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Assessment of Sustainability in the Wulo Abiye Watershed, Central Highlands of Ethiopia

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***Abstract*—**Assessing the sustainability of watersheds holds significant importance for regional natural resource management and to achieve sustainable development. This study investigated the sustainability of the Wulo Abiye watershed, central highlands of Ethiopia. The sustainability status of the watershed was evaluated by using 17 indicators representing the economic, social, and environmental dimensions of sustainable development goals (SDGs) based on the local and existing conditions of the watershed. The results indicated that environmental sustainability was at a 'high' level, while social and economic sustainability and the aggregate index were at 'moderate' levels. The overall level of community participation in the planning and evaluation phases of watershed management was at 'low' levels. The implementation phase was at 'high' level. Overall, the sustainability status of the watershed management practices and the level of community participation were at a moderate level. The study concluded that integrated support is needed to overcome the identified challenges to achieve sustainable development in watersheds.

***Keywords*—**Wulo Abiye watershed, community participation, watershed management, sustainable development.

I. Introduction

ETHIOPIA'S highlands have been seriously affected by land degradation and soil erosion. Topography, geology, climate, population growth, the nature of the economy and land related policy are contributing factors [1]-[3]. This impacts agricultural sustainability and national food security [4], [5]. In response, the Ethiopian government has initiated national watershed management campaigns through soil and water conservation (SWC) and tree planting. Large areas are covered by terraces, soil bunds, stone bunds, and millions of tree seedlings [6]-[8]. These initiatives also serve as climate change mitigation measures [5].

Watershed management plays a critical role in achieving the UN SDGs [9], directly contributing to more than 41% of the targets. This included ending poverty (Goal One), ending hunger (Goal Two), good health and well-being (Goal Three), sustainable economic growth (Goal Eight), sustainable production (Goal Twelve), climate change mitigation (Goal Thirteen), and protecting and restoring degraded lands (Goal Fifteen) [10]. Environmental sustainability, which is central to the 2030 Agenda, is directly linked with more than half of the 17 SDGs [11]. This clearly shows that the issue of sustainability in watershed management has received due attention in the SDGs.

Since 1970, there has been a long history of watershed management initiatives in Ethiopia [8]. Due to the top-down strategies, poor integration, and unmanageable watersheds (for monitoring and management), most of the implemented measures failed. This calls for a shift towards a sustainable development approach that encompasses community participation and livelihood integration [8]. Thus, community-based participatory water-shed development approach has established [7].

Despite the extensive SWC efforts initiated by the government, NGOs, and the community, challenges in sustaining watershed management persist in the country including the Wulo Abiye watershed. These challenges include ongoing soil erosion, a decrease in soil fertility, and unsustainable natural resource use. Many watersheds are food insecure [1], [6]. The community repeatedly implemented various SWC activities on the same land every year. However, these conservation efforts end in crises and make watershed management practices unsustainable.

Assessing the sustainability of watersheds holds significant importance for natural resource management and achieving sustainable development [12]. To ensure the sustainability of watershed management, it is crucial to measure the levels of community participation in the planning, implementation, and evaluation phases of watershed management [13]. Studies on the sustainability of watershed management have been limited in Ethiopia. The available studies have focused on socioeconomic and biophysical constraints [14], [15], financial and incentive constraints [16], lack of policy implementation [14], [17], and community participation [8], [18]. The study of [19] offers valuable insights by focusing on sustainability, institutional arrangement, and challenges of community-based climate smart practices.

To the best of our knowledge, there are no published studies assessing the sustainability status of watershed management in the country. An in-depth assessment of watershed sustainability is therefore needed to implement appropriate watershed management strategies and address sustainability [12]. Hence, this study focused on assessing the existing sustainability status of watershed management by taking the Wulo Abiye watershed as a case study site and using indicators selected from social, economic, and environmental pillars of sustainable development. The study's outcome will lead to the generation of evidence-based data on the sustainability of watershed management, which could be used for water resource management, agricultural development, and climate change adaptation.

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II. Materials and Methods

A. Description of the Study Area

The watershed is located from 10◦13′31″N to 10◦14′59″N and 39◦45′13″E to 39◦47′9″E, with an elevation between 3081 and 3231 m above sea level (Fig. 1). The primary economic activity in the area is agriculture.

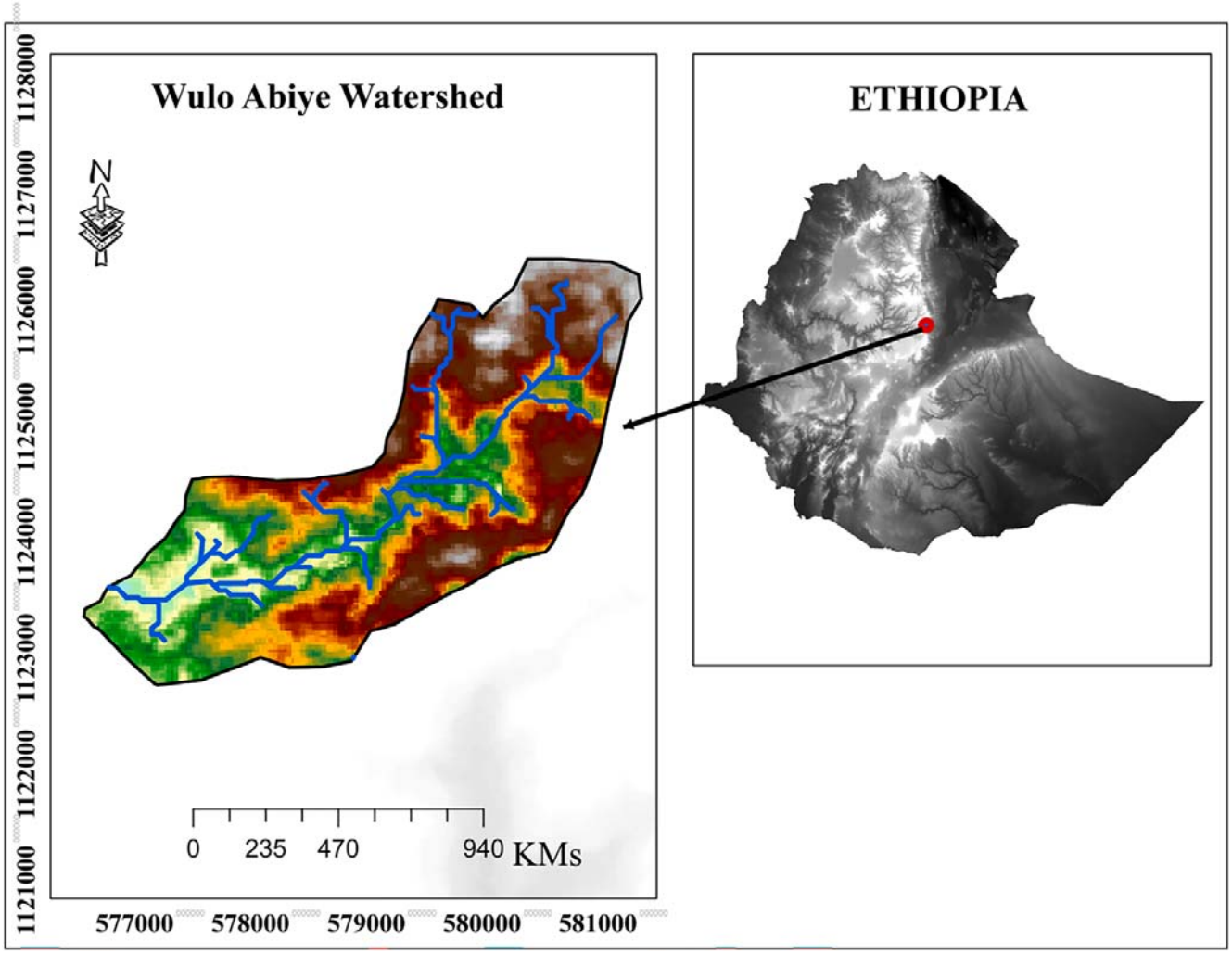

Fig. 1 Location of the study area

Barley is the dominant crop grown under rained agriculture with limited traditional irrigation. Sheep are the dominant livestock in the area. The total population of the watershed is 817, of which of which 498 (61%) are male and 319 (39%) are female. About 27% of the total area is mountainous, 25% is rugged terrain and 48% is plain lands. Black soils cover about 10% of the area, reddish soils cover about 35%, and brownish soils cover about 55%. The major land-use types include cultivation (78%), forest and bush (10%), and grassland (9%). The remaining 3% included bare land, settlement and waterbody. It has an annual rainfall of 1057 mm; while the while the annual maximum and minimum temperatures range between 21 °C and 8 °C, respectively [4], [20].

B. Data Collection and Analysis

The Wulo Abiye watershed was purposely selected based on severe and accelerated land degradation, food insecurity, and vulnerable to climate change and variability. The watershed has a total of 382 households, of which, 213 (56%) are male and 169 (44%) are female. The study used two datasets: quantitative data from a survey of 102 households and qualitative data from two focus group discussions, 10 key informant interviews, and field observations. A list of watershed communities was used to randomly select 102 respondents (representing 27% of the households). The formula provided by [21] was used to determine the sample size of the respondents.

$$n_0 = \frac{z^2 pq}{d^2} \quad (1)$$

$$n = \frac{n_0}{1+\frac{(n_0-1)}{N}} \quad (2)$$

$$n_0 = \frac{z1.96^2 * 0.1 * 0.9}{0.05^2} = 138$$

$$n = \frac{138}{1+\frac{(138-1)}{N382}} -= 102$$

where n = number of sample size when the population is less than 10,000, n0 = desired sample size, Z = 95% confidence limit, i.e., 1.96, p = 0.1 (proportion of the population to be included in the sample i.e.,10%), q = 1–0.1 i.e., (0.9), N = total number of population that is 382, and d = margin of error or degree of accuracy desired (0.05).

Before conducting the survey, respondents provided informed consent, and no personally identifiable information was collected during data collection. The quantitative data were used to develop a watershed sustainability index, while the qualitative data substantiate the results obtained from the quantitative results. The focus group discussions were conducted with the watershed committee and the watershed community, while the key informant interviews were carried out with knowledgeable farmers having long years of farming experience, agricultural development workers, district natural resources and small-scale irrigation development experts, and youth associations.

1. Assessing Sustainability in Watershed Management

To assess watershed management sustainability, various approaches can be used depending on the objective, scale, and scope of the assessment. These approaches included the use of indicators or indices, integrated assessment tools, and a barometer of sustainability [12]. In this study, the sustainability of watershed management is measured by constructing indicators selected from the social, economic, and environmental pillars of sustainable development. This method is easy to use and describes local and existing conditions of watershed management [22].

To measure the sustainability of the Wulo Abiye watershed, the criteria developed by [22] to measure the sustainable development status of micro and small enterprises were adapted, with modifications made to the watershed context. Seventeen indicators encompassing the economic, social, and environmental dimensions of sustainability were identified based on the local and specific conditions of watershed management. These indicators, along with their sub-components and assumed relationships with sustainability, are presented in Table I. During the evaluation, the indicators were assessed at three levels of sustainable development: 'low', 'moderate', and 'high' with values of < 50%, 50-75%, and > 75%, respectively. This is a linear average explained in terms of the percentages of respondents and so does not give weight to the different criteria. These values provide a measure of the extent to which sustainable development measures have been implemented for each indicator. To determine the overall sustainability status of watershed management, the indicator scores are aggregated. Equal weights are assigned to each indicator, if all the indicators have equal importance in assessing sustainability. However, the use of equal weights has advantages and limitations. Equal weights are easy to use and are free from bias in the evaluation process. In contrast, equal weights might not accurately reflect the relative importance of each indicator [22].

2. Measuring Levels of Community Participation in Watershed Management

To ensure the sustainability of watershed management, it is crucial to measure the levels of community participation at different phases of watershed management [13]. These phases include planning, implementation and evaluation. Variation in the level of participation on watershed management affects motivation to participate in campaigns, follow-up on structures, and ownership. This in turn affects watershed sustainability. The active involvement of all stakeholders in all phases is crucial for the long-term success of watershed management [15]. To measure the level of community participation in watershed management, the criteria developed by [31] to measure the extent to which people participated in different stages of watershed programs were adapted, with modifications made to the local context.

$$pi = \sum_{j=1}^{k}(PPj + PIj + PMj)$$

where PPj = total score obtained by a respondent due to participation in program planning; PIj = total score obtained by a respondent due to participation in program implementation; PMj = total score obtained by a respondent due to participation in program evaluation; k = total number of activities on which the responses of the respondents were recorded; pi = Total participation scores obtained by individual respondents in planning, implementation and evaluation; PPI=people participation index; p = mean participation score; and, N = Total number of respondents.

$$PPI = \frac{mean\ participation\ (p)}{max\ participation} * 100$$

$$P = \frac{\sum_{i=1}^{N} pi}{N}$$

Community participation was assessed and measured in relation to the three stages of participation; planning, implementation evaluation through a five-point continuum scale (1 = never, 2 = rarely; 3 = sometimes; 4 = often; and 5 = always). An instrument consisting of 12 activities was developed and used to measure community participation. These activities were identified through conducting field surveys, consulting with local experts and reviewing literature. Each activity was rated against three levels namely, 'low', 'moderate', and 'high' with values of < 50%, 50-75%, and > 75%, respectively. The scores for each of these items are aggregated to determine the overall level of community participation as did in the sustainability assessment. Table II presented watershed management phases, activities, and description.

TABLE I
INDICATORS, SUB-COMPONENTS, AND ASSUMED RELATIONSHIPS WITH SUSTAINABILITY

Indicators	Sub-components	Description and assumed
Environmental sustainability	Reduce soil loss	Soil and water conservation measures have been proven effective ways to reduce soil loss [23].
	Increase groundwater level	Watershed management activities have improved surface and ground water availability [24].
	Increases soil fertility	Watershed management activities aimed at alleviating runoff can significantly improve soil fertility and depth [7].
	Increases soil moisture	Watershed management interventions have a key role in improving soil moisture [3]
	Increases vegetation cover and biodiversity	Watershed management intervention at a given area likely contributes to improve biodiversity and natural environment [24].
Economic sustainability	Improve crop yields and farm income	Watershed management intervention has increased soil fertility and crop productivity [24].
	Create job opportunities for disadvantaged groups	Watershed management intervention brought improve income source of the society specially for youth and landless [25].
	Enhances food supplements for livestock	Watershed management intervention has increased the availability of pasture for their livestock in the watershed [24].
	Diversification of income sources	Due to the introduction of watershed management, income diversification has occurred from crops under irrigated and rain-fed farms [25].
	Increased irrigation area	The implementation of watershed management has great impact on the availability of surface and ground water and it leads to the expansion of irrigation 25]
Social Sustainability	Access to extension service	The knowledge and skills gained through extension service accelerate farmer's decision on conservation practices [26].
	Community awareness	People have understood the importance of watersheds and are working harder to uplift their economic status [27].
	Increased recreational opportunities	Watershed development has diverse social benefits like amenities and shade value, meeting places for various social events, and recreational purposes [28].
	Build and strengthen community institutions	Watershed requires cooperation among stakeholders and requires the establishment of institutions and customary rules that can address the benefit and cost sharing systems [29].
	Reduces conflict over resources like water	Soil and water conservation measures enhance infiltration and can lead to improved water availability and regulated seasonal streamflow fluctuations [29].
	Improved food security status	Watershed management interventions have a key role in contributing to poverty alleviation and sustainable livelihoods [3].
	Access to healthcare and social services	Watershed development can have indirect impacts on healthcare by improving food and nutrition security [30].

TABLE II
WATERSHED MANAGEMENT PHASES, ACTIVITIES, AND DESCRIPTION

Phase	Activities	Description
Planning	Site selection of watershed area	Area selection is an activity in which a degraded land selected as a watershed area [32].
	Identification and prioritization of problems	Working with community members to collectively identify their problem and priority needs [33].
	plan preparation for resource management	Collaborating with residents to assess socio-economic and environmental problems and potential areas for management interventions [33].
	Formulation of customary rules	Customary rules shape how natural resources are used and conserved in a given area, promoting sustainable management [34].
	Time scheduling	Develop action plans that align with the identified needs and priorities [33].
	Identification of active work forces	Identification of individuals of any gender between the ages of 18 and 65 years to participate in local watershed activities [25].
Implementation	Soil and water conservation work	The workforce was actively participating in physical SWC soil conservation mechanisms [25].
	Digging of planting pit	The workforce was actively participating in preparation for biological soil conservation mechanisms [25].
	Planting of seedlings	The workforce was actively participating in biological soil conservation mechanisms [25].
	Management activity	The participation of the working force in the protection of biological conservation measure [25].
Evaluation	Sharing information and Consultation	Exchanging data, insights, and feedback among watershed communities [33].
	Assessment of results and limitations	It is the act of assessing WSMs achievements and failures through subjective analysis [33].
	Capacity building and empowerment	Building the capacity of local communities and extension workers is an important component in watershed management [33].

III. RESULTS AND DISCUSSION

A. Background of Respondents

The average age of the respondents is 46.0 years and varied between 27 years and 71 years. About 75% are males and 25% are females. Almost all respondents are within the active working-age group and there is a high chance of engaging in labor demanding watershed management practices. The average family size was 4.7. Large family size implies a high level of participation in watershed management. Educational levels are low: more than 73% of them have not attended any formal education. These have negative implications on participation in watershed management.

B. Sustainability Status of Watershed Management

1. Component Wise Sustainability

Environmental Sustainability

Table III presents component wise sustainability assessment. The environmental sustainability of watershed management was assessed using conditions of natural resources and watershed services. Results indicated that of the five subcomponents, reducing soil loss and increasing groundwater level were found at 'high' levels and had scores of 94% and

77%, respectively. An increase in soil fertility, vegetation cover and biodiversity, and soil moisture were found at 'moderate' levels with a score ranging from 68% to 72%. The indicator wise assessment of environmental sustainability had a score of 76%, implying environmental sustainability was found at 'high' level. This finding is different from a study focusing on sustainability, institutional arrangement, and challenges of community-based climate smart practices in northwest Ethiopia where environmental dimension of climate smart practices can be sustained but at a risk level [19].

Regarding the rehabilitation of natural resources such as soil, water, and vegetation cover, a 63-year-old farmer, a key informant explains: over the past several decades, the government has implemented comprehensive SWC campaigns that focus on watershed management. These initiatives did not significantly contribute to enhancing ecosystem services and improved livelihoods. However, the approach did not initially consider the concerns of the community as it mainly aimed to satisfy the campaign objectives. As a result, the community developed a sense of participation through obligation without their consent and priorities. Recently, we observed a slight improvement in ownership and participation within the community which brought positive outcomes from the watershed.

Economic Sustainability

Improved crop yields and farm income, created job opportunities for disadvantaged groups, diversification of income sources, enhanced food supplements for livestock and increased irrigation area were used to assess the economic sustainability of watershed management. These sub-components can maximize the wellbeing of the community through the optimal use of natural resources.

Accordingly, crop yields and farm income improved, job opportunities were created for disadvantaged groups, food supplements were enhanced for livestock, and income sources were diversified at 'moderate' levels, with a score ranging from 54% to 73%. Increased irrigation area was found at a 'high' level of sustainability, with a score of 77%. The indicator-wise assessment of economic sustainability had a score of 68%, which was rated at 'moderate' level. Reference [19] reported that the economic dimension of climate smart practices in northwest Ethiopia had positive outcomes and found at sustainable level.

Participants of the Focus Group Discussion (FGD) and Key Informant Interview (KII) highlighted that watershed management intervention had a positive impact on the well-being of individuals and society in the study area. They mentioned that various watershed management activities, such as biological and physical SWC, resulted in increased surface and groundwater availability. This, in turn, led to increased cropping intensity and expanded irrigation areas, allowing farmers to produce not only crops but also vegetables such as potatoes, carrots, onions, and red roots.

Social Sustainability

The social sustainability of watershed management was assessed by focusing on how management practices impact community well-being, social cohesion, equitable resource distribution, stakeholder engagement, livelihoods, access to social services, and governance. Access to extension services, community awareness, increased recreational opportunities, conflict reduction, food security improvement, and healthcare and social service access were used to measure social sustainability of watershed management. Results indicated that access to extension service, which is an important source of information for any agricultural technology adoption and climate change adaptation, was at 'low' level of sustainability with a score of 48%. The Watershed committee and other community institutions enhance the sustainability of watersheds. Accordingly, building and strengthening community institutions were at 'high' level with a score of 78%. Overall, social sustainability was at 'moderate' level with a score of 60%. This assessment shows conditions for improvement compared to other dimensions of sustainability. Enhancing social sustainability requires promoting social cohesion, community engagement, equitable resource access, and emphasis on education and awareness. The study of [19] reported that the social dimension of climate smart practices in northwest Ethiopia can be sustained but are at risk level.

TABLE III
INDICATOR WISE SUSTAINABILITY STATUS OF THE WULO ABIYE WATERSHED

Indicators	Sub-components	Score	Status
Environmental sustainability	Reduced soil loss	94	High
	Increased groundwater level	77	High
	Increased soil fertility	68	Moderate
	Increased soil moisture	72	Moderate
	Increased vegetation cover and biodiversity	71	Moderate
Economic sustainability	Improved crop yields and farm income	71	Moderate
	Created job opportunities for disadvantaged groups	73	Moderate
	Enhanced food supplements for livestock	63	Moderate
	Diversification of income sources	54	Moderate
	Increased irrigation area	77	High
Social sustainability	Access to extension service	48	Low
	Community awareness	65	Moderate
	Increased recreational opportunities	55	Moderate
	Building and strengthening community institutions	78	High
	Reduced conflict over resources like water	52	Moderate
	Improved food security status	66	Moderate
	Access to healthcare and social services	54	Moderate

A district natural resources expert, a key informant explains:

The implementation of watershed management in the Wulo Abiye watershed has resulted in the formation of a watershed user cooperative. This cooperative provides numerous advantages for land management and sustainability of the watershed, including the development of strategic and annual plans for the watershed, providing support for watershed activities, managing the watershed's resources sustainably, serving as a representative for the watershed in development initiatives, and engaging communities in watershed development to address local challenges.

2. Overall Status of Sustainability

The overall sustainability was assessed from the ratings of each pillar (Table IV). The overall sustainability of watershed management was assessed by considering environmental, economic, and social indicators. Accordingly, environmental sustainability was at 'high' level with a high score of 76%, indicating that natural resource rehabilitation and watershed services were in good condition, contributing to the conservation and improvement of the environment. This approach is beneficial for ensuring ecological health and overall sustainability of management systems. Economic and social sustainability were at 'moderate' level with a score of 67% and 60%, respectively. This suggests more effort is needed to improve economic and social aspects of the watershed. The overall sustainability was assessed from the ratings of each pillar. Accordingly, Wulo Abiye watershed was at 'moderate' level with a high score of 68%. This indicates that the sector is not fully operating in economic, social, and environmental aspects.

TABLE IV
OVERALL SUSTAINABILITY STATUS OF WATERSHED MANAGEMENT S IN THE WULO ABIYE WATERSHED

Indicators	Score	Status
Environmental sustainability	76	High
Economic sustainability	67	Moderate
Social sustainability	60	Moderate
Overall/aggregate	68	Moderate

Despite the significant efforts in watershed management made by the government of Ethiopia, only environmental sustainability was at 'high' level, while the rest were at 'moderate' levels. Environmental sustainability is indeed a central focus of the SDGs, and watershed management plays a crucial role in achieving this objective [9]. As highlighted by [10], watershed management, especially SWC practices, directly contributes to more than 41% of the 2030 UN-SDGs. Nevertheless, results indicated that the need for a balance among environmental, economic, and social aspects.

To achieve sustainable outcomes, it is essential to harmonize the objectives of watershed management with those of the SDGs, comprehensively addressing environmental, social, and economic sustainability. Sustainable watershed management must be environmentally compatible, economically viable, and socially acceptable. This requires integrated and holistic approaches that signify a shift toward sustainable use and integrated system-based management. To achieve this, a comprehensive planning and involvement of stakeholders is needed to enhance the sustainability of the watershed. Continued investment in sustainable land and water management practices, community engagement, capacity building, and conservation of natural resources can contribute to improving the overall sustainability in the watershed. By addressing the identified areas for improvement and building on existing initiatives, it is possible to enhance the sustainability of Wulo Abiye watershed and contribute to the achievement of the SDGs in the other watershed as well. The overall assessment of sustainability in climate smart practices in northwest Ethiopia was found at a risk level [19].

C. Community Participation in Watershed Management

Sustainability of watershed management is closely linked with the active participation of communities in the planning, implementation and evaluation phases of watershed projects [15]. Community participation increases acceptance, builds trust between communities and institutions, eases effective implementation of environmental policy, and develops ownership [35]. This ensures the sustainability of watershed management programs [35].

1. Level of Community Participation During the Planning Phase

During the planning phase of watershed management, the level of community participation was assessed in various activities (Table V). The results indicated that participation across different aspects of the planning process was at 'low' level with a score of 40%. From all aspects of the planning phase, nearly half of the respondents reported that the community was involved in time scheduling. The low level of community participation during the planning phase implies that decisions were made without the consent of the local community. In addition, results obtained from KIIs indicated that watershed management planning was begun from the top management and laid down to the lower administration level without involving the community. This affects sense of ownership which in turn affects the sustainability of the watersheds in the long run. On the other hand, if the community does not participate in the planning phase, it is difficult to properly implement and sustain the watershed activities. This shows the need to enhance community engagement and participation in this critical stage. The findings are similar to a previous study by [36], who reported lower participation of the community during watershed program planning.

2. Level of Community Participation During the Implementation Phase

During the implementation phase of watershed management, 'high' level of community participation was observed with a score of 92%. All respondents participated in SWC work and digging of planting pits. Almost 98% of the respondents were involved in planting seedlings. The high level of community involvement suggests strong government enforcement for labor contributions during the implementation phase. This finding is in line with [13] which reported a high level of community participation in watershed management programs during the implementation phase.

3. Level of Community Participation During the Evaluation Phase

During the evaluation phase, activities such as sharing information and consultation, assessment of results and limitations, and capacity building and empowerment are considered. Some 30% of the respondents participated in information sharing and consultation. About 30% and 39% of the respondents participated in capacity building and empowerment, and assessment of results and limitations,

respectively. The overall community participation during the evaluation phase was 'low' level with a score of 40%. The low level of community participation in the evaluation phases of watershed management programs results lack of follow-up on the structures and willingness to participate in the annual campaigns. The study by [13] also reported low level of community participation in the evaluation phases of watershed management programs.

TABLE V
LEVELS OF COMMUNITY PARTICIPATION IN DIFFERENT PHASES OF WATERSHED MANAGEMENT PRACTICES

Phase	Watershed management activities	Degree of participation in planning phase					Total participation
Planning		Never	Rarely	Sometimes	Often	Always	
	Site selection of watershed area	77	16	4	2	1	23
	Identification of problems	53	37	7	2	1	47
	plan preparation for resource management	60	30	7	2	1	40
	Customary rules	64	23	8	4	1	36
	Time scheduling	51	20	10	19	1	49
	Identification of active work forces	56	16	14	13	1	44
	PPI	60	24	8	7	1	40
Implementing	Soil and water conservation work	-	2	3	45	50	100
	Digging of planting pit		46	25	27	3	100
	Planting of seedlings	2	47	31	18	2	98
	Management activity	31	41	18	9	1	69
	PPI	8	34	19	25	14	92
Monitoring	Sharing information and Consultation	70	13	9	7	1	30
	Assessment of results and limitations	61	25	7	6	1	39
	Capacity Building and Empowerment	70	13	10	6	1	30
	PPI	67	17	9	6	1	33
Overall PPI		45	25	12	13	5	55

4. Overall Community Participation in Watershed Management

Community involvement was most successful during the implementation phase of the watershed management program and rated a 'high' level with a score of 92%. However, community participation during the planning and evaluation phases were at 'low' level, with scores of 40% and 40%, respectively. This indicates that there was greater enforcement by the local government for labor contribution. The involvement of the community in the critical stages (planning and evaluation) was limited. During field survey, it was observed that a significant number of farmers were implementing SWC practices mainly to avoid penalties from local administrators instead of a genuine commitment to the work. Furthermore, most farmers arrive at watersheds in the early morning but leave shortly afterward.

Generally, the overall community participation index was 'moderate' level with a score of 55% (Table VI). The scores indicated that only some decisions were made in consultation with the local community. This finding is in line with the study by [18] who reported a moderate level of community participation in watershed management programs.

Associations between the Sustainability Status of Watershed Management and the Level of Community Participation

Understanding the association between watershed management sustainability and community participation is crucial for natural resource management. Overall, the sustainability status of watershed management and level of community participation were at 'moderate' levels. The study revealed high level environmental sustainability of watershed management while economic and social indexes were moderate. Community participation reached a peak level during the implementation phase. On the other hand, planning and evaluation phases observed moderate level of community participation, indicating varying degrees of involvement at different phases. Limited community participation in planning and evaluation significantly affects the sustainability of watershed management. Similarly, [18] reported inconsistencies in community engagement in different phases of watershed management programs.

TABLE VI
OVERALL COMMUNITY PARTICIPATION IN WATERSHED MANAGEMENT

No.	Participation phase	PPIs values	Level
1	Planning	40	Low
2	Implementation	92	High
3	Evaluation	33	Low
4	Overall PPI	55	Moderate

To address these challenges and achieve sustainable outcomes, it is crucial to harmonize the objectives of watershed management with SDGs in a way to comprehensively address environmental, social, and economic aspects. This approach is vital for ensuring the long-term success of watershed management practices. Thus, understanding the association between the sustainability status of watershed management and community engagement is essential for achieving lasting positive environmental and socioeconomic impacts. A previous research indicated that greater community involvement leads to better sustainability outcomes [35]. When local communities actively participate in decision-making and implementation, long-term success in watershed management is more likely observed [15]. This can lead to program sustainability,

improved resource allocation, increased support for conservation efforts, and enhance policy effectiveness [6].

D. Challenges Faced in Sustaining Watershed Management

Sustaining watershed management faces different environmental, economic and social challenges. Some of these are shortage of farmland, free grazing, lack of follow-up, climate variability, limited youth participation, lack of integration between sectors and stakeholders' sectors, conflicts between households and local leaders, and lack of awareness. Addressing these multifaceted challenges is crucial for sustainable watershed management. These challenges were identified through conducting a field survey, consultation with local agricultural experts and elderly farmers, and reviewing literature [15], [25], [37], [38]. Table VII presented challenges faced in sustaining watershed management.

1. Free Grazing

Results revealed that free grazing is a significant challenge for sustaining watershed management in the study area, with 88% of respondents rating it as a high-level problem. This practice has adverse effects on SWC measures, crop residues, and the overall sustainability of watershed management. Moreover, results from FGDs confirmed that free livestock grazing in watersheds causes damage to biological and physical SWC measures. This finding aligns with the findings of [19] where free grazing is a major challenge in sustaining watershed management activities.

2. Shortage of Farmland

The average landholding size was 0.85 ha, which is less than the national average (1.0 ha). Results revealed that farmland shortage was a critical challenge in sustaining watershed management. About 86% of the respondents reported shortage of farmland as the second most prominent factor affecting watershed management sustainability. In addition, results from KIIs and FGDs participants revealed that shortage of farmland results in reluctance to engage in watershed management practices, particularly physical SWC measures. This finding corroborates the results of [38] who reported that shortage of farm land is a major challenge in sustaining watershed management practices in Ethiopia.

3. Lack of Follow-Up

About 78% of the respondents stated that lack of follow-up was a major challenge for sustaining watershed management. This has made the lack of follow-up the third most important constraint on the sustainability of watershed management activities. Insights from FGDs and KIIs confirm the seasonal and ad hoc nature of watershed management activities, emphasizing the substantial impact of this challenge. Similarly, [19] showed that the problem of sustainable watershed development is associated with a lack of follow-up.

4. Lack of Awareness

About 76% of the respondents reported that the community had low awareness on watershed management. The different SWC measures lack sustainability due to mismanagement and some deliberate actions. Participants in the FGD mentioned that although the community's awareness of watershed management has improved due to the outputs of watershed interventions, it has not achieved the expected level of success. Similarly, [15] reported that the low awareness level of the community in the Amhara National Regional State is an obstacle to the sustainability of watershed management projects.

TABLE VII
CHALLENGES FACED IN SUSTAINING WATERSHED MANAGEMENT

No.	Challenges	% of respondents
1	Shortage of land	86
2	Lack of community awareness	76
3	Free grazing	88
4	Lack of follow up	78
5	Lack of integration between sectors and stakeholders	21
6	Climate variability	50
7	Limited youth participation	40
8	Conflicts between households and local leaders	20

5. Climate Variability

Almost half of the respondents reported that climate variability, particularly frost, was a challenge affecting the sustainability of watershed management. The heavy frost which occurs from October to December and the shortage of rainfall, both impact the sustainability of watershed management practices. Climate variability leads to destruction of biological conservation measures and rehabilitated area closures. The trees planted could not survive because of frost and prolonged dry conditions. The study by [38] reported that climate change often has a negative impact on the sustainability of watershed management practices in Ethiopia. Similarly, erratic rainfall, and recurrent droughts lead to the deterioration of SWC practices in Konso, Ethiopia [39].

6. Limited Youth Participation

Watershed management activities are labor demanding. However, the results indicated there is limited participation of the youth due to landlessness. Some 40% of the respondents replied that limited youth participation was a challenge for sustaining watershed management. According to results from FGD participants, involvement of youth in watershed management is increased from time to time due to the output of watershed intervention such as creating job opportunities from irrigation and forestation activities. However, the intervention was not as successful as expected. The study of [37] showed that the unwillingness of young people to participate in conservation practices due to landlessness is a major challenge in watershed management practices in Ethiopia.

7. Lack of Integration Between Sectors and Stakeholders' Sectors

Lack of integration between sectors and stakeholders' sectors as a major barrier to implementing sustainable watershed management was mentioned by 21% of the respondents. Results from key informant interviews showed that integration between sectors/stockholders is crucial in sustaining watersheds. However, the working environment was very

challenging and marred with corrupt practices in the study town. This finding supports a precious study by [25], which found that uncoordinated interventions of actors and institutions within a watershed were the major challenge in watershed management practices.

E. Conflicts between Households and Local Leaders

Conflicts between households and local leaders were reported by some 20% of the respondents. Results obtained from FGD and KII participants also confirmed that most watershed interventions are made without the consent of the local community. This not only affects the sustainability of the watershed but sometimes leads to conflicts between households and local leaders. Accordingly, some of the structures are deliberately destroyed. The results support [37] which indicated that conflicts between households and local leaders is a major challenge for watershed management practices.

To assess the watershed management sustainability, the indicators approach, integrated assessment tools, and a barometer of sustainability are used depending on the objective, scale, and scope of the assessment. In this study, an attempt is made to develop the sustainability of watershed management using 17 indicators for the three pillars of sustainable development (economic, social and environmental). The indicators are aligned to local and existing conditions of watershed management. Moreover, the level of participation in watershed management affects watershed sustainability. With this assumption, the levels of community participation at different phases of watershed management (planning, implementation, and monitoring and evaluation) are measured using an instrument consisting of 12 activities developed through conducting field survey, consulting with local experts and reviewing literature. The 12 activities reflect the watershed context. These make our model different from the previously developed models.

IV. Conclusions

This study presents an assessment of the sustainable development status of the Wulo Abiye watershed. Indicators were selected from key sustainability determinants covering the economic, social and environmental dimensions as the three pillars identified based on local and existing conditions of the watershed. The results show environmental sustainability was at 'high' level. Social and economic sustainability and the aggregate index were at 'moderate' levels. Level of community participation during the implementation phase was at a 'high' level, while 'low' levels were observed in the planning and evaluation phases of watershed management. This affects sense of ownership, willingness to participate in the annual campaigns and lack of follow-up on the structures which in turn affects the sustainability of the watersheds in the long run. The result indicates a shift in approach to ensure the watershed remains environmentally compatible, economically viable, and socially acceptable. Sustaining watershed management faces different environmental, economic and social challenges which need to be managed in the short and long-term. Understanding the association between the sustainability status of watershed management and community engagement is essential for achieving lasting positive environmental and socioeconomic impacts.

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