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Full Length Research Paper

Effectiveness of watershed management interventions in Goba district, southeastern Ethiopia

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Land degradation is a main ecological and economical problem in Ethiopia. The expansion of agricultural land on steep slope and continuous cultivation of agricultural fields with little protection measures exacerbated the problem. Thus, currently the Ethiopian government launched the new integrated participatory watershed management activity in different parts of the country including Goba District. But, the effectiveness of this management activity was not yet examined. This research is, therefore, intended to evaluate the effectiveness of watershed management intervention in Goba District. The study was mixed research approach which includes both qualitative and quantitative research. Household survey was conducted on 119 randomly selected respondents. Field visit, FGD and transect walk were also used for triangulation. Assessments of design and layout parameters and sediment accumulation were conducted on 60 level soil bunds. The qualitative data were analysed by categorizing in to different thematic areas and narrating. The quantitative data were analysed by using simple statistics with Microsoft excel. The result of the study indicated that soil bund (23.5%) is the dominant physical conservation intervention practiced. Out of measured parameters average depth, height, base width and top width of the bunds are out of the permissible range of Ethiopian MOA standard while average width and length are in permissible range. 100% of the structures have not got any maintenance and 58.3% of them have no any integration to stabilize the structures. The mean sediment accumulation rate of soil bunds is 45.74 t/ha/yr. Major challenges mentioned by farmers about not to construct SWC structures on their farmland were shortage of man power, poor institutional mechanism and lack of follow up and untimely seedling supply. Therefore, institutional mechanisms need to be stronger, regular maintenance and implementation of structures in line with the recommended standards need attention to increase their effectiveness.

Keywords: Watershed, soil and water conservation, tree planting, effectiveness, sediment accumulation, soil bund.

INTRODUCTION

Land degradation, which includes degradation of vegetation cover, soil degradation and nutrient depletion, is a major ecological and economical problem in Ethiopia (Hailesilassie et al., 2005). But, effective use of land and water is fundamental to growth and sustainable development. The concept of watershed management has evolved to ensure effective use of both natural and social capitals. It has been essential in a country like Ethiopia where majority of the population depends on agriculture. A large portion of the arable land in Ethiopia is characterized by low productivity, high risk and uncertainty, low level of technological change and vulnerability to degradation of natural resources (Lemma and Menfes, 2015).

To address the land degradation and loss of soils, extensive conservation schemes were launched in Ethiopia, particularly after the famines of the 1970s and 1980s (Woldeamlak, 2006). Since then, huge areas have been covered with terraces, and millions of trees have been planted (Herweg, 1993; Woldeamlak, 2006).

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However, the success rate has been minimal (Adimassu et al., 2012). This may be recognized to lack of involvement of local people in planning and implementation of the scheme and poor implementation and maintenance of the soil and water conservation structures (Wood, 1990; Herweg and Ludi, 1999). Azene (1997) explained that only 25 % of the rehabilitation target has been accomplished and most of the physical soil conservation measures and community forest plantations were destroyed in Ethiopia. Those failures were due to poor watershed management approaches that were especially focus on physical structures, not farmer's interest oriented and which was also non-participatory (Lakew Desta et al., 2005; World Bank, 2008; Waga and Jermias, 2013).

Following those drawbacks of the past approach, the Government of Ethiopia is undergoing community based watershed management activities throughout the country especially during the last 5 years (BOARD, 2012). According to Goba District Bureau of Agriculture, there are intensive watershed management activities in the local areas following the program launched by the government and almost all kebeles of the District practicing different soil and water conservation activities including both physical and biological measures. But still, the follow up for those interventions is weak and there is poor maintenance of physical structures. Effectiveness of those conservation activities for the local condition was not continually evaluated throughout the country (Kebede et al., 2013). As it is also the Governmental strategy to solve natural resources degradation and improve productivity for future sustainable development, the issue should have to get more attention.

This being a general scenario, no much study is yet done to measure the effectiveness of watershed management activities in terms of its physical and biological contribution in Goba District (the study area). This study was, therefore, intended to evaluate the effectiveness of watershed management interventions in Goba District through identifying the major watershed management interventions implemented, investigating the environmental contribution of watershed management activities, evaluating selected intervention measures in terms of their scientific standard, assessing the perception of the local community towards the intervention and identification of supporting institutions.

METHODOLOGY

Description of study area

Location: Goba District is one of the Districts' found in Bale Zone South East Ethiopia. It is located between 39^o 37' 30"– 40^o 12' 00"E and 6^o 38' 0" – 7^o 4' 0" N (Figure 1).

Topography and land use: About 45% of this District is rugged or mountainous; Mount Tullu Demtu is the highest point in this District, the Zone and the Oromia Region; other important peaks include Mount Batu. Rivers include the Togona and Shaya. A survey of the land in this District shows that 13% is arable or cultivable, 27.6% pasture, 54.6% forest (or part of the Bale Mountains National Park), and the remaining 4.8% is considered degraded or otherwise unusable (BOARD, 2012).

***Climate*:** As a part of Bale zone, Goba District has two types of rainfall regime. The long rainy season extends from March to April with high rain fall during June, July and August. The second rainy season of rain fall regime is influenced by equatorial westerly and easterly winds with rainfall during spring and autumn. The altitude of the District ranges from 1500-4377m a.s.l and the temperature varies from some times less than 0^{O}C - 23^{O}C (BZMED, 2007).

Soil and vegetation*:* The major soil types are Chromic and Pellic Vertisols in some parts, Chromic, Orthic and Vertic Luvisols around highlands and plateaus areas. The common vegetation are Afro-alpine and sub Afro-alpine vegetation which are prevailing in limited areas above 3400m of massif and found in mountain tops of Sanete plateaus and surrounding prominent mountain peaks. *Junipers procera* forest associated with *Hagenia abyssinica* and Olea trees are found at altitudes ranging from 2300-3100mm. The forest areas are also well known for their flora and fauna diversity as well as endemicity (BOARD, 2012).

Demography: According to Central Statistical Agency (CSA, 2007), the study area has a total population of about 75,809 with population density of 33 person /km^2. The average family size is 6.The average land holding size is about 1.02 ha.

Sampling Technique and Sample Size Determination

For this study, a reconnaissance survey was made to observe watershed management activities undertaken. Based on the preliminary survey, the *watershed areas in* which the local community is highly practicing watershed management activities were selected purposefully. After selection of each *watershed*, simple random sampling was employed to select sample households (HHs) to be involved in the study. Assessments of design and layout parameters and sediment accumulation were conducted on 60 systematically selected level soil bunds.

According to Dickson and Nyariki (2009), in agricultural socio-economic research usually with a 95% confidence level and an error margin of less than 10% is considered representative. The sample size was calculated using a standard formula following Freund and Williams (1983);

$$n = \frac{(z)^2(pq)}{(d)^2}$$

$$\frac{(1.96)^2(0.5*0.5)}{(0.09)^2} = \frac{0.96}{0.0081} = 118.5 \approx \mathbf{119}$$

Where: *n* = sample size

z = statistical certainty usually chosen at 95% confidence level, that is, *z* = 1.96

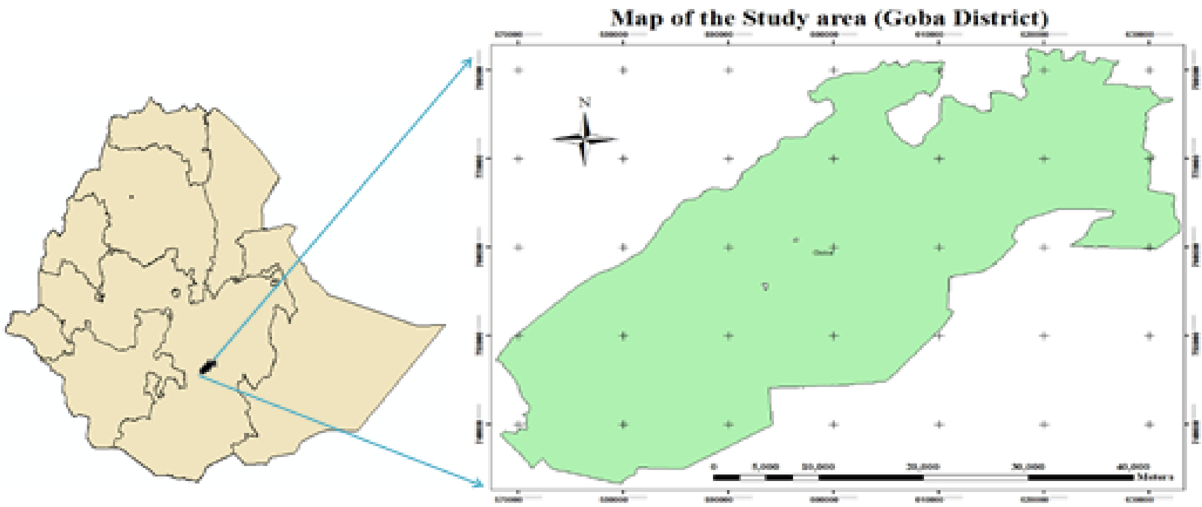

Figure 1. Map of the study area (Goba District).

p = estimated level/coverage to be investigated, usually *p* = 0.5 is chosen
q = 1-*p*
d = precision desired, which need to be less than 10% and then for this research *d* = 9%

Data Collection Methods

Formal and informal surveys were employed. Data were collected through semi-structured interview, Focus Group Discussion, field observations and field measurements. A semi-structured interview was made by local language (Afan Oromo). Key informant interviews were also made with knowledgeable people in the area who are supposed to participate in the development works.
Key informants were selected with the help of development agents (DAs) and Kebele administrators. The DAs and the kebele at each kebeles were also a part of key informant interview since they are the role play for the intervention. A total of four focus group discussions which have eight members were under taken for the purpose of triangulation. Two focus group discussions were made with women and men.

Estimation of deposited soil

To estimate the amount of deposited soil, a transect line was drawn along the gradient within each mini-watersheds at which SWC practiced. From SWC structure fall on the transect line the researchers systematically selected the structures that were considered for this study. A soil samples were collected from the deposited sediment for bulk density measurement by using Core Sampler of 3cm diameter. Soil bulk density were determined from the oven dry (at 105°C for 24 hours) mass of soil and volume of the undisturbed soil using core sample method (Landon, 1991) in Madda Walabu University Soil Laboratory.
The accumulated sediment rate (t ha^{-1} yr^{-1}) behind and inside physical structures were estimated by adopting the equations described by Gebrermichael et al*.* (2005) as:

$$A_A = \frac{0.1MA*N}{T} = \frac{10MA}{(T*D)} \text{-----------------} 1$$

$$MA = BD * VA - - - - - - - - - - - - - - \mathbf{2}$$

$$VA = WA * HA - - - - - - - - - - - - - - \mathbf{3}$$

Where*: A_A is the annual sediment accumulation inside structures (t ha^{-1} yr^{-1}); MA, mass of accumulated sediment per unit length (kg m^{-1}); T, age of the structure (yr); D, average spacing between structures (m);N, number of bunds with hectare which is 100/D; BD, dry bulk density of sediment accumulated inside structures (kg m^{-3}); V_A, the unit volume of accumulated sediment (m^3 m^{-1}); H_A = depth of the accumulated sediment (m); W_A, width of the sediment zone; and *, multiplication symbol.*

Measurement of physical structures layout and design

The layout and design of soil bunds were evaluated by comparative analysis with the scientific standards of ministry of agriculture (MOA) (Lakew Desta et al., 2005). The indicators were slope requirements, width, height, spacing, length, base width, top width and management requirements. For this purpose sub-watershed at which soil bunds were constructed were selected based on preliminary survey and then transect line were laid along the altitudinal gradient. Following the transect lines the bunds were systematically selected by avoiding the boarder bunds to reduce the biasness.

Data Analysis

The qualitative data were analyzed by categorizing in to different thematic area and narrating each topic separately and the quantitative data collected by formal survey and direct measurement were analyzed by using simple statistics with Microsoft excel.

RESULT AND DISCUSSION

Major Watershed Management Interventions

As one of the highland part of Bale Zone, the study area exposed to degradation of natural resources, particularly vegetation and soils. Efforts have been made in Bale Zone including the study area, mainly by Office of Agriculture and rural development to mitigate the problem more intensively in the last 5 years (BOARD, 2012). Physical soil and water conservation as 'improved' practices have been implemented and promoted by the office and some concerned Organizations. The greater part of SWC effort made in the area was directed to controlling soil loss from cultivated fields. According to the results from the survey most of the sampled respondents indicated Soil bund (23.5%) is the dominant physical conservation intervention practices in the study area followed by waterway (21%) and gully treatment (17.4%), respectively (Table 1).

Evaluation of Soil Bund design and layout

The soil bunds were selected for the reason of its intensive implementation in the study area. The other types of SWC structures were also constructed but they are rare and not researchable due to they were already destructed and difficult to take design and layout parameters measurements. Totally, 60 soil bunds were randomly selected and depth, width, height, base width, top width and length of the bunds were measured and recorded. Finally, the parameters were compared with scientific standards of MOA guideline for watershed development in Ethiopia. Generally, the result of the study indicated that *out of measured parameters average depth, height, base width and top width of the bunds are out of the permissible range of Ethiopian MOA standard while average width and length are in permissible range* (Lakew Desta et al., 2005) (Table 2).
This result indicated that about 98.6% of its ditch depth, 85.8% of embankment height, 98% of embankment base width and 96.4% of embankment top width were out of the range of MOA standard (Table 2). This value shows there were poor construction effort and no emphasis were made on scientific standard.

Management effort and compatibility of soil bunds with slope condition

The result of the field survey indicated that out of 60 observed soil bund structures 100% of them have not got any maintenance and 58.3% of them have no any biological integration to stabilize the structures. Even, 41.7% of them were stabilized with species not recommended for bund stabilization (Figure 2). Nyssen et al*.* (2007) indicated when the depression behind the bunds gets filled with sediment and they have no maintenance, their trapping efficiency strongly decreases. The mean slope of the study area were 23.24% with standard deviation of 7.8 while a minimum and maximum slope recorded during the collection of data for evaluation of conservation measures were 9.5% and 37.5%, respectively. These result indicated that the mean of the slope were not compatible for soil bund. Additionally, the result from survey indicated that from 60 observed soil bunds 63% of them are not compatible with the slope condition. The watershed development guideline developed by MOA of Ethiopia restricted soil bunds for the areas which have below 20% slope range (Lakew Desta et al., 2005).

Sediment Accumulation of soil bunds

The result of field survey indicated that the mean sediment accumulation rate of soil bunds in the study area were 45.74 t/ha/yr (Table 3).
Bewket and Sterk (2003) indicated soil loss rates ranging between 18 to 79 t/ha/year from two micro-watersheds in northwestern highlands while Nyssen et al*.* (2007) reported 57.3 t/ha/yr in North Ethiopia and also stated effective soil loss reduction by the bunds is 68% while sediment accumulation rate were 57t/ha/year. When the result of this study compared with Nyssen et al*.* (2007) it is very encouraging and the mean annual soil accumulation estimated in this study is larger than the mean annual soil loss of 42 t ha/yr predicted by Hurni (1988) for Ethiopian cropland.

Farmer's View of Watershed Management Interventions

Empowering farmers to have a now how to alleviate degradation and how to maintain sustainability of natural resources through training has a great contribution in conserving watershed resources. The result from survey indicated most of the farmers support the positive impact of SWC structure on their farm land. Out of the selected farmers more than 85.8% of them address that SWC structures have advantage **(**Figure 3**)** by improving their

Table 1. Major Soil and Water Conservation Practices introduced to the study area.

No.	Major SWC Practices	Frequency	Percent
1	Soil bund	73	23.5
2	gully treatment	54	17.4
3	Water ways	65	21
4	Cutoff drain	43	13.9
5	Stone bund	15	4.8
6	Area Closure	36	11.6
7	Tree & grass Planting	24	7.7
	Total	**310**	**100**

Table 2. Mean values (±SEM) of selected soil bund design & layout parameters (N = 60).

Comparison	**Soil Bund Design & Layout parameters**					
	Trench/Ditch		**Embankment**			
	Depth (m)	Width (m)	Height(m)	Base width (m)	Top width (m)	Length (m)
Goba Woreda mean value	0.329 (±0.0112)	0.572 (±0.48)	0.252 (±0.035)	0.428 (±0.024)	0.237 (±0.039)	59.5 (±3.587)
MOA standard	0.5- 0.6	0.5- 0.6	>0.6	1- 1.2	0.3-0.5	30-60
Percent of structures in range	1.4%	46.5%	14.2%	2%	3.6%	83.3%

land through preventing erosion, increasing in land productivity, increase soil depth and, moisture conservation. The study conducted in Amhara Region by Addisu et al. (2013) also indicated that the participants had evaluated the SWC works as good. Similarly, 92% have believed there were differences between conserved and none conserved areas in terms of soil erosion problems and productivity. Farmers asserted that their conserved farm plots are more fertile than the non-conserved ones since the latter are more prone to soil erosion than the former. In similar study conducted Gunano watershed of Wolaita southern Ethiopia farmers perceive that soil bunds improve the fertility of the soil and then increase yield (Esser et al., 2002). The study conducted in Bokole watershed, Southern Ethiopia also indicated that soil bunds have the capacity to improve the productivity of the soil (Kebede et al., 2013). Additionally, 87% of the respondents indicated that the watershed management interventions in the study area were highly focused on solving priority problem of the local people (Figure 3). This indicates that watershed management intervention maintaining soil through protecting soil from different degrading factors.

From the survey and group discussion it was observed that currently Governmental Organizations working in the area provide technical and material support including short and long term trainings concerning watershed management interventions. Farmers of the area received regular technical advice from DAs or other technicians. The more the farmers gain important message and advices on soil conservation, they become more initiated and interested to do soil conservation activities (Paulos et al., 2004). This also will help farmers to be aware of the importance of soil conservation practices.

However, both during focus group discussion and interview the farmers' response (61.1%) indicated that there were no institutional mechanisms to manage assets created during watershed management interventions. This leads constructed structures to destruction by plowing, livestock interference and lack of maintenance. Addisu et al. (2013) indicated that establishment of community based monitoring and follow up system and managing information (related to watershed management) by the community itself need to be major focus area of the intervention. World Bank (2008) also stated that watershed management works best when there is a supportive policy and legal framework, particularly (a) policies that facilitate decentralized and participatory development, (b) institutional arrangements that allow and encourage public agencies at all levels to

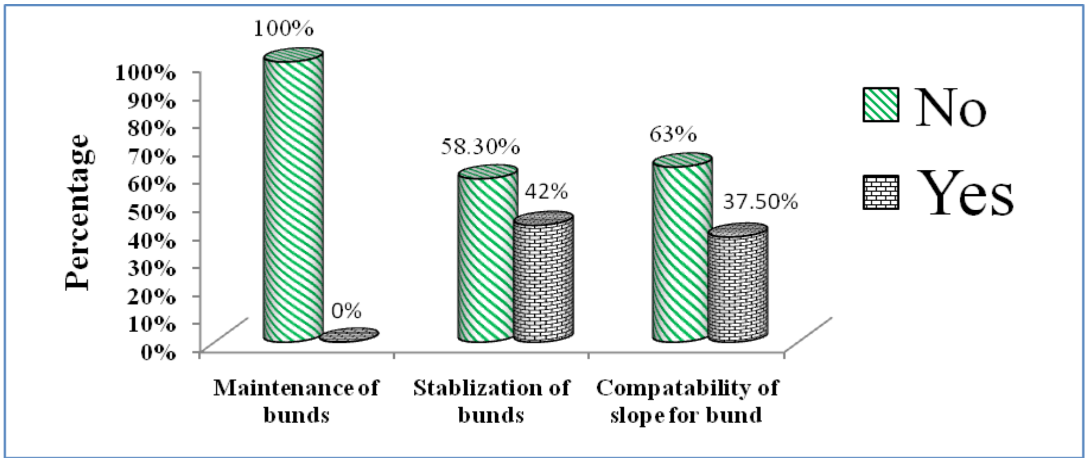

Figure 2. Evaluation result of soil bunds interms of maintenance, stability and compatibility.

Table 3. Sediment accumulation rate (t/ha/yr) of soil bunds surveyed in the study area.

N	Mean	Std Dev	Minimum	Maximum	Std Error
60	45.741	18.073	13.649	95.126	3.689

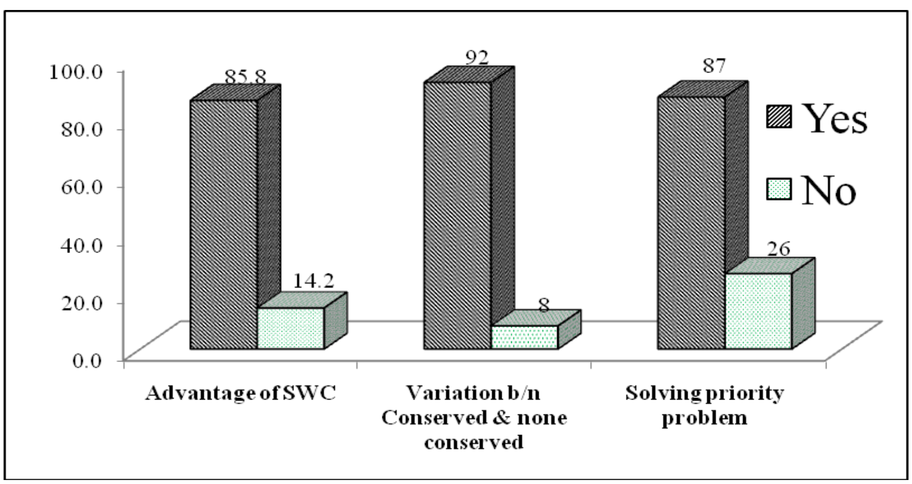

Figure 3. Role of watershed management interventions in Solving Priority Problems.

work together, and (c) an approach to access to natural resources that reflects local legislation and tenure practices and problems.

CONCLUSION AND RECOMMENDATION

CONCLUSION

From the result of the study the researchers concluded that soil bund (23.5%) is the dominant physical conservation intervention practices in the study area followed by waterway (21%) and gully treatment (17.4%), respectively.

Out of measured parameters depth, width, height, base width, top width and length of the bunds all parameters are out of the range of Ethiopian Ministry of Agriculture standard except width and length of the bunds. This indicated that the design and layout of structures were not constructed in line with the scientific standard. This shows there were poor construction effort and no emphasis were made on scientific standard.

Out of 60 observed bunds 100% of them have not got any maintenance and 58.3% of them have no any integration to stabilize the structures. This result indicated the structures are under destruction and they may have no sustainability.

The mean sediment accumulation rate of soil bunds in the study area were 45.74 t/ha/yr which indicate the good environmental contribution of bunds.

72.6% of respondents indicated there is erosion problem on their farm land but 59.3% of them have no any SWC structures on their farmland. Major problems mentioned by household farmers about not to construct SWC structures on their farmland were due to shortage of man power, gentle slope nature of the land and land shortage as structures reduce farm size and due to they didn't accept even the SWC structure works to construct on their farm lands. Institutional mechanisms were very weak to manage conservation assets created in the study area through watershed management intervention.

RECOMMENDATION

- Layout and design of bunds, maintenance and management of created asset need due attention
- In addition to people participation which is recognized as key to the success of sustainable watershed management plan, all stakeholders, downstream users of watershed resources, government concerned institutions, NGOs and other concerned parties should be involved from the very beginning in watershed management plan.
- Institution buildings for watershed management need to be raised as one of the most neglected part of watershed projects. In this respect, it is being recognized that there is a need for improved understanding and identification of institutional and organizational arrangements required for an effective watershed management
- The current watershed management approaches mostly focuses on soil and water conservation, but effective watershed management requires multidisciplinary and innovative approaches based on the local situation.
- A detailed baseline survey of the watershed is needed before onset of the watershed activities at watershed level to understand and document the impact of intervention.

CONFLICT OF INTEREST

The authors declare that there is no conflicts' of interest regarding the publication of this paper.

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