EJED 2023 5(1):53–68

Ethiopian Journal of Environment and Development

http://www.du.edu.et/duj

EJED

Effects of Community Based Watershed Management on Rural Livelihoods: The Case of Lume Woreda, East Shewa Zone, Oromia, Ethiopia

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Received: 08th August 2023 *Accepted: 19th September 2023*

DOI: **10.20372/ejed.v05i1.04**

Abstract

In Ethiopia, natural resource degradation is worsening and posing significant risks, especially to the livelihoods of rural communities. Community-based watershed management is fundamental for managing natural resource degradation and minimizing its associated risks on the livelihoods of rural communities. The main objective of this study was to examine the effects of community-based micro watershed management on rural livelihoods. The study used descriptive survey research design to achieve the intended objectives and employed quantitative and qualitative data. The total sample size of 251 respondents was taken using a systematic random sampling technique from a study population of 2595 households inhabited in four selected Kebeles. A questionnaire, interviews, field observation, and document analysis were used to collect the data. Besides, statistical methods such as percentage of frequencies, mean, standard deviation, bar graphs, paired sample t-test, and chi-square test were used in data analysis. Results show that there was a statistically significant difference in crop productivity before and after interventions of community-based watershed management practices (p= 0.05). The findings also demonstrated that the livelihoods of the rural community were improved in terms of food availability, income, annual saving capability, and household affordability for medical care. Qualitative data results also proved that the trend of community-based micro watershed management adoption, different activities were consistently practiced by the community and demonstrated an improvement in area coverage for conservation structures. Consequently, the household heads gained knowledge and experience via the process, enabling them to have a favorable perspective on watershed management measures and their impacts. Contrarily, the result added that some challenges were observed in reducing the improvement of livelihoods, such as lack of management and maintenance of previously conserved micro watersheds, less protection of conserved watersheds from animal and human interference, inadequate follow-up, and low integration between sectors. It can be concluded that intervention in watershed management significantly improved the rural community's livelihoods. It is recommended that improvement in the practice of community-based watershed management is necessary. Therefore, the agriculture and natural resource management office of the woreda should mobilize and coordinate the community and other relevant resources. These actions are also vital for addressing the challenges observed in the watershed management activities.

Keywords/Phrases: Community based, Lume *Woreda*, Rural Livelihoods, Watershed

1 Introduction

Natural resources are the basis for the sustenance of the poorest people in many developing countries. The world's poorest people who live in rural areas depend on natural resources for their livelihoods (World Bank, 2018). The general economy and standard of living in developing nations like Ethiopia depend on the productivity of their land (Gezahegn *et al.*, 2018). However, the most productive topsoil layer is degraded by erosion and poor conservation practices, causing a reduction in agricultural production, which results in significant risks to rural communities.

According to Wang *et al.* (2016), the watershed management approach has emerged to deal with the complex challenges of natural resource management and alleviate associated problems. The development of watershed planning in Ethiopia started in the 1980s for implementing natural resources conservation and development programs. Since then, the majority of non-governmental groups and the government have centered their efforts on the watershed logic for rural development (Lakew *et al.*, 2005). Eyasu (2002) and Bekele (2003) reported that the approach at the time was top-down in implementation and mainly focused on engineering measures for reducing soil erosion.

However, the large watersheds' selection for implementation, which was difficult to manage, and the top-down planning approach, where a range of interventions remained limited, made the program less effective (MOAE, 2005). The approaches neglected post-rehabilitation management aspects and disregarded local knowledge, socioeconomic conditions, and available resources. Realizing these limitations, the government launched Community-Based Micro Watershed Management (CBMWM) in the early 2000s to accomplish integrated natural resource management and livelihood enhancement goals (MOAE, 2005). Following such interventions, the best practices from the programs for the Tigray and Oromia regions were partially studied and documented.

Literature sources indicate that one of the main causes of unstable livelihoods is the destruction of natural resources, which is exacerbated by rising population and climate change (WARDO, 2013). These factors mainly affect the rural communities whose livelihoods mainly depend on utilizing natural resources. The livelihood of rural communities depends primarily on agricultural production for food and to meet the economic demands of their families. Based on this, in recent years, intensive efforts have been made by the government of Ethiopia to implement CBMWM practices to improve the livelihoods of rural communities through conservation activities. However, the extent to which these resources are conserved, protected, and managed determines the levels of livelihood improvement of the rural community and, thereby, sustaining the program. The efficiency of conservation measures varies from place to place, as discussed in different literature. For instance, multiple positive effects like reduction in soil erosion and improvement in soil fertility, soil moisture, and crop yield were recorded due to the intervention of CBMWM in Gemechis *Woreda* of Oromia region (Dejene and Etefa, 2018). A study in central zones of southern Ethiopia indicated that integrated watershed management is a method of continuous restoration, growth, and efficient use of available natural resources in a watershed and a multidisciplinary approach to offset soil depletion (Mekonen and Fekadu 2015).

The research findings of Abebe (2015) showed that natural resource conservation has contributed to improving rural livelihoods in the Tigray region. The same study added that some of the contributions were alternative income generation through honey production and growing vegetables and crop production improvements. However, the benefits were not adequate due to free grazing and conflicts over communal lands. On the other hand, research conducted by Demesew *et al.* (2020) showed that the efficiency of conservation measures in the watershed over periods was assessed as being ineffective in the humid highlands of Ethiopia, while the implemented measures were effective in preventing soil erosion in the semiarid highlands of Tigray region.

Recently, other studies conducted in different parts of the country showed that Watershed Development achievements (WSD) were not effective. Likewise, the study in southwestern Ethiopia addressed that lack of effective community engagement, poor technology implementation, insufficient policy, lack of stakeholder participation, and lack of ownership strongly contribute to the failure of CBMWM practices (Meshesha & Birhanu 2015). In south-east zones of Ethiopia, it was reported that all the stone bunds in watershed management were lost due to lack of maintenance and overgrazing (Tiki *et al.*, 2016). Similarly, studies carried out by Gebremariam & Desalegn (2018) on farmers' perception of integrated watershed management at the Maego watershed in North Ethiopia and research by Meseret and Gashaw (2021) on trends of community-based interventions on sustainable watershed development in the Gumara watershed in the north Ethiopian highlands showed ineffective projects.

Hence, the community withdrew from conservation efforts, even on their farmlands, due to the deterioration of the quality and standards of installed measures by the campaign. From this point of view, it is difficult to expect the benefit of WSD activities in the long term (Meseret & Gashaw, 2021). These studies have shown that the level of livelihood improvement brought as a result of CBMWM differs from place to place; pointing out the need for many studies to be done in divergent research areas because each watershed has a unique set of issues. On the other hand, the effects of CBMWM have not been well evaluated and documented in the study area, though it has been widely implemented for years. Indeed, the rural community livelihood in the study area is still low despite the implementation of CBMWM. Hence, the objective of the study was to evaluate the effects of CBMWM practices on the livelihoods of rural communities and trends in implementing management practices in Lume Woreda in the East Shoa zone of Oromia regional state in Ethiopia.

2 Materials and Methods

2.1 Description of the Study Area

The study was conducted in Lume '*Woreda*', East Shoa Zone of Oromia Regional state, Ethiopia.

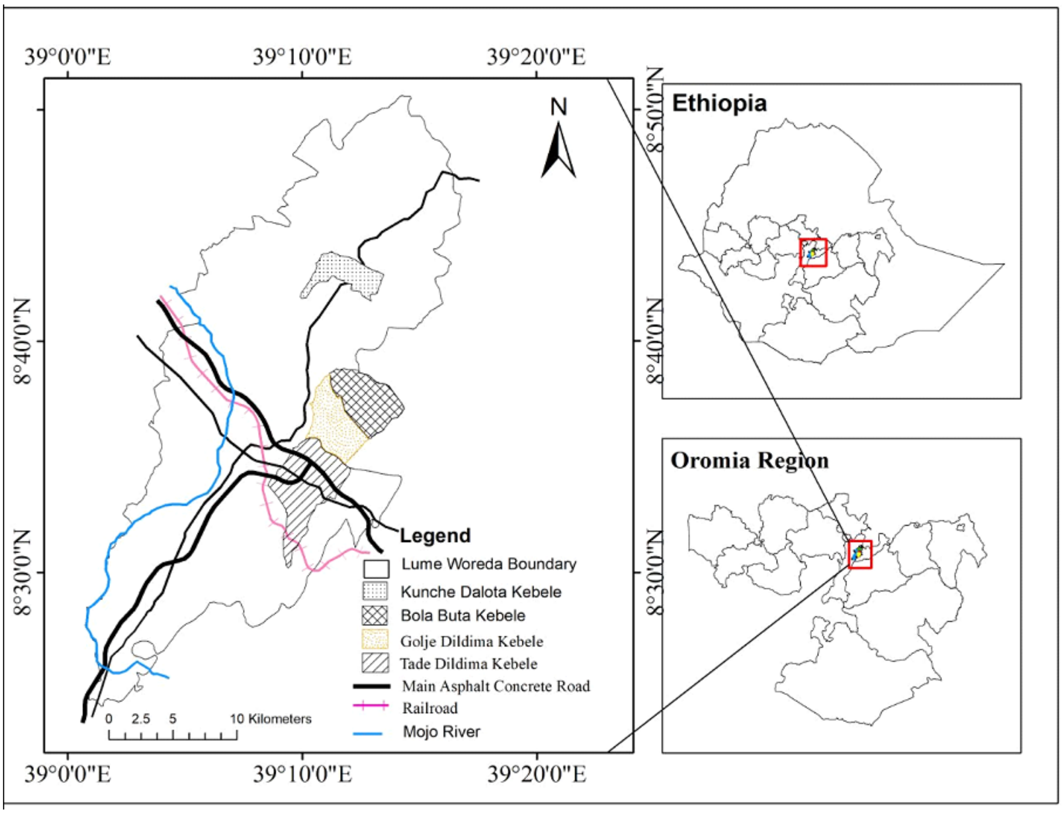

Figure 1. Location Map of Lume *Woreda* and survey area. (Source: developed using CSA (2007) and ArcGIS 10.8 version software)

Astronomically, the *Woreda* lies between 8^{o}22'30"N to 8^{o}50'42"N and 39^{o}01'30"E to 39^{o}15'35"E with altitude ranges from 1500 to 2300 m.a.s.l. Lume *woreda* is located in the Great East African Rift Valley system, at about 75 kilometers Southeast of Addis Ababa. The *woreda* is bounded on the South by the Koka Reservoir, on the West by Adea *woreda*, on the South-west by Liben Chukala *woreda*, on the North-west by Gimbichu *woreda*, on the North by the Amhara Regional state, and on the East by Adama and Boset *woredas*. The *woreda* spans 65,130 hectare.

Lume *woreda* receives an average annual rainfall of 500 to 1200 mm. The distribution of rainfall is weakly bimodal and starts with small rains from March/April to May, and the main rainy season extends from June to September (Lume Woreda Agriculture and Natural Resource, 2013). The average annual temperature is 18-280 ^{o}C. The *woreda* agro-climatic zone comprises 30% highland, 45% mid-highland, and 25% moist lowland. Considering the population and housing census carried out in 2007, the total population of the *Woreda* is increasing yearly by about 2.9%, and the projected population number of the *Woreda* by 2020 was 176,545 (CSA, 2020). The *woreda* has 35 rural *kebeles* and has 5 urban *kebeles*, covering around 675.15 km^2, and having a population density of 261.5 individuals per km^2.

2.2 Data Sources and Types

The study adopted a descriptive survey research design with both quantitative and qualitative approaches. The study population was 2595 rural households found in four selected *kebeles*, represented by household heads who are decision-makers concerning farming and conservation activities.

The researchers used primary and secondary data sources. Hence, primary data was collected from a survey of sample households, interviews with officials, development agents (DA), and representatives of *Kebele* watershed committees, and observation in the field. Secondary data was generated by reviewing unpublished documents, such as reports from the Woreda Agricultural Office, Market & Trade Development Office, and Health Office, which were relevant to addressing the research question.

2.3 Sample Size Determination and Sampling Technique

For sample size determination, Yamane formula at a 94% confidence level was used. The sample size was determined as follows:

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

Where "*n*" is the sample size, "*N*" is the population size (household heads) of four *Kebeles*, and "*e*" is margin of error. When substituting the above equation:

$$n = \frac{2595}{1+2595(0.06)^2} = 250.9$$

Therefore, a total sample size of two hundred fifty-one (251) respondents was selected. In line with this, the allocated sample size to each *Kebele* was calculated through proportional allocation methods (Cochran, 2002) as follows. Where *ni* = the required sample size from each selected *Kebele*; *Ni* = total number of households in each selected *Kebele*; *N* = total number of households, in all selected *Kebele*; and *n* = total sample size from the study population. Additionally, the researchers selected 4 experts from the *Woreda* agriculture office who work on natural resources 4 *Kebele* watershed committee representatives (one from each sample *Kebele*) 2 elders, and 4 DAs for KII (Key informant interview).

The study involved different sampling techniques. Out of 35 *Kebeles* in the *Woreda*, four *Kebeles* were selected purposively because CBMWM practices have been implemented and well managed in these selected *Kebeles* than in other *Kebeles* in the *Woreda*, their accessibility for transportation, and they are relatively nearby to conduct the study.

To select individual households for the survey, a systematic sampling technique was used where only the first unit of the sample was chosen at random, and the remaining units were chosen at predetermined intervals from the sampling frame (Thomas, 2020). Accordingly, lists of households from selected *Kebeles* were collected. The first household was selected randomly from households in the list. Then, using the formula, every 10th household was selected. This was done to spread the samples more evenly over the entire household.

2.4 Data Collection Methods

The questionnaire was prepared mainly to address the specific objectives of the research. It was divided into five sections: personal and socioeconomic characteristics; the effects of community-based micro watershed management on the livelihood of rural communities; trends in the implementation of CBMWM practices; perceptions of the community on their livelihood improvement due to CBMWM, and challenges that hinder the success of community-based micro watershed management. The questionnaire had closed and open-ended items to collect quantitative and qualitative data. Before distributing the questionnaire to the respondents, it was piloted on 12 households to check for alignment and clarify confusion. The interviews were conducted in local languages.

The respondents were given a brief explanation of the purpose of the study and its merit so that they were able to respond accordingly to the target. The enumeration was done by research assistants, and all the assistants were closely supervised throughout the data collection process. Finally, out of 251 households, 247 (98%) filled out and returned the questionnaire. According to Macfarlan (2014), key informant interviews refer to interviewing people who have informed perspectives on an aspect of the issue being evaluated. The key informant interview was carried out sequentially after completing the questionnaire.

Data can be gathered through observation by keeping an eye on people or events. A participatory observation technique that enables us to communicate with stakeholders about what is observed was undertaken to answer research questions. In order to triangulate the quantitative data, field observation was employed to track the actual practical application of CBMWM on the ground and its effects on rural populations' livelihoods. Photographs of some conservation structures and income-generating activities were taken and discussed. Procedurally, the survey data instrument was tested by pilot study to check its validity in the study.

Secondary data were also collected from government offices' reports and other documents related to the study. Accordingly, basic data such as the topography feature, land use system, demography and socioeconomic conditions, average crop productivity, the status of implementation of watershed management practices, and its trend were collected from the Woreda Agriculture office. The climatic data on temperature and rainfall distribution was gathered from the Ethiopian metrological agency of Adama branch. Similarly, the Woreda Health and Trade Offices provided community-based health insurance data and the average price of the main crops, respectively, which were used in the analysis of research results.

2.5 Data Analysis

To analyze quantitative data, descriptive statistics such as mean, standard deviation, and percentage were employed. The data analyzed by descriptive statistics were demographic characteristics, the trends of implementation of CBMWM, and challenges that hinder the success of CBMWM toward livelihood improvement.

Furthermore, inferential statistical techniques such as paired sample t-tests and chi-square tests were also employed as a set of tools in this study. Paired sample t-test was used to compare the mean score on some continuous variables from two data sets (Kennedy, 2016). In this study, a paired sample t-test was used to analyze the changes in scores for livelihood improvement tested before watershed management intervention and after intervention. This was assessed by surveying the total annual income of respondents before and after the intervention. Also, a chi-square test was used for categorical variables to explore relationships between improvements due to CBMWM and farmers' perceptions. Qualitative data obtained from open-ended questionnaires, interviews, and observations were analyzed and described through concepts and opinions qualitatively using narratives.

2.6 Research Ethical Consideration

This study was conducted under universal research ethical standards. Ethical and legal standards of research were maintained. A letter of permission was obtained from the Lume Woreda Administration to conduct the study in the selected *kebeles*. Oral communications were made with the research participants before the onset of data collection. However, the researchers refrained from overstating the purposes and implications of the study for agitating the participants. In the questionnaire survey, respondents were given the freedom to respond to the questions with their willingness. During qualitative data collection, ethical elements such as respect for humanity, confidentiality of personal ideas, respect for privacy, and freedom of attitude expression were maintained.

3 Results and Discussions

3.1 Demographic and Socioeconomic Characteristics of the Respondents

Results in table 1 revealed that among the respondents, 93% were males and 7% were females, implying that watershed management is more labor intensive and the participation of females is higher in indoor activities.

Table 1. Demographic & socioeconomic characteristics of the respondents (N=247)

Variables	Category	N	%
Sex	Male	230	93
	Female	17	7
	Total	247	100
Education level	Unable to read and write	49	20
	Able to read and write	127	51
	Grade 1-4	36	15
	Grade 5-8	24	10
	Grade 9-12	11	4
	Total	247	100
Marital Status	Single	15	6
	Married	218	88
	Widowed	3	1
	Divorced	11	5
	Total	247	100
Household livelihood activities	Agriculture	229	93
	Agriculture & Trade	18	7
	Total	247	100
Land ownership	Owned	186	75
	Rented	61	25

Source: Own computation from the household survey, May 2022

In addition, CSA (2012) states that the proportion of women-headed households in Ethiopian rural areas is less than one-sixth due to socially connected factors. This figure shows variations from place to place owing to many factors like awareness, employment, social norms, and duties in the family system. The marital status results showed that most of the respondents (88%) were married, which is an important element for practicing watershed management as it is additional input during watershed practice. It was also noted that 93% of the respondents' livelihood activities were agriculture and 7% were agriculture and trade activities in combination, indicating that if the watershed environment is protected, it will initiate their livelihoods gradually. Moreover, the results revealed that 75% of the respondents owned farmland, and 25% plowed rented land. Private farmland ownership probably initiates the participation of farmers in watershed management activities. Almost 80% of the respondents were able to read and write. This ability helps the community understand the awareness of implementing watershed management practices and enhances the utilization of improved agricultural technologies. This finding goes with research findings, which stated that education improves a person's capacity to recognize and react to novel situations and their skill set, which includes the effective use of agricultural inputs (Mondala *et al*., 2012).

3.2 Trend of Community Based Micro Watershed Management Practices

This study considered trends in the application of WSD activities and community involvement in the activities. The long-term viability of the watershed development program is crucial for improving the livelihood of smallholder farmers (Meseret & Gashaw, 2021). Regarding the trends of farmers' participation in CBMWM, most of the respondents (83%) agreed that there is a constant trend of improvement, whereas 14% were neutral and 2% disagreed. Furthermore, 7% of sample households rated their interest in watershed management practices as good, 71% as medium, and 21% as poor. The sample survey results revealed that the trend of watershed management practice shows improvement in area coverage, for which 89% of the respondents agreed, while 10% were neutral, and 1% disagreed. This result implies that the participation of households in the CBMWM revealed improvement in realizing the work targets for the long-term protection of the resource base. This participation enhances their awareness of watershed management and its associated benefits.

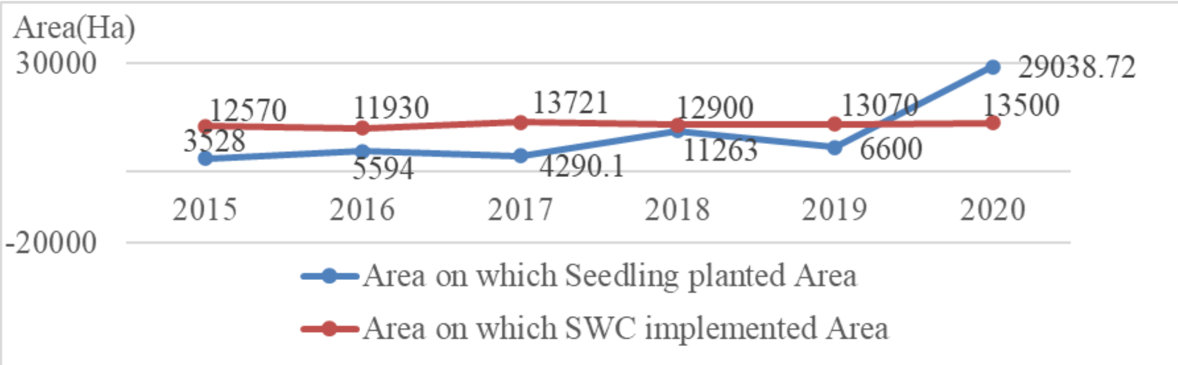

Figure 2. Trends in the area covered by conservation and the number of seedlings planted. (Source: Lume Woreda Agriculture and Natural Resource Office)

Moreover, the data in figure 2 illustrates the trends of achievement for different years in area coverage, which nearly supports the research findings explained above. According to key informants and experts interviewed, the reason for the increase in plantation achievements from 2019 onwards was the country's green legacy agenda and the resultant movements.

3.3 Effect of CBMWM to the livelihood of rural community

3.3.1 Effect of CBMWM to crop productivity and production

Results of the Paired sample t-test in table 2 reveal that the average productivity of '*Teff*' before and after the intervention is 13.31 and 16.99 quintals, with a standard deviation of 3.76 and 4.03, respectively. Additionally, the mean difference between the *Teff* production before and after the intervention is 3.68 quintals. Similarly, the average productivity of Wheat before and after the intervention is 19.41 and 25.02 quintals. Also, the mean difference between the Wheat production before and after the intervention is 5.61 quintals. Moreover, the average productivity of Beans before and after the intervention is 14.51 and 17.68 quintals. Again, the mean difference in Beans production before and after the intervention was 3.17 quintals. In addition, the average productivity of Maize before and after the intervention was 21.05 and 28.89 quintals. The mean difference in Maize production before and after the intervention was 7.84 quintals. Finally, the results revealed that there is a statistically significant difference in crop productivity before and after the interventions, as the p-values of all pairs (0.000). These results have significant implications for rural households whose survival depends primarily on agricultural production, both for food and to meet the economic demands of their families.

Table 2. Main crop production in quintal before and after CBMWM intervention (N=247)

Variable	Mean	Mean difference	T-Value	P-Value
Teff production before intervention	13.31 (±3.760)	3.68	21.84	0.000
Teff production after intervention	16.99 (±4.029)			
Wheat production before intervention	19.41 (±5.610)	5.61	17.19	0.000
Wheat production after intervention	25.02 (±6.536)			
Bean production before intervention	14.51 (±4.981)	3.17	16.89	0.000
Bean production after intervention	17.68 (±5.553)			
Maize production before intervention	21.05 (±6.374)			
Maize production after intervention	28.89 (±5.826)			

Source: Own computation from the household survey, May 2022

As indicated in table 2 above, there is a statistically significant difference between before and after interventions of the main crops, *Teff*, Wheat, Bean, and Maize productivity in the study area since the p-values of all pairs (0.000) were less than 0.05, which were supported by the views of the local communities. Thus, according to the interviews, the increase in crop production was attributed to the introduction of watershed management activities like physical and biological structures, which contributed to the improvement of soil moisture availability reduction in soil erosion, and the enhancement in the utilization of improved agricultural technologies and practices adopted by farmers who were assisted by the training given in watershed management programs which have similar sense with the findings of Haregeweyn *et al.* (2008). Haregeweyn and her co-researchers state that watershed management practice at the micro level is essential for improving the performances of the ecosystem, like reducing sedimentation problems in different reservoirs and improving the water table of the surrounding areas, thereby enhancing the quality of springs and streams. Furthermore, it increases the capacity of the land to support and produce sufficient yield of cereal crops. It was observed that utilization of these components with conservation activities improves productivity per unit area of land. The findings of this study are in line with Tamirat *et al.* (2018), who described that most of the conservation practices introduced through CBMWM campaigns were able to reduce soil erosion and increase crop yields.

3.3.2 The effect of soil and water conservation in improving productivity

The results of respondents presented in Table 3 showed that 85% agreed, 14% strongly agreed, and 1% of the sample household heads responded neutral with the reduction of soil erosion after watershed management practices. Furthermore, the results revealed that most respondents (84%) agreed, 7% strongly agreed, and 9% were neutral on the improvement in vegetation coverage after watershed management. The response of sample households (96%) showed that there was an improvement in the change of gully-affected areas to productive land after watershed management intervention.

The protection of soil from being washed away by erosion due to different watershed management activities like gully treatments and planting of trees play a substantial role in improving the productivity of crops. During field observation (Figure 3), it was realized that management practices changed degraded and gully areas into lands that can produce forage crops, grasses, and trees serving different purposes in the study area. Because of the implementation of moisture-saving structures on the hill or upper site, there was an improvement in soil moisture. Especially at downstream sites, as the farmers expressed, there is an increase in the height of their crops in the field, and ultimately, agricultural productivity and environmental conditions of the study area are improved sustainably.

Table 3. CBMWM's role in addressing soil erosion & gully problems (N=247)

Variables	Category	N	%
Soil erosion decreased	Strongly agree	35	14
	Agree	209	85
	Neutral	3	1
	Total	247	100
	Improved	238	96
Change of gully area to productive land intervention	No Improvement	9	4
	Total	247	100
	Strongly agree	17	7
Vegetation coverage improved after watershed management	Agree	207	84
	Neutral	23	9
	Total	247	100

Source: Own computation from the household survey, May 2022

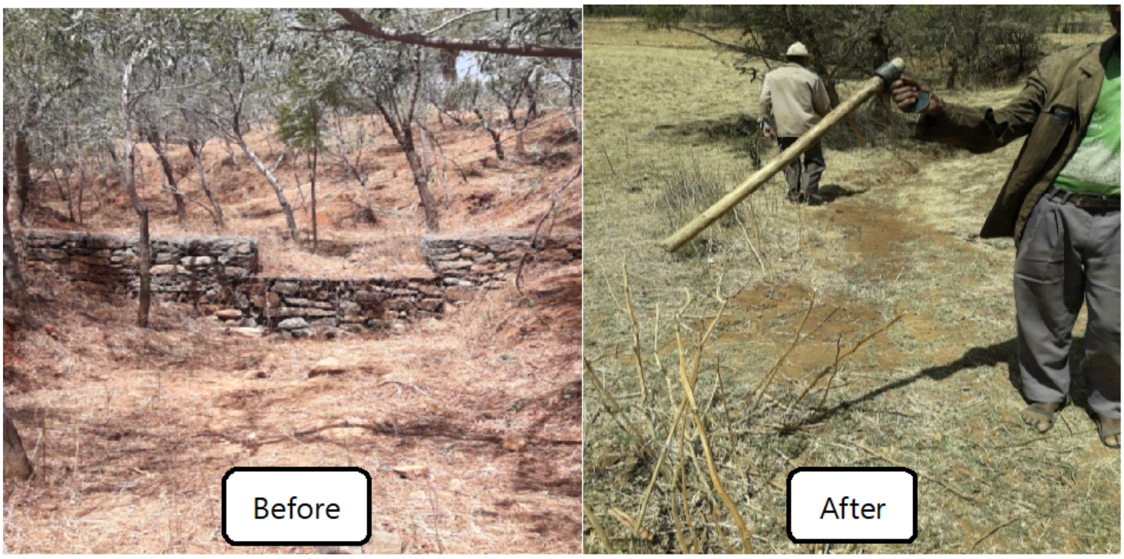

Figure 3. Conservation structure in Bola Buta *Kebele*. (Photo taken by the first author May 2022)

This was consistent with the study conducted by Abiyot *et al*. (2018), which explains how CBMWM improves biodiversity, raises soil fertility, lowers soil loss, and helps mitigate climate change. Figure 3 shows constructed check dams and plantations of soil-conserving trees used to reduce soil erosion and protect the washing away of soil from the farmland. Due to this, the washed-away soil from the upper stream is retained and deposited in between structures along the way, forming stable land.

3.3.3 The role of CBMWM program in the utilization of Agricultural technology

Figure 4 shows that 85% and 7% of respondents agreed and strongly agreed, respectively, on the improvement in the utilization of agricultural technologies after watershed management, while 7% were neutral and 1% disagreed. This result implies that most of the respondents observed improvement concerning the use of agricultural technologies following the watershed development activities, which in turn results in crop improvements.

As indicated by Arslan *et al.* (2020), the term "technology" is used in this context to refer to improved germplasm, fertilizer, and improved agronomic practices because watershed has those components to improve rural livelihood through resource conservation and management measures like moisture conservation, crop rotation, and intercropping.

According to the key informants' interview, it was stated that watershed management activities enhanced the proper utilization of improved agricultural technologies like improved crop varieties and improved farming practices such as row planting, crop rotation, and intercropping by farmers, which helped them improve productivity. The study conducted by Mondala *et al.* (2012) indicated that the average productivity of all crops per hectare was also found to be higher in the rehabilitated watershed than in the control villages, which is a clear illustration of the land treatment and productivity enhancement operations carried out as the watershed development program's component.

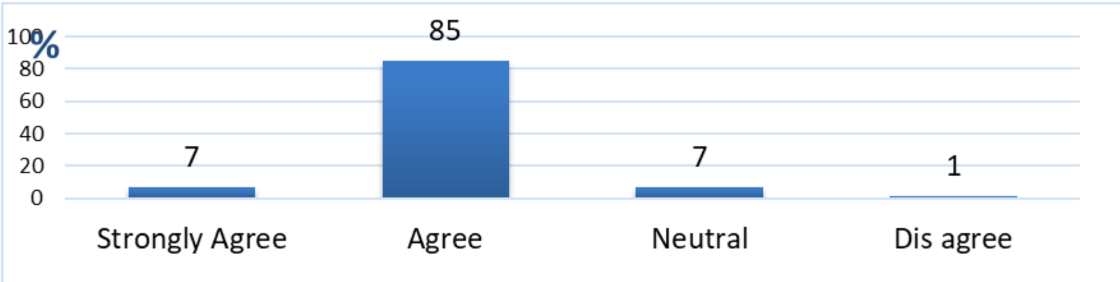

Figure 4. Improvement in the utilization of agricultural technology after watershed management. (Source: Own computation from the household survey, May 2022)

3.3.4 The effect of CBMWM on the economy of rural communities

As part of agriculture, crop production was the most essential source to boost household income in the study area, as described by informants. The main crops in the study area were *Teff*, wheat, beans, and maize.

As seen in Table 4, there was a difference in the average income of 107,700 Birr, 91,900 Birr, 73,000 Birr, and 38,716 Birr/hectare from the main crops of *Teff*, wheat, bean, and maize, respectively, after watershed management intervention. Due to the intervention of different watershed management practices, the productivity of most crops was increased, which in turn increased the household's income. This result is supported by research findings of Gebrehaweria *et al.* (2016), who reported that there was a positive impact of watershed management on the production and productivity of crop livestock, farm incomes, socioeconomic conditions, and livelihoods.

Table 4. Average crop productivity and income levels before and after CBMWM

SN.	Crop type	Before intervention (2011)			After intervention (2020)			Difference in total income (Birr)
		Quintal per ha	Price per quintal (Birr)	Total income (Birr)	Prod. Per quintal per ha	Price per quintal (Birr)	Total income (Birr)	
1	*Teff*	24	800	19,200	30	4230	126,900	107,700
2	Wheat	41	520	21,320	51	2220	113,220	91,900
3	Bean	17.5	600	10,500	25	3340	83,500	73,000
4	Maize	34	400	13,600	41	1276	52,316	38,716

Source: Own computation from Woreda Agriculture & Trade Office, May 2022

This result implies that the majority of the household's cost of living is covered by the income generated through selling their crops. However, at this point, it should be noted that the increase in income is not only due to an increase in production but also due to the price inflation of crops.

3.3.5 The effect of CBMWM in food and feed availability and productivity of livestock

Paired sample t-test results showed that the average length of months the household's harvest covered for consumption before and after the intervention was 10.88 and 12.11, with a standard deviation of 2.11 and 1.35, respectively. The mean difference in the time length of the households' harvest covers their consumption before and after the intervention is 1.23 months. This result is due to different reasons. Firstly, because of CBMWM intervention, the productivity of the crops improved, as discussed in the previous section. Secondly, since there is an improvement in household income, they cover the expenses needed for the household, and they enable to save the crops for sale. When compared to farm inputs and non-food items, the cost of accessing food items at home is higher in rural expenditure, especially during off-seasons (Girma *et al.*, 2013). The aggregate of these helps the household to elongate the average length of time the household's harvest covers for consumption and hence improve food availability and socioeconomic condition after the intervention. This is consistent with a report from the Global Theme on Agriculture, which claimed that watershed management increased crop yields and provided the community with more food and fodder (Pathak *et al.*, 2007).

Table 5. Effect of CBMWM in food & feed availability and productivity of livestock

Variable	Mean	Std. Deviation	Std. Error Mean	Mean difference	t-Value	P-Value
Length of month a harvest cover before intervention	10.88	2.112	0.135	1.236	9.670	0001
Length of month a harvest cover after intervention	12.11	1.347	0.086			
Source of animal feed before intervention	1.84	1.259	0.081	0.889	10.253	0.001
Source of animal feed after intervention	2.72	0.676	0.043			

Source: Own computation from the household survey, May 2022

3.3.6 CBMWM's effect on the creation of income sources, livelihood and saving capability

Saving is one of the key factors in any nation's household's welfare and economic growth. Research conducted by Dejene (2003) indicated that rural households in Ethiopia mostly make their savings from the money they receive from selling agricultural goods. The amount of savings depends on one's level of education, family size, average annual income, typical annual expenses, ownership of livestock, and availability of credit service (Genemo & Bekele, 2021). The paired sample t-test showed that the average annual saving capability of households before and after the CBMWM intervention was 5994 birr and 11083 birr, with a standard deviation of 8993 and 13621, respectively. The mean difference between the average annual saving capability of households before and after the intervention was 5089 birr. The average saving after the intervention is 11083 birr, comparable to a research finding which reported that sample households practiced saving with an average amount of 11365.3 birr (Girma *et al.*, 2013). This result has meaning for rural households, which allows them to cover expenses at hard times, like purchases of agricultural inputs and even food during the off-season, as discussed by informants. Similarly, the average source of additional income from products other than crops before and after the intervention is 1.85 and 2.92, with a standard deviation of 1.18 and 1.53, respectively. The mean difference between the source of additional income other than crops before and after the intervention was 1.07. Finally, the annual saving capability of a household and the average source of additional income revealed that there is a statistically significant difference between before and after intervention at p=0.001.

The key informants also explained that the annual saving capability of households improved after watershed management intervention due to the improvement in the income of farmers. In addition, saving culture was developed via awareness created by the training given in the program. Moreover, the introduction of CBMWM in the study area helped the household heads to have a source of additional income, such as the sale of wood, forage, seed, grass, daily labor, and trade, in addition to other agricultural products. Research conducted by Gebremariam & Desalegn (2018) reported that following watershed management, income from rain-fed crops, livestock, poultry, and off-farm sources of income, including food-for-work programs, increased.

In addition, during field observations (Figure 5), it has been observed that farmers were engaged in additional income-generating activities like beekeeping around their homesteads. However, they were very limited in the number and type of activities they were engaged in when compared to the available potential.

Figure 5. Income generation from beekeeping activity in Tede Dildima *Kebele*. (photo captured by first author, May 2022)

It was observed that activities such as homestead vegetable production, poultry production, dairy activity, fattening, and beekeeping are possible alternative potentials that households can engage in to improve the socioeconomic condition of their households by integrating with watershed management.

3.3.7 The Effect of CBMWM on Social Aspects

Regarding the experience developed in natural resource management after the intervention, the analysis results revealed that 89% of the respondents developed experience, whereas 11% did not. In addition, the results of respondents show that 24%, 11%, and 4% of the job opportunities created were in the daily laborer, forest management, and trade categories, respectively. However, the contribution of CBMWM intervention in creating additional jobs was below 50% as sample households responded. Some of the reasons raised by informants were lack of access to electricity, road, and lack of experience.

3.3.8 CBMWM's effect on strengthening social and human capital

As discussed by informants, there were household heads organized into their micro-watershed names and managed enclosed areas for rehabilitation purposes. They also established cooperatives in the name of their micro-watershed and solved common problems like the construction of roads and service delivery like goods, savings, and credit services, which indicate the development of their social capital. Such achievements are examples of the Chaltu cooperative of the Gerersa watershed in Tede Dildima and Ade Mamo watershed in Bola Buta. Furthermore, farmers were given training like family planning and benefited from it while working together on conservation practices. Thus, watershed management facilitates the community to come together, share their experiences, and develop knowledge that helps them alleviate their common problems, hence improving their livelihood. These are parallel with research findings stating that social associations have been established and strengthened through the watershed management practice (Joseph & Fikirte, 2013).

3.3.9 Effect of CBMWM on the health and education sector

The results reveal that most respondents (94%) were members and users of health insurance. The findings also indicated that the majority of respondents (90%) agreed, 9% neutral, and 1% disagreed with the improvement in affordability of household healthcare costs following the intervention. Improvements in affordability of households for health costs after intervention since watershed management plays a significant role in improving income and productivity of crops, as discussed in earlier topics. Due to this, many household heads cover necessary payments and become members and users of health insurance. The membership enabled household members to get treatment in their nearby health centers without any other extra costs. The research findings of Jackson & Mulyunyi (2015) reported that adopting watershed management measures had increased household incomes for 85% of the households included in the study. The additional revenue was used to meet other family requirements, including paying for medical care, clothing, and home development. Further, the results revealed that 94% of the respondents agreed that watershed management helps the education sector by providing trees for the construction of schools and their fences and for cooling the climate of the school environment. According to key informant reports, due to the CBMWM program, different seedlings planted around most schools have become trees that are used for various purposes.

3.4 Community Perception towards their livelihoods as a result of CBMWM

Farmers who are concerned about soil deterioration and expect to benefit from conservation are more likely to choose appropriate conservation techniques and strategies into practice (Gizaw, 2010). Contrarily, it's likely that farmers may not want to use any conservation technique if they fail to recognize the problem of soil degradation, which could result in the loss of any potential benefits. They believed that building actual soil and water conservation structures requires a lot of labor, reduces arable area, and is challenging to plow. Therefore, one crucial element revealed in this study is how farmers perceive themselves.

3.4.1 Farmers' perspectives on use of trees from enclosure areas and the program's long-term viability

Watershed management facilitates frameworks that ensure not only the conservation of land resources but also the use of them in a manner that will not cause ecological imbalance. Regarding the perception of the community on their livelihood improvement due to CBMWM, most of the respondents (83%) believed that there is a perception that households can use trees in enclosed areas of a watershed for firewood and other purposes in the study area. As discussed with key informants, they reported that aged and fallen trees in the enclosed areas of the watershed are used for firewood and even for sale, which serves as additional income for farmers. This finding has implications for developing a sense of ownership over the watershed that they manage.

3.4.2 Farmers' perceptions of the effects of CBMWM on livelihoods

The results revealed that 59% of the respondents agreed, 30% strongly agreed, and 11% disagreed regarding the household's willingness to participate in watershed management. Similarly, 64%, 27%, and 9% of the respondents agreed, disagreed, and strongly agreed that there is improvement in agricultural production, income, and the environment due to watershed management. A chi-square test for independence (with Cramer's V) indicated a significant association between community perception of livelihood improvement due to CBMWM and knowledge development on implementation of CBMWM as p is less than 0.05, Cramer's V=0.158; knowledge development on the effect of CBMWM on livelihood as p is less than 0.05, Cramer's V= 0.203; and household willingness to participate in CBMWM as p is less than 0.05, Cramer's V=0.171.

3.5 Challenges that Hinder the Effects of CBMWM

The results revealed that the majority of respondents (81%) believed that the challenges that minimize the role of watershed management in livelihood improvement are lack of management, maintenance, and protection. Regarding access to necessary inputs for conservation activities, 67%, 25%, and 8% of the respondents agreed that they were accessing inputs, not accessing inputs, and poorly accessing inputs, respectively. Given the treated communal and enclosed area protection from animal and human destruction, the response of sample household heads showed that 60% were protected, 28% were not protected, and 12% were not protected as required. The result also shows that 58% of respondents agreed that they accessed integration between sectors in helping the farmers to have additional income-generating activities, and 42% did not. This finding implies that there was no adequate integration between the sectors in assisting the farmers to have more additional income-generating activities, even though there was an improvement after intervention.

4 Conclusion

Though the practices of micro-watershed management by the communities and their outcomes were not adequate, some improvements were observed in the study site. Some of these outcomes were improvements in crop-livestock productivity, food availability, diversification of livelihood activities, agronomic practices, and diversification in agricultural inputs. Likewise, rehabilitation of degraded lands, reduction in soil erosion, and improvement of vegetation cover were also among the major achievements recorded at the site, mainly as a result of watershed management practices carried out over the last three decades. It was also noted that the surrounding communities can get construction materials from the managed watershed.

Another positive effect of community-based micro-watershed management activities is that it allowed the local communities to work together, which enabled them to share information and discuss common agendas like saving and credit services from nearby institutions. As inferred from the results of the study, community-based micro-watershed management is carried out every year and shows improvement in area coverage, though it is not sufficient. Thus, individual farmers have experience in carrying out conservation activities and have positive perceptions of watershed management practices and their effects. Thus, the conclusion is that the introduction of CBMWM has improved livelihood elements like the natural, financial, social, and human capital of rural communities. However, some challenges reduce the benefits obtained from watershed management practices, such as low participation of females, lack of maintenance of previously conserved watersheds, free grazing, and expectation of immediate outcomes by the farmers.

Acknowledgments

The authors wish to express their sincere gratitude to all institutions and individuals for their full cooperation in providing the necessary data and information in the whole research process. The authors are also grateful to the anonymous reviewers and editors for their management of the review and publication process of the manuscript.

Conflict of Interest

The authors fully declare that they have no competing interests in publishing the manuscript.

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