International Journal of Environmental Monitoring and Analysis
2025, Vol. 13, No. 3, pp. 103-113
https://doi.org/10.11648/j.ijema.20251303.14

Research Article

Socio-economic and Biophysical Resource Characterization in Gur Watershed, Girar Jarso District, North Shewa Zone, Oromia

Endale Bedada Begna*, Woubalem Abera Ayansa

Oromia Agricultural Research Institute, Fitche Agricultural Research Center, Fitche, Ethiopia

Abstract

Socio-economic and biophysical resource characterization builds necessary foundation for the plan and obtains proper information for elective planning, implementation and monitoring of the research in the field of natural resources. The objective of the study was to identify and characterize existing socio-economic and biophysical resources and document baseline information on socio-economic and biophysical aspects used as benchmark for planning and impact monitoring in the watershed. The site was selected depending on agro-ecological representation, prevalence of resource management and land degradation problems. The data were collected through field observations, HH survey, FGD and KII's and the collected data were analyzed using SPSS software. Results of study indicated that, decline of soil fertility, soil erosion, and shortage of agricultural inputs are the major crop production constraints in the watershed. According to the results, the farmers majorly implemented physical SWC measures such as stone bund, stone faced soil bund, water ways. About 97.7%, of the sample farmers in the Gur watershed were participating in construction of SWC measures by their own interest respectively. Analysis of the result shows that the major constraints in practicing of physical SWC structures were serves as breed and hiding places of rodents, it requires large number of labors and lack of training to construct. According to the field measurement data of implemented stone bund in most sample sites of the study watershed failed to meet the standards. Based on the above findings, enhancing the farmers' awareness on the importance of SWC structures and based on their agro-ecologies promotion different introduced physical, biological and agronomic SWC measures were recommended.

Keywords

Baseline, Constraints, Intervention, Households

1. Introduction

In Ethiopia, Agriculture is the mainstay of the economy, which contributes for 15% of the total GDP, 10% of export revenues, 70% of employment and 70% of raw material requirements of agro-based domestic industries and also a major source of the national food supplies [1, 2]. Especially, population who live in rural areas are highly dependent on natural resources base for economic their development, food security and other basic necessities [3]. So as to ensure agricultural development at the desired rate and on a sustainable basis, sustainable management of natural resources particularly soil,

*Corresponding author: endenat2008@gmail.com (Endale Bedada Begna)

Received: 22 May 2025; **Accepted:** 11 June 2025; **Published:** 30 June 2025

Copyright: © The Author(s), 2025. Published by Science Publishing Group. This is an **Open Access** article, distributed under the terms of the Creative Commons Attribution 4.0 License (http://creativecommons.org/licenses/by/4.0/), which permits unrestricted use, distribution and reproduction in any medium, provided the original work is properly cited.

water and forest resources, are crucial. However, the pressure of intensive human activities and improper farming and management practices pose serious threats to the sustainability of the natural resources and maintaining ecological balance. These impose great pressure on land resources, worsening environmental degradation and raising the risk of food shortages [4]. Understanding these, Ethiopian government has been promoted a watershed based natural resource development and management in the country as a suitable strategy for improving productivity and sustainable intensification of agriculture since 1980's.

Watershed development program has emerged as a new paradigm for sustainable rural livelihoods and it occupied the central stage of rural development in the fragile and semi-arid environments of the developing nations. Integrated watershed management research is expected to improve the interaction between the physical, social, technological, economic and policy dimensions; interdisciplinary approach to solve problems; and the full participation of all stakeholders during problem identification, planning, implementation, monitoring and evaluation. Management of natural resources at watershed scale produces multiple benefits in terms of increasing food production with minimum disturbance to the environment, improving livelihoods, protecting environment, addressing gender and equity issues along with biodiversity concerns. It encompasses the holistic approach to manage watershed resources that integrates forestry, agriculture, pasture and water management, which can be broadened to rural development with a strong link to the livelihoods of the local people [5]. At the earlier the concept of watershed management had a narrow focus primarily for controlling erosion, floods and maintaining sustainability of useable water yield. However, recently watershed management is not only for managing or conserving natural resources in a holistic manner, but also to involve local people for betterment of their lives. Its management is more people oriented and process based, than only physically target oriented [6]. Factors that contribute to the success of watershed management are multi-dimensional, including biophysical, institutional and socioeconomic elements. The presence of supporting institutional structures and the extent of community participation were also other factors found to significantly influence the 'success' of watershed management [7].

Socio-economic and biophysical resource characterization is important to measure project performance before making any changes to project processes. If we do not have baseline data then there is no way to evaluate whether a change is making a difference. It allows those involved in the project to understand the initial livelihood conditions of the people and what needs to be done to reach the goal of improving the livelihoods of the poor. Thus, baseline characterization builds necessary foundation for the plan and obtains proper information for elective planning, implementation and monitoring of the research and development endeavors particularly in the field of natural resources [8]. Therefore, proper resource characterization of watersheds is a prerequisite for appropriate policy directions for enhancing productivity and sustainable development.

Objectives of the study

1) To assess and characterize existing socioeconomic and biophysical resource in the watershed
2) To identify major constraints of crop production in the watershed
3) To document baseline information on socioeconomic & biophysical resource for planning and impact monitoring

2. Materials and Methods

2.1. Study Area Description

The study was undertaken at Gur watershed in Girar jarso district. The district is dominated by mountains associated with hills, valleys and gorges, including lowland areas found along river valleys. Its altitude ranges from about less than 1000m to over 3540m. About 20.7, 42.6 and 36.7% of the total area of the zone is covered by lowland, midland and highland agro-ecological zones respectively [9]. In North Shewa Zone, there are six major soil types namely vertisols, cambisols, rendzinas, haplic phaozems, pellic and arenosols [10].

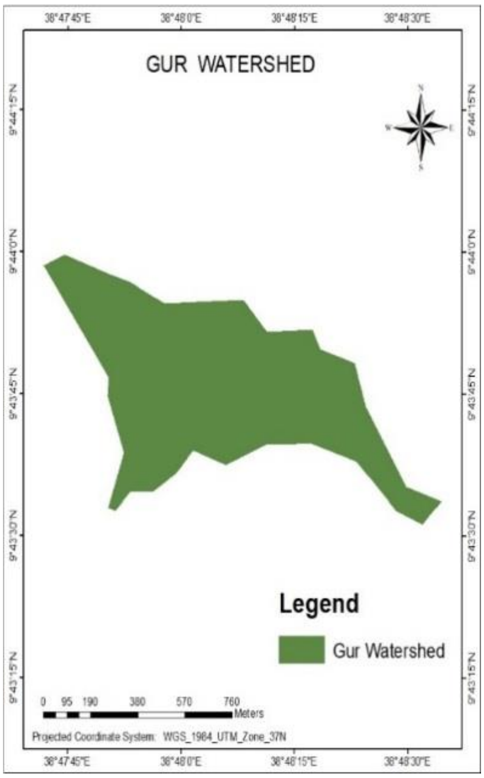

Figure 1. *Maps of the study watershed.*

2.2. Site Selection

The study watershed was purposively selected based on prevalence of resource management and land degradation problems, agro-ecological representation and road accessibility for this study. Based on the preliminary outlet identified during the site selection process, the watershed boundary was delineated using GPS readings.

2.3. Data Types and Sources

The study data was obtained from primary and secondary sources. The primary data was gathered through field observation, HH survey, FGD and KII. An intensive filed observation was carried out to get detailed information about biophysical and major terrain features such as topography, erosion status and SWC practices. The household survey was conducted to gather data about demographic and socio-economic characteristics, institutional services, biophysical characteristics, plot level characteristics, and various land management practices conducted by farmers in the watershed. Secondary data was collected from regional, zonal and district level of agricultural and information and communication offices.

2.4. Sampling Techniques and Sampling Size

As the sampling techniques, both probability and nonprobability sampling techniques were used for the study. Probability sampling technique was used for HH survey and nonprobability sampling technique was used for FGD and KII. Sample household farmers from the watershed was selected by using simple random sampling technique with some stratification based on watershed position considering upper, middle and lower position of the watershed. The number of respondent's sample size was determined using the formula developed by [11] sample size determination technique.

$$n = N/1 + N(e)^2$$

Where: n= number of sample size;

N= is population size;

e= is the level of precision (5%, 7% and 10%).

Accordingly, for the study, about 44 households were selected from the watershed. Three key informants were selected purposely from the district agricultural experts, agricultural extension workers and watershed user cooperatives administrators. Eight knowledgeable participants were purposely selected for focus group discussion.

2.5. Data Analyses

The collected data from both primary and secondary sources were analyzed using SPSS software version 20. The structured household survey data were analyzed and interpreted with appropriate statistical tools. Among the statistical tool's descriptive statistics, frequency, percentage, and graphs were used.

3. Results and Discussion

3.1. Demographic and Socio-economic Characteristics of the Respondents

Demographic and socio-economic characteristic information is a guide to and starting point for research about basic information on the areas of investigation.

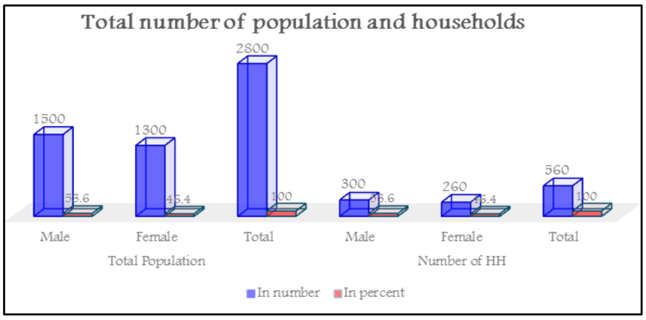

Figure 2. *Total number of populations and households in the watershed.*

Total population and households: According to districts agriculture office, the total number of populations in Gur watershed is estimated to be 2800 and the result of the study shows that out of the total population, the percent of males in the watershed was higher than that of females (Figure 2).

The total number of household heads in Gur watershed are estimated to be 560. The result revealed that out of the total number of household heads, the percent of male household heads in the watershed was higher than that of female household heads (Figure 2).

Table 1. *Age class, marital status and educational levels of HH of respondents (n = 44).*

Characters of HH heads	Categories of characters	Frequency
Gender	Male	39(88.6%)
	Female	5(11.4%)
	Total	44(100%)
Age	Min	24
	Max	72
	Mean	44.3
	20-60	41(93.2%)

Characters of HH heads	Categories of characters	Frequency
	>60	3(6.8%)
	Total	44(100%)
Marital status	Married	41(93.2%)
	Widowed	3(6.8%)
	Total	44(100%)
Education level	Uneducated	29(65.9%)
	Elementary	14(31.8%)
	Secondary	1(2.3%)
	Total	44(100%)
HH family size	Min	2
	Max	10
	Mean	5.6
HH Land holdings (ha)	Min	0.4
	Max	6
	Mean	2.2
	<1	7(15.91%)
	1-2	13(29.55%)
	2-3	12(27.27%)
	3-4	7(15.91%)
	>4	5(11.36%)
	Total	44(100%)

Source: Household Survey, 2024

Gender of the household heads: The result of the study (Table 1) indicated that in Gur watershed out of the total sample respondents, 39 (88.6%) of them were male while the rest 5 (11.4%) of them were female. The result revealed that the percent of male headed households of participated in watershed was higher than that of female headed households in the watershed (Table 1).

Age of the household head: Age is one of the important characteristics of the community which plays a significant role in any kind of employment pattern, mobility and quality of work done, particularly in agriculture. The results of the study (Table 1) indicate that the age distributions of most of respondents (93.2%) in the watershed were in the age category from 20-60 years group and 6.8% were in the age category of above 60 years. More than half of the respondents from the watershed are in the middle age group and the proportion of middle age group household heads is higher in the watershed (Table 1). This indicates that the sample households are characterized by a high proportion of productive age group (20-60 years) and a low number of old-age persons (> 60 years). The middle age group had strong relationship with the construction and maintaining of SWC activities than old one. The mean age of sampled households is 44.3 in the watershed.

Marital statuses: With regard to marital status, the result of household survey in the Table 1 indicated that, from the total sample respondents of the watershed, about 93.2% married, and 6.8% widowed. The proportion of married respondents was much larger than the others in all watersheds.

Educational level: The level of education affects the planning and managerial abilities of the farmer in decision-making. The results (Table 1) indicated that, from the sampled household heads of the watershed, about 65.9% of respondents had no formal education, 31.8% were educated to elementary school and only 2.3% of household heads were having been reached secondary school. From the total sample of the respondents, only a few respondents have completed their secondary school. These indicate that, adoption of new technologies, the planning and managerial capacity of most farmers might be affected by their weak decision-making abilities due to lack of education. [12] indicate that, better education level of the household heads has strong and positive relationship with their adoption of new technologies because of their ability to find new information and their understanding of new technologies.

Family size: According to the survey results, the family size of the sample farmers of the watershed ranged from 2 to 10 persons and the average family size of sample households was 5.6 persons. In the watershed about 59.4% of the households had a family size above the average and the remaining 40.7% had household sizes less than the average. Therefore, the study populations of the watershed were relatively higher household sizes than national household average size of 5.1 members per household [13]. The study conducted by [14, 15] stated that, large family size was necessary to provide the labor requirement for the construction and maintenance of SWC practices.

Land holding: In the context of watershed, land ownership determines the participation of the community in watershed development activities to conserve, manage and use of natural resources. The result of survey (Table 1) indicated that, from the sample farmers of Gur watershed about 15.91% of the respondents had landholdings below 1 ha and 29.55% had between 1 and 2 ha. According to the survey data, in the watershed, the household heads had a range from 0.4 to 6 ha and the average land of the sampled household heads was 2.2 ha. Land shortage is cited among the priority problems faced by farmers, especially for those young household heads. [16] reported that practice of conservation measures is positively related to landholding size.

3.2. Major Crops Grown in the Watershed and Production Constraints

Information on crop production and yield of all major crops grown in the production system required to examine spatial and temporal changes in area under different crops and possible crop substitution.

According to the data from the household survey (Table 2), interview, and group discussion, the majority of the farmers in the study watershed is dependent on agriculture and homestead livestock production. In the watershed, farmers are mainly dependent on teff, and wheat production from cereal crops and vetch, faba bean, and chickpea production from pulse crops.

Table 2. *Major crops grown in the watershed.*

Crop type	Frequency	Productivity (qt/ha)
Teff	30(68.2%)	8
Wheat	24(54.5%)	10
Vetch	21(47.7%)	9
Faba bean	17(38.6%)	7
Chickpea	8(18.2%)	8

Source: Household Survey, 2024.

Table 3. *Major crop production constraints in the watershed.*

Major Constraints	Frequency	RBQ	Rank
Soil erosion	31(70.5%)	39.1	4
Soil fertility	32(72.7%)	58.2	1
Land shortage	25(56.8%)	56.3	2
Deforestation	20(45.5%)	11.3	8
Climate change	23(52.3%)	30.5	6
Agricultural inputs	32(72.7%)	21.9	7
Crop disease	33(75%)	55.1	3
Crop productivity	24(54.5%)	30.5	5

Abbreviation: RBQ= Rank Based Quotient.
Household Survey, 2024.

Rank Based Quotient was calculated using formula developed by [17]. The RBQ values obtained from respondents along with their preferential ranking against each constraint of the study. Analysis of the result of Rank Based Quotient (Table 3) showed that in Gur watershed about 58.2% of the sampled households have encountered decline of soil fertility problems followed by land shortage problem (56.3%) in the watershed.

3.3. Sources of Income and Information and Extension Services in the Watershed

Source of income for farmers: The result of survey (Table 4) shows that in the watershed selling of crop production alone (27.8%) followed by selling of both crop production with livestock production (25%) and off-farm activities (18.2%) were the major income sources of the farmers. Most of farmers in the watershed were rearing different types of animals for different economic or social interests. The response of farmers in the watershed showed that most of the sample households generate their annual income mainly from selling of milk. The farmers also use the production of a given crop to meet various needs (for domestic consumption, source of income and seed), depending on crop type and the product of crops. Survey result (Table 4) indicated that some farmers in the watershed were engaged in off-farm activities including daily laborer, hand craft, petty trade, sales of alcohol (areke) and remittance as a supplementary source of income.

Table 4. *Sources of income in the watershed.*

Source of income	Frequency
Crop production	12(27.8%)
Livestock production	7(15.9%)
Off farm activities	4(9.1%)
Crop & Livestock production	11(25.0%)
Crop production & Off farm activities	8(18.2%)
Livestock production & Off farm activities	2(4%)
Total	44(100%)

Source: Household Survey, 2024.

Sources information for farmers: Information sources used to disseminate agricultural research findings to farmers for on farm activities include researchers, extension officers, knowledgeable farmers, research institutions; mass media, commercial and government agencies. The information obtained can help farmers identify efficiencies that lead to higher productivity and profitability, lower input costs, and optimized fertilizer use. According to the survey result (Figure 3), most farmers have got the new technology information through DA (87.5%), followed by farmer to farmers (53.1%) and media (50.0%) in the watershed. Previous studies [18, 19] suggest that agricultural extension agents' communication skills are a strategic asset for enhancing the adaptive capacity of farmers.

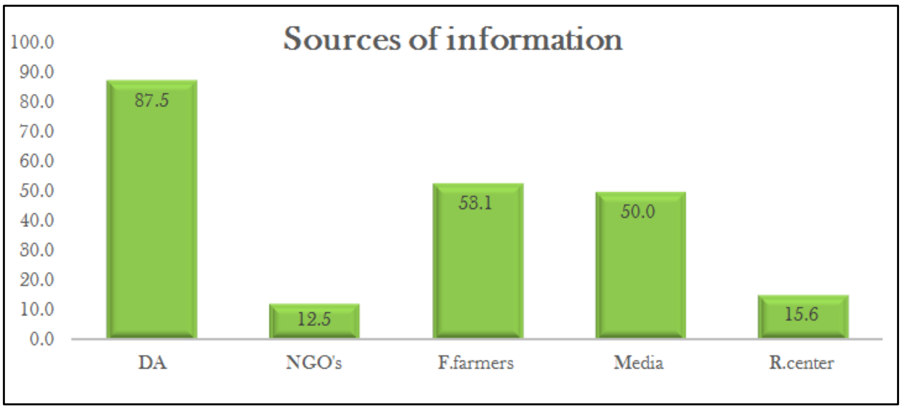

Figure 3. *Sources of information in the watershed.*

Extension Services for farmers: Agricultural extension services have been shown to build farmers' agricultural knowledge and skills, disseminate new technology and change farmers' attitudes [20] as well as promote community development through human and social capital development, facilitate access to markets and work with farmers towards sustainable natural resource management [21]. Moreover, it represents local farmers' frequency of contact with DAs and frequency of participation in extension planning, training, field day, and demonstration regarding agriculture and livestock production. Thus, extension service has a positive impact on enhancing natural resource management.

Table 5. *Extension services in the watershed.*

Do you get extension service?	Frequency	
	In (#)	In (%)
Yes	37	84.1
No	7	15.9

Source: Household Survey, 2024

The household survey result (Table 5), shows that, about 84.1% of the respondents in the watershed have got extension service on natural resource management. The result indicated that, most of farmers in watershed have got better extension service on natural resource management in the watershed.

3.4. Biophysical Resource in Watershed

3.4.1. Vegetations Coverage in the Watershed

Vegetation coverage has great contribution in interception rainfall, keeping sediment loss and manages soil fertility. As the responses of sampled farmers, the major tree species found in the watershed were Eucalyptus globulus, Acacia lahai, Ficus sur, Dodonaea angustifolia, Carissa edulis, and Maytenus senegalensis. The response of key informants shows that, most of the tree species in the watershed were extinct from the watershed. Deforestation and agricultural land expansion were the major cause of extinction of the tree species in the watershed. The elders said that with time and coming up of new generation they were forced to distribute part of forested land as part of land inheritance. This resulted to further clearing of hilltops, ridge summits and slope lands. Reduction of vegetation cover due to farming and grazing activities has led to increase in soil erosion and reduction of soil fertility [22], which has impacted negatively on crop and livestock production, and the livelihood strategies [23]. According to [24], assessment reported show that globally around 13 million hectares of forest were converted to other uses or loss through natural as well as anthropogenic activities that cause reeducation in forest area coverage and indigenous species.

3.4.2. Slope Characteristics of the Watershed

The local slope gradient (S) influences flow velocity and the rate of erosion. Increase in slope steepness and slope length will increase erosion as a result of respective increases in velocity and volume of surface runoff [25]. The effects of topography on land degradation depends on the effects of slope steepens and slope length.

Slope gradient of the study watershed are classified into six classes. According to the result of the study, most of the lands (87.3% of the watershed) in the watershed were categorized under sloping (35%), gently sloping (32.6%), and moderately steep (22.7%) slope category (Table 6). This indicate that more of the watershed landscape might be exposed to extreme flooding at time of high rain fall occurrences which implies that the need of soil and water conservation structures for sound natural resources conservation in the watershed. This is in line with the findings of [26] stating that the soil erosion increased exponentially with increasing slope gradient.

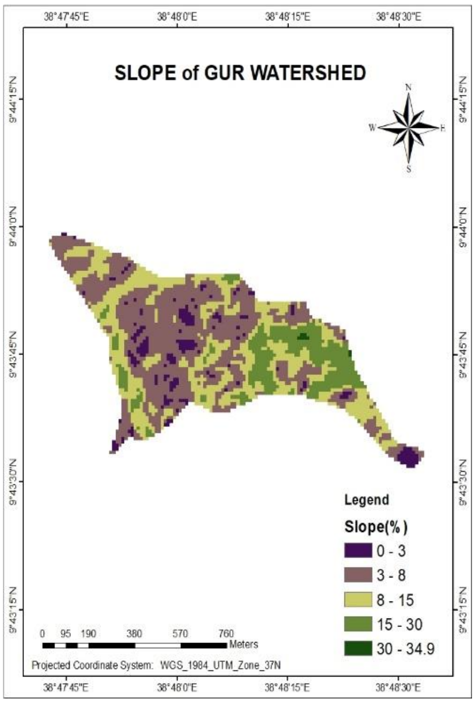

Figure 4. *Slope maps of the watershed.*

Table 6. *Area coverage of each slope classes in the watersheds.*

Slope Class	Area (ha)	Area (%)
Flat or almost flat (0-3%)	37.3	7.4
Gently sloping (3-8%)	164.5	32.6
Sloping (8-15%)	176.6	35
Moderately steep (15-30%)	114.5	22.7
Steep (30-50%)	11.7	2.3
Total	504.6	100

Reference: MoARD, 2005

3.5. Major Soil and Water Conservation Measures Implemented in the Watershed

In the watershed, different SWC structures were implemented. The result of survey (Table 7) shows that, in the watershed the most physical SWC measures practiced by farmers were water ways, cut-off drains, stone bund, and stone-faced soil bund. Physical conservation structures such as stone bund, stone faced soil bund, and soil bunds, modify terrain through changing slope length and angle, which in turn reduce runoff velocity, enhance water infiltration and trap sediments washed down the terrain [27, 28]. The major agronomic and biological SWC measures implemented by farmers in the watershed were contour plowing, plantation of trees and agro-forestry practices. Others such as stone check dam, and brush wood were implemented for gully control in the watershed.

Table 7. *Types of SWC measures implemented in the watershed.*

Types of conservation measures		Frequency	
		In (#)	In (%)
Physical SWC measures	Terracing	4	12.5
	Soil bunds	17	53.1
	Stone bunds	28	87.5
	Stone faced soil bunds	26	81.3
	Cutoff drain	29	90.6
	Water way	30	93.8
Gully control	Stone check dam	6	18.8
	Brush wood	5	15.6
Agronomic and Biological SWC measures	Contour plowing	14	43.8
	Tree planting	3	9.4

Source: Household Survey, 2024.

3.6. Community Participation in Soil and Water Conservation Practices

The community participation in soil and water conservation is mostly dependent on their perception of the soil erosion problems and the significance of the conservation technologies [29].

Table 8. *Community participation in SWC works in the watershed.*

Do you participate in any SWC works?	Frequency	
	In (#)	In (%)
Yes	43	97.7
No	1	2.3

Source: Household Survey, 2024.

According to the household survey (Table 8), the level of farmers' participation in SWC practices varies in the watershed. About 97.7% of the sample farmers in the Gur watershed are participating in the construction of soil and water conservation measures by their own interest respectively, but they participated in only decide the date and days of conservation work, give labor force as well as provide construction materials. The reports by [30, 31] as well as [32] showed that the national guideline for SWC recommends full community participation from problem identification to the maintenance of the SWC structures. According to KII and FGD participants, the higher community participation in Gur watershed were related to the land degradation (soil erosion) problem is more serious and better information among farmers for SWC work. The land in the watershed were highly exposed the soil to erosion, because of undulated topography and steep slopes. The loss of soil caused the reduction of agricultural products that adversely increased the interest of the farmers to participate in the SWC work.

3.7. Maintenance of Implemented Soil and Water Conservation Structures

According to the survey result (Table 9), about 84.1% of Gur watershed respondents maintained the implemented conservation structures. The result indicated that, the farmers in the watershed had better awareness about the conservation activities and other related issues.

Table 9. Maintenance of SWC structures in the watershed.

Are you maintain SWC measures	Frequency	
	In (#)	In (%)
Yes	37	84.1
No	7	15.9

Source: Household Survey, 2024.

3.8. Major Constraints in Practicing of Physical Swc Structures in the Watershed

Analysis of the result (Table 10) shows that about 83.1% of the households have encountered SWC structures serve as breed and hiding places of rodents followed by the construction of SWC structures require large number of labors in the watershed. Training on soil and water conservation technologies is one of the important factors that influence the involvement of farmers in natural resource conservation.

Table 10. Major constraints of physical SWC structures.

Watershed	Major constraints	Frequency	RBQ	Rank
Gur watershed	Require large labor	26	77.5	2
	Difficult to plough and turn the oxen	21	65.6	4
	Lack of construction material	22	56.9	5
	Breed and hiding places of rodents	30	83.1	1
	Lack of training	22	66.9	3

Source: Household Survey, 2024.

3.9. Technical Standard of Implemented Conservation Structures in the Watershed

According to the data from the household survey, FGD and KII the farmers perceived that SWC structures are effective measures to control soil erosion and improving land productivity. In the study watershed, the most widely used physical conservation measures were water ways cut-off drains, stone bund, and stone-faced soil bund (Table 7). However, according to the field measurement data of implemented physical SWC structures in most sample sites of the study watershed failed to meet the standards. During field measurement, we didn't consider technical standard of cut off drain and water ways against the standard. Because, cut-off drain and water ways in the watershed were constructed traditionally and used for temporary at the rainy season. We consider technical standard of stone-bund against its standard. The measured parameters for stone bund from the field measurement were compared with the recommended standards of design of the embankments (height, bottom width, and top width), length of bunds, vertical interval and spacing between consecutive bunds based on the slope and the soil depth as given by [30, 32].

In the watershed, the soil depth at three parts of the watershed range from 0.45m to 1.20m and with an average soil depth of 0.75m. The slope steepness of the farm plots in the upper, middle and lower parts of the watershed was varied between 8% to 12%, 18% to 24% and 16% to 22% with the average slope of 10%, 21.3% and 18.7% (Table 11).

Table 11. *Technical result of stone bund conservation structures in Gur watershed.*

Watershed position	Parameters	Implemented			Recommended			Deviation		
		Site 1	Site 2	Site 3	Site 1	Site 2	Site 3	Site 1	Site 2	Site 3
Upper	Slope in (%)	8	10	12	5-10	10-15	10-15			
	Eh (cm)	45	50	50	70-100	70-100	70-100	-25	-20	-20
	Ebw (cm)	55	50	60	75	75	75	-20	-25	-25
	Etw (cm)	50	50	60	30-40	30-40	30-40	10	10	20
	Length (m)	85	90	75	60-80	60-80	60-80	5	10	0
	VI (m)	1	1.4	1.6	1	2.2	2.2	0	-0.8	-0.6
	Spacing (m)	30	28	25	20	12	12	10	16	13
Middle	Slope in (%)	22	18	24	20-25	15-20	20-25			
	Eh (cm)	55	50	60	70-100	70-100	70-100	-15	-20	-10
	Ebw (cm)	60	50	70	75	75	75	-15	-25	-5
	Etw (cm)	60	45	60	30-40	30-40	30-40	20	20	20
	Length (m)	60	70	45	60-80	60-80	60-80	0	0	-15
	VI (m)	1.6	1.5	2	2.5	2.2	2.5	-0.9	-0.7	-0.9
	Spacing (m)	24	26	15	8	12	8	16	14	7
Lower	Slope in (%)	16	22	18	15-20	20-25	15-20			
	Eh (cm)	55	50	60	70-100	70-100	70-100	-15	-20	-10
	Ebw (cm)	50	65	60	75	75	75	-25	-10	-15
	Etw (cm)	50	50	55	30-40	30-40	30-40	10	10	-15
	Length (m)	75	70	65	60-80	60-80	60-80	0	0	5
	VI (m)	1.6	2	2.2	2.2	2.5	2.2	-0.6	-0.2	0
	Spacing (m)	20	8	12	12	8	12	8	0	2

Abbreviations: Eh=embankment height, Ebw=embankment bottom width, Etw= embankment top width, VI= vertical interval.

According to the result (Table 11), at the upper part of the watershed, about 88.8% (44.4% below and 44.4% above) of the implemented stone-bund parameters were fails to meet the standard and at the middle part of the watershed, about 88.9% (55.6% below and 33.3% above the standard) of the implemented stone bund parameters were fails to meet the standard. About 77.8% (50% below and 27.8% above the standard) of the implemented stone bund parameters at lower stream were also fails to meet the standard. This implies that the farmlands are susceptible to be damaged by soil erosion problems due to their improper design.

4. Conclusion

The data collected from field measurement, field observation, interview, and group discussion revealed that the farmers implemented physical soil and water conservation measures such as stone bund, stone faced soil bund, soil bund, terracing, water ways and cutoff drain and contour ploughing and plantation of trees at different sites were implemented from agronomic and biological conservation measures. Among the implemented conservation measures, stone bund, stone faced soil bund, water ways and cutoff drain were the mostly implemented SWC structures in the watershed. Most of the sample farmers in the watershed were participating in construction of SWC by their own interest, but they participated in only decide the date and days of conservation work, give labor force as well as provide construction materials and the major constraints in practicing of physical SWC structures were, it serves as breed and hiding places of rodents, it requires large number of labors and lack of training to construct. Based on the national SWC guideline for different agro ecologies, physical features, and climatic conditions, the physical design of the implemented SWC technologies in the sampled site failed to meet standard dimension/design.

5. Recommendation

Based on the above findings the following recommendations can be drawn for further consideration and improvement in the study watersheds;

Soil fertility management:

1) Classification and characterization of soil properties of the study watershed.
2) Providing awareness creation training for farmers, woreda's experts and DA's on preparation of organic fertilizers.
3) Introducing of organic fertilizers preparation and application system to increase integrated use of organic and inorganic fertilizers use.
4) Promotion verm-compost technologies to enhance soil fertility.

Soil and water conservation:

1) Enhancing the farmers' awareness on the importance of SWC structures since most farmers belief that implementation of structure is minimizing their land area for cultivation, serve as breed and hiding places of rodents and due to SWC structures difficult to plough and to turn oxen during ploughing.
2) Well organized training should be given for farmers to fill the technical gap on their skills.
3) Based on their agro-ecologies promotion different introduced agronomic and physical soil and water conservation measures.
4) Field level conservation work should be done to use the local knowledge and positive motive of the community in a way to avoid the existing constraints of SWC work against the standard.
5) Promotion of integrated conservation agriculture and low-cost gully and degraded land rehabilitation.

Agroforestry and plantation forestry:

1) Awareness creation on effects of deforestation and forest degradation on climate change.
2) Introduction of agro-forestry practices and multipurpose trees in the watershed.
3) Integration of multipurpose trees with physical soil and water conservation measures in the watersheds.
4) Crop production:
5) Introduction and demonstration of improved and high yielding crop varieties that are resistant or tolerant to the already existing and emerging disease to increase production and productivity of crops.
6) Introduction and demonstration of climate-smart agricultural technologies in all crops

Abbreviations

DAs	Development Agents
Ebw	Embankment Bottom Width
Eh	Embankment Height
Etw	Embankment Top Width
FGD	Focus Group Discussion
GDP	Gross Domestic Product
GPS	Geographical Positioning System
ha	Hectare
HH	Household
In (#)	In Number
In (%)	In Percent
KII	Key Informant Interview
m	Meter
qt	Quintal
RBQ	Rank Based Quotient
SPSS	Statistical Package for Social Science
SWC	Soil and Water Conservation
VI	Vertical Interval

Acknowledgments

The authors gratefully acknowledged Oromia Agricultural Research Institute for providing financial fund for this research activity. And also, we extend our acknowledgement for all staff members of Fitche agricultural research center who directly or indirectly helped in data collection and other research activities.

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] FAO. (2016). Trade Reforms and Food security: Conceptualizing the linkages. World Health Organization- on line http://www.who.int/trade/glossary/story028/en/

[2] MOA (Ethiopia Ministry of Agriculture), 2010. "Animal and Plant Health Regulatory Directorate." Crop Variety Register 13.

[3] Danyo, S., Abate, A., Bekhechi, M., Köhlin, G., Medhin, H., Mekonnen, A., & Wikman, A. (2017). Realizing Ethiopia's green transformation: Country environmental analysis, environment and natural resources global practice. Washington, DC: World Bank.

[4] IFAD., (2016). Federal Democratic Republic of Ethiopia. Country strategic opportunities programme. Executive Board—119th Session. Rome.

[5] Rhoades R E and Elliot T S., 2000. Participatory watershed research and management: where the shadow falls". London: *International institute for Economic Development* (IIED).

[6] Abbaspour, K. C., Rouholahnejad, E., Vaghefi, S, Srinivasan, R., Yang, H., & Kløve, B. (2015). A continental-scale hydrology and water quality model for Europe: Calibration and uncertainty of a high-resolution large-scale SWAT model. *Journal of hydrology*, *524*, 733-752.

[7] Gebregziabher, G., Abera, D. A., Gebresamuel, G., Giordano, M., & Langan, S. (2016). *An assessment of integrated watershed management in Ethiopia* (Vol. 170). International Water Management Institute (IWMI).

[8] Brooks, K. N., F folliott, P. F., Gregerson, H. M., & DeBano, L. F. (2003). Hydrology and the Management of Watersheds. Third edition, Iowa State Press, Blackwell Publishing Company.

[9] Girar Jarso Woreda Agriculture and Rural Development Office. (2022). Annual Report on Natural resource Conservation of Girar Jarso woreda, Ethiopia.

[10] FAO, 2006. Guideline for soil description, 4th edition. Stylus Publishing, LLC, Rome.

[11] Yamane, T. (1973). Statistics: An introductory analysis.

[12] Fikru, A. (2009). Assessment of Adoption Behavior of Soil and Water Conservation Practices in the Koga Watershed, Highlands of Ethiopia. Unpublished Master Thesis, Cornell University, School of Graduate Studies, New York. (Country Not Stated).

[13] CSA (2007). Population and Housing Census of Ethiopia. Results for Oromia Region Vol.1.

[14] Chomba, G. N. (2004). Factors affecting smallholder farmers' adoption of soil and water conservation practices in Zambia. Michigan State University. *Department of Agricultural Economics.*

[15] Abera, B. (2003). Factors influencing the adoption of soil and water conservation practices. *North Western Ethiopia*.

[16] Wagayehu. B and Lars. D, (2003). Soil and water conservation decision of subsistence farmers in the Eastern highlands of Ethiopia: a case study of the Hunde Lafto. Addis Ababa, Ethiopia.

[17] Sabarathnam, V. E. (1988). Manuals of field experience training for ARS Scientists. *NAARM, Hyderabad*, *21*.

[18] Prokopy, L. S., Carlton, J. S., Arbuckle, J. G., Haigh, T., Lemos, M. C., Mase, A. S., Babin, N., Dunn, M., Andresen, J., Angel, J., Hart, C., Power, R. (2015). Extensions role in disseminating information about climate change to agricultural stakeholders in the United States. *Climate Change* 130(2), 261-272.

[19] Ali, M., Man, N., Abd Latif, I., Muharam, F. M., Omar, S. Z. (2018). The use of information and communication technologies in agricultural risk management by the agricultural extension services in Malaysia. *Int. J. Agric., Environ. Food Sci*. 2(1), 29-35.

[20] Khan, M., Nawab, K., Ullah, J., Khatam, A., Qasim, M., Ayub, G., Nawaz, N. (2012). Communication gap and training needs of Pakistan's agricultural extension agents in horticulture. Sarhad J. Agric. 28(1), 129-135.

[21] Bonye, S. Z., Alfred, K. B., Jasaw, G. S. (2012). Promoting community-based agricultural extension agents as an alternative approach to formal agricultural extension service delivery in Northern Ghana. *Asian J Agric Dev.* 2(1), 76-95.

[22] Muia, V. K., & Ndunda, E. (2013). Evaluating the impact of direct anthropogenic activities on land degradation in arid and semi-arid regions in Kenya. *Wudpecker Journal of Agricultural Research*, *2*(6), 173-182.

[23] Ifejika, S. C., Kiteme, B., Wisemann U. (2008) Droughts and famine, the underlying factors and causal links among agro-pastoral households in semi-arid Makueni District, Kenya. *Glob Environ Chang* 18: 220-233.

[24] FAO, 2010c. Global Forest Resources Assessment 2010 key findings, Rome. foris.fao.org/static/data/fra2010/keyfindings-en.pdf

[25] Dore, M. H. I., & Lamarche, J. F. (2005). *Dating climate change: evidence from time series data on precipitation*. Brock University mimeo.

[26] Jordan, G., van Rompaey, A., Szilassi, P., Csillag, G., Mannaerts, C., Woldai, T. (2005). Historical land use changes and their impact on sediment fluxes in the Balaton basin (Hungary). *Agric. Ecosyst. Environ*., 108, 119-133.

[27] Vancampenhout, K., Nyssen, J., Gebremichael, D., Deckers, J., Poesen, J., Haile, M., & Moeyersons, J. (2006). Stone bunds for soil conservation in the northern Ethiopian highlands: Impacts on soil fertility and crop yield. *Soil and Tillage Research*, *90*(1-2).

[28] Nyssen, J., Poesen, J., Gebremichael, D., Vancampenhout, K., D'aes, M., Yihdego, G., & Deckers, J. (2007). Interdisciplinary on-site evaluation of stone bunds to control soil erosion on cropland in Northern Ethiopia. *Soil and Tillage Research*, *94*(1), 151-163.

[29] Nigussie, Z., Tsunekawa, A., Haregeweyn, N., Adgo, E., Cochrane, L., Floquet, A., & Abele, S. (2018). Applying Ostrom's institutional analysis and development framework to soil and water conservation activities in north-western Ethiopia. *Land use policy*, *71*, 1-10. https://doi.org/10.1016/j.landusepol.2017.11.039

[30] Lakew Desta, V. C., Wendam-Ageňehu, A., & Abede, Y. (2005). Community based participatory watershed development: A guideline. *Development MoAaR (ed), Addis Ababa, Ethiopia*.

[31] Adgo, E., Teshome, A., & Mati, B. (2013). Impacts of long-term soil and water conservation on agricultural productivity: The case of Anjenie watershed, Ethiopia. Agricultural Water Management, 117, 55-61. https://doi.org/10.1016/j.agwat.2012.10.026

[32] MoARD. (2005). Community based participatory watershed development: A guideline. Ministry of Agriculture and Rural development.