table 7, erosion has been recognized as the primary cause, with 88.11% of respondents reporting it, which underscores its extensive effect on agricultural productivity and land quality. Poor management of agricultural lands (49.73%) and over-cultivation (43.78%) were also indicated as major causes, showing the unsustainable practices in agriculture that degrade soil quality.

Table 7 Major reasons of soil ruin in the study catchment (multiple responses)

Causes of soil degradation	Frequency	Percentage
Soil erosion	163	88.11
Mismanagement of cultivated lands	92	49.73
Over cultivation	81	43.78
Overgrazing	71	38.38
Deforestation	65	35.14

Overgrazing (38.38%) and deforestation (35.14%) were also mentioned as other causes, showing the effects of livestock and vegetation clearance in degrading the soil. Overall, from the findings, it is clear that the interaction of natural factors like erosion and human activities like poor management of lands and exploitation of resources contributes to soil degradation.

4. **Conclusion**

Various factors influence farmers' conservation choices. The multiple logistic regression analyses revealed that elements for instance education level, family number, extension contact, agro-ecology, farm size, and marital status, perception of erosion intensity, land use, land ownership, and source of livelihood meaningfully affected the implementation of soil and water management practices on farm plots. Consequently, policy measures and development initiatives intended to improve farming efficiency by encouraging soil and water management techniques in the research area must consider the essential features determining acceptance, especially the nature of the innovation and farmers' preferences. The results of this study emphasize education as a significant household trait that positively influences adoption behavior. Therefore, participants in SWC projects should involve knowledgeable farmers as exemplars to illustrate the benefits of enhanced conservation methods. Despite the presence of agricultural extension services in the region for numerous years, the study found that their impact on promoting the use of improved conservation technologies is still constrained. Thus, incorporating more robust resource conservation elements into the current extension system is crucial to boost farmers' adoption of enhanced SWC practices. Given the continuing land degradation and deteriorating soil productivity in the study area, these actions necessitate immediate and harmonized application. Delaying better labor organization and stakeholder coordination will continue to reduce the efficiency of SWC investments and threaten agricultural sustainability. Thus, accountable institutions should prioritize this issue in the current planning cycle and integrate it into ongoing extension programs without delay, particularly in high-slope and erosion-prone areas.

Conflict of Interest

The authors declare no conflict of interest

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