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Soil-water conservation measures for landscape restoration and factors affecting its adoption in Bure district of southwest Ethiopia

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Abstract
Soil and water resources are vital for sustaining life on earth. Nevertheless, they are under threat of deterioration causing severe erosion despite the fact little attention is given to their effects. The study aimed to assess soil-water conservation measures for landscape restoration and factors affecting its adoption in Bure district of southwest Ethiopia. The study employed cross-sectional survey design and mixed approach to attain the intended objectives. Through multistage sampling procedures, 151 households were selected to conduct the survey. Data were collected using survey questionnaires, key informant interview, focus group discussion and field observation. The study utilized binary logistic regression model to assess factors affecting the adoption of soil-water conservation measures in the study area. The result revealed that there are various indigenous and adopted soil-water conservation practices in the area. Among these, fallowing, manuring, mulching, contour plowing, crop rotation, traditional waterways are indigenous practices, whereas terracing, soil and stone bund, fanjuu, vetiver and elephant grass are the adopted soil-water conservation practices. The result of binary logistic regression indicated that sex, age, family size, educational status, distance of farmland from residence, participation in the training significantly affects the decision of households' adoption of soil-water conservation practices at $P < 0.05$ significance level in the area. It was found that soil-water conservation measures played a noteworthy role in retaining and/or restoring soil fertility, regulating temperature, upturn soil moisture, upholding agricultural production, reducing soil erosion, restoring vegetation cover and mitigating anthropogenic land degradation in the study area. Conclusively, concerned stakeholders should collaborate to strengthen and maintain the process of implementing soil-water conservation measures for sustainable land resource management of the area.

Keywords
Soil-water conservation measures, Adoption, Binary Logistic regression

Introduction

The natural environment is made up of a variety of priceless natural resources that are essential to human life and growth, including soil, water, air, land, forests, plants, and animals. According to Asnake et al. (2018), any modifications made to one of these elements are counterbalanced by adjustments made to another element of the environment. In order to withstand such changes a wide range of practices of natural resources management (NRM) have been used. Many different techniques of natural resource management have been employed to survive such changes. However, much of Africa is experiencing high rates of degradation of its soils and other natural resources be-

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cause to low adoption rates of sustainable NRM practices, particularly among the poorer smallholder producer subpopulation (Mohammed et al., 2018). Therefore, it is extremely difficult to maintain sustainable agricultural intensification in rural Africa, where the majority of people are employed in agriculture and live in extreme poverty, in order to achieve the universal goal of reducing poverty and vulnerability (Daniel and Mulugeta, 2017). Agriculture has a big role to boost economic development, providing food security, and reducing poverty, especially in developing nations. However, various eroding agents are depleting the soil used for agricultural purposes. Mohammed et al. (2018) reported that the International Soil Reference and Information Centers' survey report on soil deterioration indicated that various eroding agents are responsible for the degradation of 9 million hectares of land worldwide. Due to a num-ber of causes, land degradation has emerged as a major environmental concern that the world commu-nity is currently paying close attention to (Yirgu, 2022). It is a serious threat to the productive capacity of land resources at national and regional level which requires immediate attention as it endangers the livelihood of the people. Land degradation as deterioration of a balanced ecosystem and the loss of ecosystem services and thus, integrated management of land degradation which considers all ecosystem goods and services, biophysical as well as socioeco-nomic aspect is very crucial to address the problem (Krasilnikov et al., 2016; Keesstra et al., 2023; Mulska et al., 2022; Akinci and Yildirim, 2023; Rodriguez Sousa, 2023). A farm's soul is its soil. Crop and fodder output will be maximized by good soil management. However, due to inadequate management techniques, this priceless resource has been degraded and lost at an alarming rate, mostly in the developing countries (John & Merrell, 2010). Degradation of Ethiopia's soil resources has become a major issue that affects the people's social, economic, and political lives in many domains. It is among the main obstacles to the nation's agricultural development and food security (Daniel & Mulugeta, 2017). Land resources producti-vity has been endangered by many factors including but not limited to overexploitation of natural resour-ces and fuel woods, expansion into marginal lands with low cropping potential, traditional agricultural practices, low productivity due to depletion in soil organic matter, soil fertility, poor soil moisture holding capacity and soil erosion and population pressure on fragile ecosystem particularly in highland areas of the Rift Valley, the Ethiopian plateau and great Lakes areas (FAO, 2011). Land degradation is exacerbated by deforestation, traditional agricultural practices, lack of alternative sources of fuel, overgrazing, topographic gradient, population growth, land tenure insecurity, lack of clear institutional setting, shortage of financial resources, inadequate physical capital, poor stakeholders' involvement at all level of decision, weak extension services, chemical deterioration (Berry, 2008). In order to control deteriorating factors in Ethiopia, different soil water conservation (SWC) practices have been introduced. According to Yitayal and Adam (2014), various types of these conservation practices including terraces, area closure, and other types have been practiced on individual and collective lands through the productive safety net and food for work programs since the 1970s and 80s. Smallholder farmers in Ethiopia in general and the study area in particular have not largely accepted the established methods, despite significant efforts being made to ensure economic and ecological benefits. Despite the Ethiopian government's introduction of several soil and water conservation measures, farmers were unable to use them and raise agricultural production as required (Asnake et al., 2018). Degradation of soil resources is one of the main obstacles to agricultural productivity worldwide, particularly in emerging countries like Ethiopia generally and Bure District specifically. One of the districts of Ilu Aba Bor in Ethiopia's Oromia Region is Bure District. There is extreme soil erosion, land fragmentation, deforestation, and land pressure on a sizable portion of the districts' territory. As a result, the soil is unable to meet the population's fast expanding needs. The district has consistently been abused and neglected. Consequently, the majority of people living in rural areas experience food insecurity. This is primarily due to soil erosion and the issues it causes, which render the land unsuitable for farming. Consequently, the farmers' livelihoods are still negatively impacted by severe erosion. Runoff has carried away the rich topsoil, leaving the exposed subsoils that are often low in readily available minerals. Steep, undulating terrain that is prone to soil erosion characterizes the research locations. In addition, the region has a lot of rain, albeit only during a few months of the year. Moreover, agriculture plays a major role in the economy of society by producing crops that need seed beds with finely tilled soil. This demonstrates unequivocally the necessity of efficient soil and water

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conservation measures. To stop land degradation, several techniques for conserving water and soil were established, but acceptance of these measures is still falling short of expectations. According to (Belete, 2017; Berhanu et al., 2016), institutional, physical, demographic and socioeconomic issues were some of the most important barriers to the adoption of soil conservation. Nevertheless, the majority of these research were conducted in Ethiopia's north and other regions, with the study area receiving little attention. Therefore, the study aimed to assess soil-water conservation measures for landscape restoration and factors affecting its adoption in Bure district of southwest Ethiopia.

Conceptual framework of the study

Given that agriculture plays a significant role in developing nations, scientists and policymakers have been particularly interested in the ongoing adoption of innovative techniques for conserving soil and water in these areas (Menale et al., 2008). The issue of sustainnability for many nations, especially emerging nations whose economies primarily rely on agriculture, is inte-grating SWC principles with the agricultural sector (Fikru, 2009). The implementation of water and soil conservation measures, however, is lacking. Due to these consequences, numerous research have been carried out throughout the world, including in Ethio-pia, to determine the key elements influencing the adoption of water and soil conservation techniques (Berhanu et al., 2016; Daniel & Mulugeta, 2017). These comprise institutional, physical, socio-economic and demographic aspects (Fig. 1).

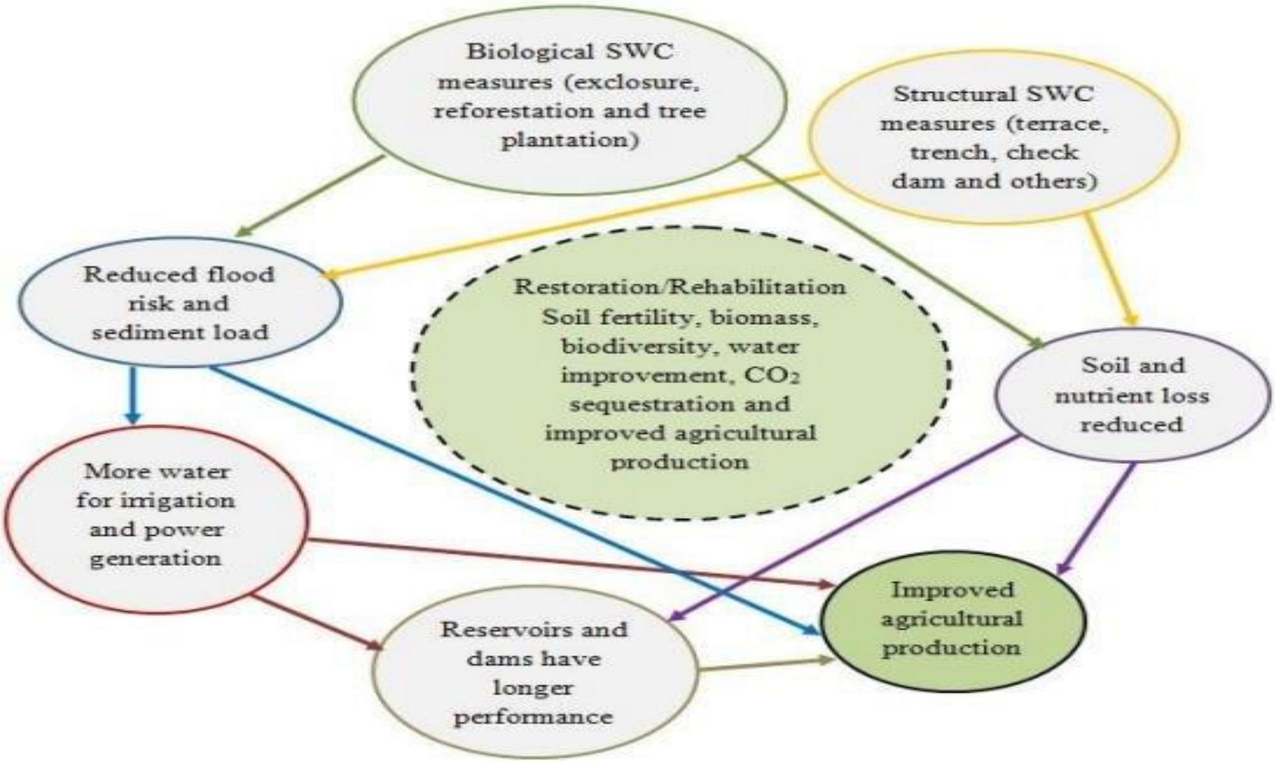

Figure 1. *Conceptual framework of the study*

Materials and methods

Study site

Bure district is situated in the southwest part of Ethiopia. Geographically, it is located between 8°10'00 - 8°30'00"N latitude and 35°00'00" - 35°20'00" E longitude with an average elevation of 1705 meters above sea level. Relatively, the district is bounded by Gambella regional state in west, Darimu in north, Halu and Nono sale in south and Mettu district in east (Fig. 2). According to Bure District agricultural office (2023), the total area of the district is about 113,619 hectares and the district lies in moist *Woina Dega* (cool sub-humid) and *Kolla* (warm semiarid) agro-ecological Zones. The average temperature ranges between 16.5°C and 26.5°C whereas mean an-

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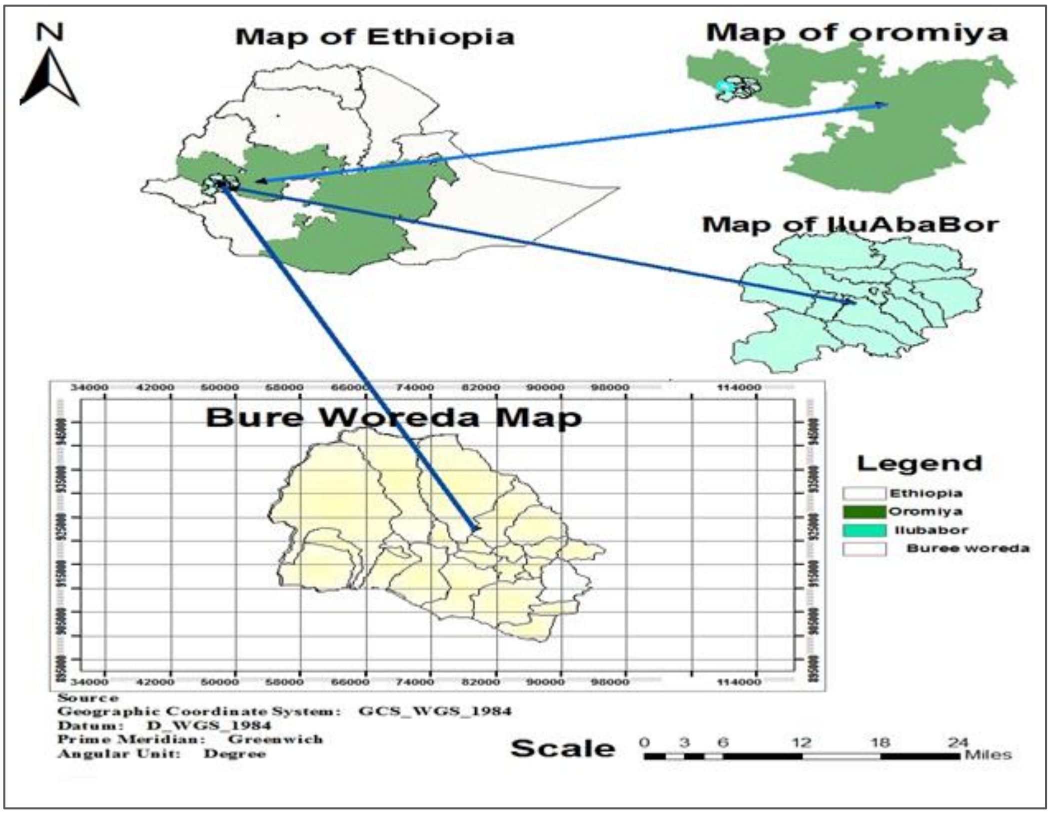

Figure 2
Location map of the study area

nual rainfall is 1280 mm. There are two towns and 19 "kebeles" (the lowest administrative unit in Ethiopia) under the district. According to FAO soil classify-cation system and data obtained from the Digital World Soil Map, the area has Dystric Nitosols, Pelvic Vertisols, Dystric and Orthic Acrisols; and agricultural land, forest land, grazing land, settlement area and wetlands are the major land use types of the area. The total population in the District is 71,174 of which 40,714 are males and 30,460 are females. Majority of the people (95%) live in rural areas engaged in agri-culture.

Research design and approach

The research design used in the study was a cross se-ctionnal survey, which is employed when data is ga-thered from the sample population one at a time. Ad-ditionally, a concurrent triangulation inquiry technique and mixed research approach were used, in which di-rect collection of both quantitative and qualitative da-ta was done, with the results being triangulated during analysis. This is mostly because using a mixed appro-ach which allows one to examine the issue from seve-ral perspectives.

Data sources and collection tools

Data were gathered for this study from primary and secondary sources. Primary data were gathered from households, which included information on age, education level, farming experiences, family size, and marital status. Additionally, farm characteristics, such as the number of plots and size of livestock held, were gathered, as were local soil management techniques. During the data gathering and analysis process, multiple methods were triangulated to assure the quality and trustworthiness of the data. Data were gathered through key informant interviews, focus groups, and field observations. Secondary data, including published literature, were gathered from the district's sustainable land management office, development agents, and experts in natural resources.

Sample size and sampling techniques

The study followed multi-stage sampling technique. First, the researchers purposively selected three Kebeles out of 21 kebeles of the district based on the SWC practices and improved livelihood enhan-ced in the area. These Kebeles are Obo Miriga, Sibo Abo and Nebo Miriga. Second, the study employed Yamane (1967) formula to determine sample size to calculate the sample size. Lastly, 151 households of the sample kebeles were selected using simple random sampling techniques. The formula used is

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calculated as:

$$n = N/[1+N (e)^2] \quad n = 244/[1+244 (0.05)^2] = 151 \quad [1]$$

where n is the sample size, N is the population size, and e was the level of precision. When this formula is applied for the above data with ±5% Precision Level (sampling error), Confidence Level is 95% (Table 1).

Table 1. *Distribution of sample household in the study area*

Sample Kebele	Total household	Sample of household
Obo Miriga	90	58
Sibo Abo	70	43
Nebo Miriga	84	50
Total	244	151

Source: Field Survey, 2023

Method of data analysis

Both qualitative and quantitative methodologies were used to organize, summarize, and analyze the data that was gathered using a variety of data gathering technologies. With SPSS version 23 and Microsoft Excel, data were arranged and examined. Farmers' decisions to implement soil conservation methods in the area are investigated using both descriptive and inferential statistics, including binary logistic regression models. Thematic narrative and FGDs were used to examine the data obtained from field observations, interviews, and focus group discussions (FGDs).

Binary logistic regression model specification

When the dependent variable includes two categories, binary logistic regression is a well-liked and frequently used model for nominal outcomes (Wulff, 2014). In this study, the dependent variable is dichotomous (i.e. farmers' decision to practices or not to practices SWC practice). The response variable was a binary variable, which was assigned as value of '1', if farmers adopt SWC practices, and a value of '0' if a farmer not-adopt SWC measures. Therefore, to investigate fac-tors those affecting farmers' practices of soil conser-vation (SC), binary logistic regression model was employed. The binary logistic regression model was specified as follows.

$$Y = \beta_o + \beta_1 X_1 + \beta_2 X_2 + ...+\beta_{12}X_{12}+ \epsilon \quad [2]$$

In this model Y is the dependent variable representing SWC practices , X_1, X_2 +... + X_{12} are predictor or explanatory variables of the model and **ϵ** is the random (or unexplained) part of the model. The residual term ϵ is again assumed to be normally distributed with mean 0 value and variance .The unknown parameters β_o, β_1... β12 are called the regression coefficients.

Description of variables used in binary logistic regression model

A variable that is hypothesized to be impacted by modifications in an independent variable is called a dependent variable. The dependent variable in this study is binary, meaning that it represents the far-mers' choice to use SWC or not. The explanatory variables or predictors chosen for the model were based on empirical literatures. Explanatory variables are those that are presumptively related to the adop-tion of SWC measures or an outcome variable. Ta-ble 2 below provides a detailed presentation of the independent variables and their hypothesis.

Dependent (Y1) and Independent (explanatory) variables (X1-Xn) description			
Variables	Variables Description	Measurement	Sign
Y1=scp	Probability of being soil conservation adopter or not	Dummy (0=Soil conservation adopter 1=Soil conservation non-adopter)	
X1= sex	Sex of households	Dummy (0=Male 1=Female)	Positive
X2=age	Age of households	Continuous (Measured in year)	Positive
X3= fsize	Family size of households	Continuous (Measured in number)	Positive
X4=educ	Educational status of households	Dummy (0=Cannot read and write 1=1-4 2=5-8 3=9-12 4= >12)	Positive
X5=fls	Farmland size of households	Continuous (Measured in hectare)	Positive
X6=fexp	Farming experience of household	Continuous (Measured in year)	Positive
X8=nfi	Net farm income of household	Continuous (Measured in Ethiopian Birr)	Positive
X9=extser	Use of extension service by household	Dummy (0=Yes 1= No)	Positive
X10=dfl	Farmland from residence	Continuous (in hour/minute)	Negative
X11=pit	Household participation of soil conservation training	Dummy (0=Yes 1=No)	Positive
X12=creser	Household credit service	Dummy (0= Yes, 0=No)	Positive

Table 2 *Variables description, measurement and expected sign*

Source: Field Survey, 2023

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Results and discussions

The results of the respondents' socioeconomic characteristics are covered in this section, along with the causes that contribute to soil degradation, household farmers' practices for conserving soil and water, and the determinants of these practices. Additionally, the impact of SWC measures to the area's landscape restoration is discussed. The identification of the factors influencing the soil and water conservation practices in a particular location is influenced by an individual's gender. There were roughly 42 (27.8%) female respondents and roughly 109 (72.2%) male respondents. According to the data above, men made up the majority of responders. Age has an impact on the household's total efforts to conserve water and soil. Regarding this, the bulk of responders fell within the 31–40 year old middle adult age range. Regarding marital status of the respondents, majorities 112 (74.2%) are married, 24 (15.9 %) are single, 10 (6.6%) are divorced and the remaining 5 (3.3%) are widowed (Table 3). The socioeconomic level, which establishes the state of rural land management, may also be correlated with household size. The likelihood of farmland degradation and/or deforestation increases with household size. However, larger homes are associated with more important social networks and human resources, which might be useful in an emergency (Cutter et al., 2003). A large household may indicate that there are plenty of farm laborers available. Table 3 reveals that just 4 respondents (6, or 4.0%) have a household size of 1-3 individuals, whereas around 27.1% of the respondents have a household size of >7 and above. Consequently, 104 (68.9%) of the respondents, or the majority, have 4-6 households family members. On average the study area almost exceeding the national average of rural household size which is 4.9 as CSA (2008) census report. Table 3 shows that 108 (71.5%) of household respondents were have their own land whereas small or large in hectares while 43 (28.5%) were not have their own land except homestead area. Regarding economic activities, survey results show that agriculture is the mainstay of the study area and that all the sample respondents had access to land. Farmers with large farm size are expected to practices better Soil and water conservation practice. This is because when farmers have large farm size, they plan different management practices due to the large land holding size. As revealed in Table 3, about 4 (2.6%) of the respondents owned land ≤0.25hectares, 3 (2%) of the households owned land ranges from 0.26-0.5 hectares, 66 (43.7%) owned land between 0.6-1 hectares and 78 (51.7%) owned land between 1.1-1.5 hectares. If the current rate of rapid population expansion keeps up, there will undoubtedly be a greater shortage of farmlands in the future, which will have an impact on the amount of grain produced per household.

Table 3. *Socio-economic characteristics of respondents* Source: Field Survey, 2023

	Attributes and Categories	Frequency	Percentage
Sex	Male	109	72.2
	Female	42	27.8
Age in years	20-30	8	5.3
	31-40	65	43.0
	41-50	54	35.8
	Above 50	24	15.9
Marital Status	Married	112	74.2
	Single	24	15.9
	Divorce	10	6.6
	Widowed	5	3.3
Family size in number	1-3	6	4.0
	4-6	104	68.9
	>7	41	27.1
Land size in hectare	≤ 0.25	4	2.6
	0.26-0.5	3	2.0
	0.6_1	66	43.7
	1.1-1.5	78	51.7

The most common SWC practices applied in the study area

Soil degradation is a one of the major challenges to farming practice to ensure food security of a given area and it affects all spheres of social, economic and life of the population. Such problem can be minimized by using different SWC techniques. In the study area, farmer households use different soil conservation practices. Various methods to conserve soil in the study area such as fallowing, mulching, terracing, manure, crop rotation, soil and stone bunds and others (Fig.3).

Soil fertility maintenance practices in the area

Fallowing. This is a method by which a much used land is allowed to rest so that during this time, the nutrients lost are regained (Figure 4). As can be seen from figure3, 132 (87.4%) of the respondents practice fallowing. Households make their farmland idle for 3 to 4 years in the study area to retain their soil fertility, but this approach is the most common among far-

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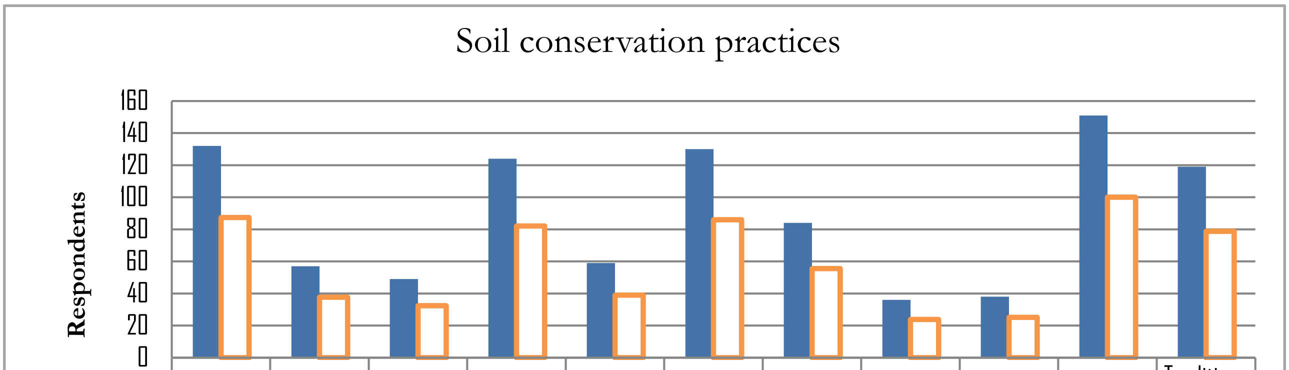

	Fallowing	Mulching	Terracing	Strip cropping	Manure	Crop rotation	Soil bund	Stone bund	Vetiver grass	Contour plowing	Traditional waterways
Frequency	132	57	49	124	59	130	84	36	38	151	119
Percent	87,4	37,7	32,4	82,1	39	86	55,6	23,8	25,1	100	78,8

Figure 3. *The common SWC practices in the study area* (Source: Filed Survey, 2023)

mers having ample land. The result of study (Ajayi et al., 2003; Nadeem et al., 2019; Abba et al., 2020) has consistency with this study where they confirmed that idling land for two to three years enhances soil fertility.

Mulching. It is covering the surface with grass or crop residues in the study area to reduce evaporation and soil erosion so as to make soil retain moisture that in turn leads to fertility enhancement (Figure 5).

Figura 4. *Fallowing activities in the study area* (Source: Field photo, 2023)

Figure 5. *Covering land with crop residues as mulching activity* (Source: Field photo, 2023)

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As can be seen from figure 3, 57 (37.7%) of the households used mulching (crop residue on their farm lands). Hence, farmer households of the area leave crop residues after harvesting and protect cattle or other animal not to eat. They let the residue stay on the farm land until rain comes for the next cultivation. The study result of Prem et al. (2020) and Wang et al. (2009) has similarity with this study as they revealed mulching activity has good contribution to conserve soil, retains moisture in soil and facilitates fertility.

Manuring. It is technique of using animal dung on the farmland to add fertility of soil (Figure 6). Households of the area construct barn (Kraaling) on their land where they plan to cultivate make cattle in it for three to four days and then change subsequently. In the area, about 59 (39%) of the respondents follow this approach on their farm land. This practice is most common among farmers having number of cows. Even, some of them mix inorganic fertilizer with it and use on their farmland and get good productivity or yield for their crop. The manure applicability and using it by cycling has a great contribution in increasing soil fertility and this in turn increase agricultural productivity (Mafongoya et al., 2006; Watson et al., 2002; Stockdale et al., 2006). The result of these studies has similarity with current study.

Physical soil conservation practices in the area

Terracing. It is another method of soil conservation technique that is used by the people of the area during the researchers' field observation (Figure 7). The field survey result showed that 49 (32.4%) of the respon-dents use terracing on their farmland. Farmers of the area construct terraces along the lower slopes to withstand erosion by food making water accumulated in it. This activity is practiced in group of campaign among households in the area. However, farmers with small farmland suffer to use it as it takes part of their plot, but household farmers with vast land are more practitioners based on survey made by researchers. The study result of Maetens et al. (2012) and Telles et al. (2022) agrees with this study as they strongly revealed different types of terracing contribute for soil conservation.

Figura 4. *Fallowing activities in the study area* (Source: Field photo, 2023)

Figure 7. *Terracing activity in the study area* (Source: Field photo, 2023)

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Contour plowing. It is a technique that involves plowing the land sideway contour as opposed to plowing up and down to make soil not susceptible to run-off (Figure 8). All households 151 (100%) use contour plowing practice during their cultivation. Even, they make linear line like feature (furrows) to reduce erosion occurrence after harvesting seed (Figure3). The study output of Shinde et al. (2019) and Farahani et al. (2016) agrees with this study where they assured contour plowing has enormous role in soil erosion prevention and conserves soil.

Figure 8. *Contour plowing and furrows in the study area* (Source: Field photo, 2023)

Soil and stone bund. Soil and stone bund is constructed with water collection or erosion prevention channels at the upper side of the farmland along the contour (Figure 9a; 9b). This method is important in controlling soil loss, enhancing soil moisture retaining capacity and ultimately increasing productivity of farmland. Stone bund is most common at where much amount of stones is there to easily bund it. According to the field survey, 84 (55.6%) and 36 (23.8%) of the respondents follow soil and stone bund practices in the study area respectively on their farmland (Figure3). Sometimes ribboning style of stone bund is made in the study area. The focus group discussants stated that, construction of soil bund contribute in alleviating soil erosion on their farmland. They also forwarded that stone bund is tiresome and laborious as takes time to collect stones and construct bund. Therefore, these practices are made in group or campaign. The study by Negasa (2022) and Kanito et al. (2021) have similarity with this study result as their study showed soil and stone bund practice have role in soil conservation and storing water.

Figure 9. Stone bund (a) and Soil bund (b)

Traditional waterways. It is diverting the direction of floods to reduce its force but not guaranteed for erosion prevention (Figure 10). Of the total respondents, 119 (78.8%) agreed traditional waterways is practiced in the area in which households divert run-off by using materials such as hoe (Figure 3).

Figure 10. *Traditional waterways in the study area* (Source: Field photo, 2023)

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Agronomic soil conservation practices in the area

Strip cropping. This method is cultivating different crop/s in rows. Hence, some crops are erosion resistant than other (Figure 11). The survey result showed 124 (82.1%) respondents use strip cropping on their farmland (Figure3). Based on researchers' field observation, farmers with small land size are more practitioners of this approach. According the study (Mishra and Prased, 1966; Unger et al., 1991; Francis et al., 1986) output, strip cropping has a great role in soil conservation strategies and this idea agrees with this study.

Figure 11. *Strip cropping with different crops* (Source: Field photo, 2023)

Crop rotation:. This is cultivation of different crops alternatively. That means growing the same crop in the same field for successive years will exhaust one particular kind of soil nutrient (Figure 12). The survey result also showed that about 130 (86%%) of the respondents use such techniques in the area under study (Figure 3) they have reported that if they grow maize one year, they will grow sorghum or other crops in the next year. Crop rotation has great role soil conservation and fertility enhancement (Ball et al., 2005; Tariq et al., 2019; Rusinamhodzi, 2015; Jayaraman et al., 2021).

Figure 12. *Crop rotation after harvesting maize and substituting by beans* (Source: Field photo, 2023)

Vegetative soil conservation practices in the area

Vetiver grass: It is type of grass planted in row/s on plot of land so as to reduce erosion (Figure 13). From the total respondents, 38 (25.1%) of households revealed that farmers of the area use this method between farmland or on ridges of their land to control erosion of run-off most of the time (Figure3). The study conducted by (Jiru and Wari, 2019; Sivamohan et al., 1993; Gesesse et al., 2013; Truong, 2000; Erskine, 1992) proved in their study as planting different vetiver grasses has advantage to control erosion and even fertility enhancement on farmland, so this idea agrees with this study.

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Figure 13. *Types of Vetiver grasses used by households in their farmland* (Source: Field photo, 2023)

Binary logistic regression result on factors affecting the adoption of SWC practices in the area

Soil resource conservation techniques can be influenced by different factors in different areas. In the study area, there are also different factors that affect soil conservation practices. Binary logistic regression model was used to investigate factors that affect household decision to adopt SWC conservation. The dependent variables were analyzed with predictor or explanatory variables. A statistically significant fitted model ($\chi 2$= 106.300, p = 0.000), suggesting that the model had strong explanatory power. The Nagelkerke R Square value shows that about 67.3% of the variations in the adoption of SWC were explained by the explanatory variables considered in the study. Among the hypothesized factors, only statistically significant variables were presented. In the model, about eleven explanatory variables were entered. Of these variables, seven variables including sex, age, family size, educationnal status, distance of farmland from residence, participation in the training concerning soil conservation and credit service were found to be significantly affected soil conservation practice adoption of house-holds in the area (Table 5).

Sex of household heads. It was expected that male household heads could apply soil conservation practice and adopt it than female households. As it can be understood from Table 3, sex was statistically significant at a 5% level of significance (B = 1.054, P-value = 0.046) and positively related with soil conservation practice ratifying consistency with the prior hypothesis. The odd ratio indicated that male households were engaged in the adoption of soil conservation practice by the factor of 2.868 than female households where other things held constant. This study has similarity with Ejaz et al. (2022) study on Pothohar, Pakistan that found socio demographic factors determine soil conservation practices.

Age of household heads. Age was expected to have a positive influence on households' adoption of soil conservation practice. As a result, this independent variable is statistically significant at a 1% significant level (B = 0.108, P-value = 0.000) and it is positively related to soil conservation practice that was consistent with prior expectation. The odd ratio of this variable indicated that other things being constant, the probability of being a soil conservation adopter increases by a factor of 1.114 as the age of household increase by one unit other things remain constant. The stud by Kehinde et al. (2022) on Oyo state, Nigeria has similarity with this result that identified determinants including age and household size have significant influence on adoption of soil conservation practices. The study by Abebe and Sewnet (2014) concluded age, family size, access to training and getting credit service positively affect soil conservation practices which has similarity with this study result.

Family size of household heads (fsize). Household heads' family size was expected to have a positive influence on households' adoption of soil conservation practice. As the number of family size increases, the labor force needed to practice soil conservation also increases. This variable is statistically significant at a 1% level of significance (B = 1.152, P-value = 0.000) and it is positively related to the state of soil conservation practice. So it is consistent with prior hypothesized expectations. The odd ratio of this variable showed that other things become constant, the probability of being a

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Table 5
Logistic regression model on determinants of SWC practices adoption

variables	B	S.E.	Sig.	Exp (B)
Sex	1.054	.528	.046**	2.868
Age	.108	.022	.000*	1.114
Fsize	1.152	.131	.000*	3.164
Educ	.990	.395	.012**	1.372
Fls	.146	.598	.808	1.157
Fexp	.004	.032	.911	1.004
Nfi	.001	.001	.222	1.001
Extser	-.085	.500	.864	.918
Dfl	-.051	.022	.022**	.052
Pit	1.624	.512	.002*	5.073
Creser	1.046	.445	.019**	2.847
Constant	-12.550	1.826	.000	.000

*,**represents significant at 1% and 5% significant level
-2 Log likelihood Ratio=166.77, Chi-squared=276.847

soil conservation adopter increases by a factor of 3.164 as the number of families increases by one unit. This result has consistency with the study results of (Kehinde et al., 2022; Ngaiwi et al., 2023; Dangiso and Wolka, 2023; Babu et al., 2023) that revealed family size generates labor force to adopt soil conservation practices.

Educational status of household heads (educ). Education is expected to positively influence the adoption of soil conservation practice. As the status of education increases, the percentage of household heads' adoption of soil conservation practice also increases. This is because; they get an insight into the use of soil conservation practice as they become more educated. This independent variable is statistically significant at a 5% probability level (B=0.99, P-value=0.012) and positively related to soil conservation practice that is consistent with the prior hypothesized idea. The odd ratio implies that as the households become more educated the probability of adopting soil conservation increases by a factor of 1.372 where other things remain constant. The study conducted by Sumaryanto et al. (2022) in West Java, Indonesia has similarity with this study that confirmed education is determinant factor to adopt soil conservation application.

Distance of farmland from residence (dfl). It was hypothesized that the distance of farmland negatively influences the adoption of soil conservation. As it can be observed from table 3, this variable was statistically negatively significant at a 5% probability level [B=-0.051, P-value=0.022]. This negative value has consistency with the hypothesized one. The odd ratio of this independent variable implied that the probability of adopting soil conservation practice decreases by a factor of .052 as the distance from residence increases by one unit. This is because; a farmer who was far and not nearby their land become hesitant to follow and then the land become vulnerable to erosion agents. This result has similarity with result found by (Chuma et al., 2022; Ngaiwi et al., 2023; Yifru and Miheretu, 2022) that revealed distance between homesteads and place of soil conservation area has significance. The nearer the area, the good conservation applicability is.

Participation in training of soil conservation (pit). Participation in training as an independent variable was expected to have a positive relation with soil conservation practice. This means that as the household heads participate in training given concerning soil conservation, they get information about to practice. As it is revealed in the logistic regression table 3, this independent variable is statistically positively significant at 1% probability level (B=1.624, P-value=0.002) and become consistent with prior expectation. The odd ratio revealed that as being other things remain constant, as training given for household increases by one unit, the probability of adopting soil conservation practice also increases by a factor of 5.073. The study result conducted by (Dessie et al., 2013; Bruyn, 2017; Pannel et al., 2006) strongly agreed that getting different training improve farmers practicing of soil conservation practices that agrees with this study.

Credit Service (creser). Taking part in getting credit service was expected to have positive rela-

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tionships with soil conservation practice. As an independent variable, it was statistically significantly positively related to soil conservation practice at a 5% probability level (B=1.046, P-value=0.019) that was consistent with prior expectations. This is because farmers taking part in getting credit service contribute some part of it for soil conservation practicing. The odd ratio of this independent variable implied that the farmer household who had access to credit service adopts soil conservation practice by a factor of 2.847 than those who had no access to credit. The result of study by (Pande et al., 2011; Abebe and Sewnet, 2014; Muhamud and Joyfred, 2015) agrees with this study out which they agreed accessing credit services of households plays great role in soil conservation practices.

Contributions of SWC measures for landscape restoration in the area

In the study area, even though its practice adoption is not equal among the households, after such SWC practices visible changes and contributions are enhanced. Figure15 shows perception for the contribution of SWC practices in the study area. From the total households, 144 (95.3%) suggested that it increase water volume in their locality. The other, 141 (93.3%) of them revealed it contributes for saving their fertilizer. The more the practice done the more the erosion is reduced from their farmland and fertilizer is not wa-shed away or reduced to be eroded from soil. Additionally, 123 (81.4%), 121 (80.1%) and 120 (79.4%) of the respondents agreed it uses them to regulate temperature, increase vegetation cover and improve soil fertility enhancement respectively. This means, as huge number trees will be planted, huge amount of Oxygen will be released to atmosphere and forest will be dense more. When households follow kraaling (change barn with cattle in their farmland) it increases soil fertility. On the other hand, 119 (78.8%), 111 (73.5%) and 109 (72.5%) of them confirmed SWC practices use them as generating income, fodder for their cattle and reduce soil erosion respectively. Here, when grass such as vetiver grass is planted in their land, it roots serves as braking force of run-off and regulates erosion. They also harvest it and sell to the market to get income as well as make it for their cattle food. Lastly, 98 (64.9%) and 77 (50.9%) of them assu-red SWC practices reduce water pollution and increa-se soil moisture. For instance, practices such as terra-cing, soil and stone bunds and planting trees reduce force of erosion agents that cost them to buy fertilizer during farming and reduce water pollution. Practices such as mulching or covering land with crop residues also increase the soil moisture retention.

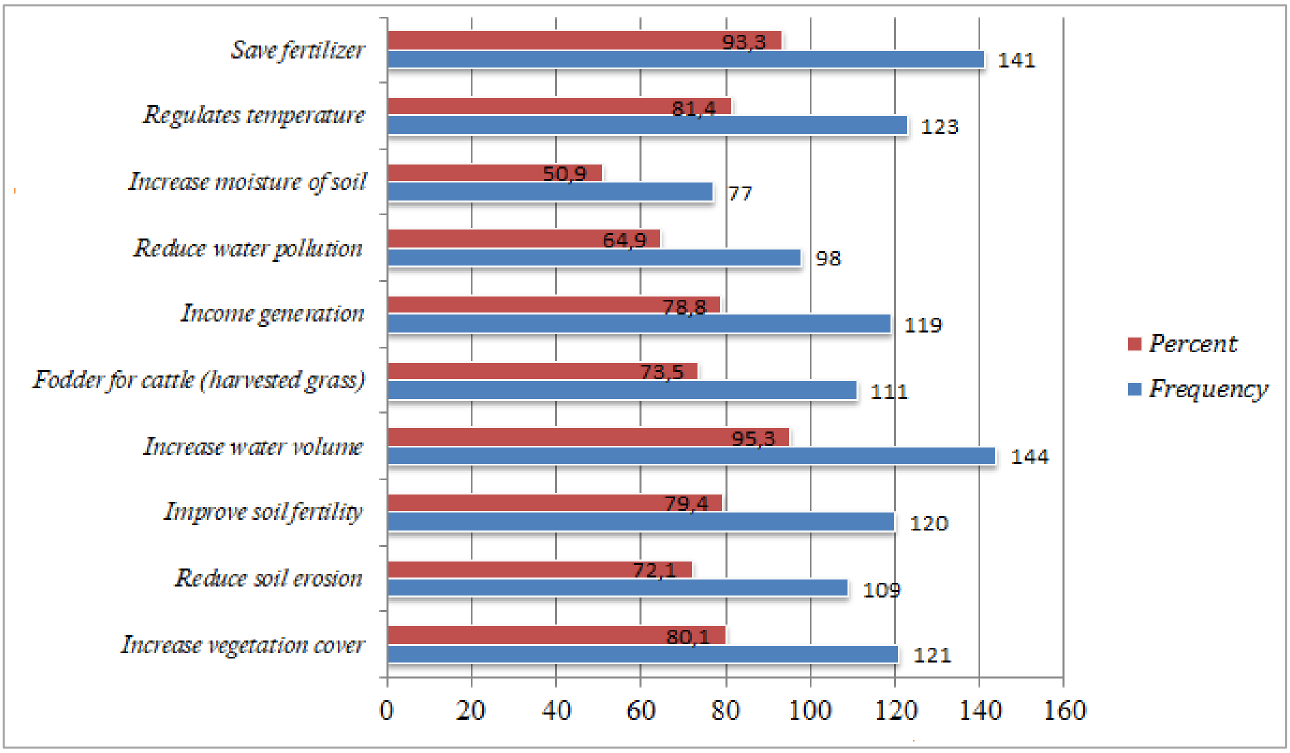

Figure15..*Households perceived contribution of SWC practices in the study area*

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tionships with soil conservation practice. As an independent variable, it was statistically significantly positively related to soil conservation practice at a 5% probability level (B=1.046, P-value=0.019) that was consistent with prior expectations. This is because farmers taking part in getting credit service contribute. Based on Key informants' idea, soil and water conservation is essential to environmental sustainability. It helps protect natural resources and watersheds, restores habitats for plants and wildlife, improves water quality, and makes soil healthier which in turn affects livelihood of the farm households certainly. In addition, soil conservation also creates economic opportunity, control the loss of nutrients from agricultural land, prevent pollution of water bodies, decrease rates of sedimentation in reservoirs, rivers, canals and ditches and to limit crop damage by wind-blown deposits or burial beneath water. This in turn contributes positively to the livelihood of the farmers in the study area. In agreement with this result, Meresa et al. (2023) found that SWC measures have been contributing in the process of controlling soil erosion and increasing soil fertility, moisture, crop yield, income and better livelihood status of the smallholder farmers. Information obtained from focus group discussants clearly indicated that soil-water conservation measures played a noteworthy role in retaining and/ or restoring soil fertility, regulating temperature, upturn soil moisture, upholding agricultural production, reducing soil erosion, restoring vegetation cover and mitigating anthropogenic land degradation in the study area. In this regard, the discussants suggested that local governments and other stakeholders should work cooperatively to strengthen and sustain the implementation process of soil-water conservation measures in the area.

Conclusions and recommendation

For humans to survive, soil is the most essential resource. However, one major agricultural and environmental issue that modern humans face is soil degradation. Because soil erosion reduces the potential to increase agricultural productivity and output, it poses a threat to food security. Due to its effects on the agricultural sector across Ethiopia, particularly in the Bure district, soil erosion poses a threat to the country's economic development. Therefore, the goal of the study was to evaluate the degree of soil erosion and use appropriate conservation techniques in the studied region. The survey's findings showed that the region had a variety of adopted and native soil-water conservation techniques. Among these, fallowing, manuring, mulching, contour plowing, crop rotation, traditional waterways are indigenous practices, whereas terracing, soil and stone bund, fanjuu, vetiver and elephant grass are the adopted soil-water conservation practices. The result of binary logistic regression indicated that sex, age, family size, educational status, distance of farmland from residence, participation in the training significantly (P<0.05) affects the decision of households' adoption of soil-water conservation practices in the area. It was found that soil-water conservation measures played a noteworthy role in retaining and/or restoring soil fertility, regulating temperature, upturn soil moisture, upholding agricultural production, reducing soil erosion, restoring vegetation cover and mitigating anthropogenic land degradation in the study area. Conclusively, in order to preserve their land and promote a sustainable environment, local governments and other stakeholders should collaborate to strengthen and maintain the process of implementing soil-water conservation measures in the area.

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