The impact of SWC measures on social, environmental and economic aspects in Mizraf watershed in Tigray

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Abstract- The general objective of the research was to assess the impact of SWC measures on social, environmental, and economic aspects in Mizraf watershed in Tigray, Northern Ethiopia. Data were collected through semi-structured interviews, transect walks, field observation and field measurements demonstrated that Degradation Status after implementation of SWC highly reduced & all most 80% of it was reclaimed. The results of the positive impact of SWC measures implemented in this watershed were. The gully depth averagely reduced to 1m deep & it is all most dead (reclaimed). New spring water developed its discharge was measured 42.3 lit per second and the tunneling, rill, and sheet erosions are ceased out and this contributed to land productivity. However, some of the check dams constructed in both the upstream and downstream parts of the landscape collapsed due to faulty construction, and the Bureau of Agriculture as well as the Food for Work campaign program coordinators did not give enough follow-up and monitoring of check dam maintenance.

Index Terms- land degradation, impact assessment, soil and water conservation, Mizraf watershed, northern Ethiopia

I. Introduction

1.1 . Importance and principles of SWC

Under natural conditions, the protection of soil loss depends on selecting an appropriate strategy of soil conservation [1]. Soil and water conservation are crucial at preventing the loss of nutrients from agricultural land, prevent pollution of water bodies, reduce rates of sedimentation in reservoirs, rivers, ditches, and canals [2]. The basic principles of controlling soil erosion by runoff include reducing rain droplets on the soil, reducing runoff volume and velocity, and increasing the resistance of the soil erosion[3, 4]. The two technical means by which the principles of soil and water conservation can be achieved are the barrier approach and the cover approach [3, 4].

1.2. Impact of Soil and Water Conservation Measures

The basic advantages of SWC structures are to significantly reduce soil loss and its consequences. In practice, the loss of soil particles and essential plant nutrients and applied fertilizers can be reduced through the structures. In addition to that, the reduction of slope length between structures also reduces the volume of runoff and thereby reduce soil loss. Most structures gradually develop to the bench and decrease the slope gradient and velocity of runoff. Owing to these characteristics of the structures, [5]. [6] reported that grass strips, bench terraces, and fanyajuu reduce soil loss by 40, 76, and 88%, respectively, compared to the land without those structures.

In Debre Mewi, Ethiopia, stone bund and soil bund decreased soil erosion by 72.9 and 83.7%, respectively compared to non-treated land [7]. In northern Ethiopia, especially in Tigray, the stone bund is current in reducing soil loss by 68% particularly at an early age. Its effectiveness decline as the gradient on the upslope side of the bunds accumulates sediment and thus needs frequent maintenance to keep the effectiveness of the bunds [8]. Another study in the Tigray region reported that stone bunds can trap as much as 64% of the soil moved by water erosion [9]. Even though soil bunds decrease soil erosion by 47% in an experimental site established in the central highlands of Ethiopia when compared to the non-terraced land, the absolute soil loss from the terraced site was still high (24 t ha-1 year-1) [6]. and required certain techniques to reduce soil loss to a recommended tolerable range [4] And in the Somali region [10], compared to the untreated site.

In Tanzania, the construction of physical SWC was effective in conserving soil moisture (26-36%) compared to the land without those structures, [5]. The higher yield and biomass production at the upslope of the stone bund are attributed to, among other advantages, the moisture-conserving role of those structures [8]. The second-order stochastic dominance analysis in the Hunde-Lafto area, in eastern Ethiopia, inferred SWC alleviated the adverse impacts of soil moisture stress in crop production, especially in the circumstance of unfavorable rainfall[11].

The soil system remains a basic factor of crop yields when compared with plant genetic potential and weather conditions because of the environment it provides for root growth [12]. Therefore, increasing and sustainable agricultural production should focus on only maintaining higher levels of useful biological productivity but also at ensuring that the system is stable enough to maintain soil quality [13]. The key soil characteristics that affect agricultural yield sustainability are nutrient content, water holding capacity, organic matter content, soil reaction, topsoil depth, salinity, and soil biomass [2]. The relationship between soil erosion and soil productivity is multifaceted and includes various factors which often depend on each other [14]. The effect of soil erosion on soil properties and hence crop yield varies with location and management [12]. Generally, the loss of soil organic matter and minerals influence crop production [15]. Erosion can also have a direct impact on production through the formation of rills and the following washing out of seeds or through the accumulation of eroded materials on germinated crops [14]. However, total soil is the solitary most important factor in explaining productivity changes [16]. Therefore, the total soil loss can be reduced by physical SWC measures, among others.

Agricultural productivity and SWC objectives are highly complementary because conservation of soil, water, and natural vegetation yield to higher crop productivity and livestock, and thus the improvement of livelihoods [17]. [16] reported that without any SWC, crop yields will decline approximately by 1.5% year-1, being equivalent to a 30% decline over 20 years. The SWC structures not only act as merely a barrier to water-induced erosion but also form a total barrier to tillage erosion[7].

The physical SWC techniques are deemed as an investment for which a substantial benefit is speculated later and for years to come. However, practical models and empirical equations are less available to project the effects of SWC structures, as they touch many parameters and create a complex matrix. Moreover, the off-site role is less feasible to predict and commonly overlooked even in existing estimations and computations.

The short-term impacts of bunds or terraces are the reduction of slope length and the formation of small retention basins for runoff and sediment and to reduce the quantity and eroding the capacity of the overflow [18]. The medium and long-term effects of bunds include the decrease in slope gradient by forming bench terraces [19]. In the long term, slow-forming terraces created by bunds are often related to high spatial variability in soil fertility and crop response which is because of soil moisture and tillage erosion in between structures [18].

The study by [11], in the Hunde-Lafto area in eastern Ethiopia, showed that SWC resulted in higher yields in scarce rainfall conditions. Grass strips, bench terraces, and fanyajuu have increased maize yields by 29.6%, 101.6%, and 50.4% and bean yields by 33.3%, 40%, and 86.7%, respectively as compared to sites without those structures [5]. The effect of SWC structures is detected after several years of the structure being built. In three-year-old structures, [20]. documented 10 and 15% yield increments in Debre Mewi and Anjeni (Ethiopia) watersheds, respectively, as compared to the yield before constructing those structures (fanya juu, soil bund). In this study, yield reduced in the first and second years. In line with this,[21] reported that 79.3% of the interviewed farmers observed the increment of yield after 2 years of SWC structures (the soil bund and stone bund) were put in place. [22]. indicated a 4-50% reduction in yield during the first 3-5 after the construction of SWC structures due to waterlogging problems followed by subsequent yield increases ranging from 4-15%.

[18] reported that after a few years of its construction, stone bunds increased cereal and teff yields by 8 and 11%, respectively, even by considering the area lost as the result of the conservation structures. Indigenous stone bunds (Kab) sites have improved sorghum yields by 56-75% as compared to another non-terraced land in north Shewa, Ethiopia[19]. [23] showed that stone bunds, soil bunds, and grass strips have a significant output on crop yield in the low rainfall areas of the Blue Nile basin in Ethiopia and high risk-reducing effects in high rainfall areas. This current study indicated that grass strips have the highest production elasticity among SWC technologies in this low rainfall area. In these areas soil bunds have risk averting impacts. The stone bunds elapsed 3-21 years increased crop yield by 0.58-0.65 t ha-1 in Tigray, Ethiopia[18] .

Stone bunds contribute to agricultural productivity because of soil moisture conserving role. Results based on multiple plot observations per household showed agricultural sites with stone bunds are significantly productive than those without it in dry areas but not in the high rainfall areas of northern Ethiopia[24]. [8] projected the yield variations on sites with stone bunds and estimated a 7% increment compared to non-terraced site.

Soil erosion and sedimentation are natural phenomena involved in landscape formation [25],. For decades, the off-site impact of land degradation mainly in the form of soil erosion is a widely reported and even more negative impact on the economy than on-site impact, especially in developed countries. Notable off-site impacts are siltation, eutrophication, water yield and flooding, and damage on infrastructures. Reservoir sedimentation has tremendous economic and environmental impacts. Some of the experienced impacts include the Consequence of storage loss on production loss, downstream effects of reservoirs on the river bed, reduction in efficiency of power generation due to sedimentation, and contamination due to sediment[26],. Between 1950 and 1970, mega irrigation schemes and hydropower dams were constructed in Asia, Africa, and Latin America to stimulate agricultural development and economic development while ensuring water and electricity supply[27]. faced a siltation problem. It is estimated that 1.5 billion Mg of sediment is deposited each year in the USA reservoirs [28]. In Australia, for major dams constructed for domestic water supply, agriculture and mining were completely silted in 25 years. According to the Egyptian Aswan high dam lifespan is only half of the original design life due to high inflow of sediment from Ethiopian highland. In Ethiopia, the problem of siltation is even more serious than the other parts of the world owing to the high intensity of rainfall, rugged topography and where more than 85% of the population depends on agricultural activates for their livelihood. For instance, investigation on 50 micro dams constructed for an irrigation scheme in Tigray region showed that the area-specific sediment yield of the reservoirs ranged between 345 to 4935 t/km/year with a mean of 1900 t/km/ year, the figure higher than global and Africa average of about 1500 and 1000 t/km/year. Many dams constructed to store water for irrigation and drinking were being silted up while under construction [29, 30]. Serious sedimentation is in the Borkena dam, in northern Ethiopia where the dead storage volume of the reservoir completely silted before construction ended [22]. [1] reported an earth dam in the headwaters of Modjo River was filled with 96000 m3 of silt only two years after construction. Nationally investment in hydroelectric dams in Ethiopia is mainly in the Omo-Gilgle basin. Although no sufficient research on the issues, emerging evidence depicted that the sustainability of Gilgel Gibe dams was under question. For stance, [1] reported that Gilgel Gibe river alone contributes sediment load of 277,437 t/year and the total sediment load of 4.50 × 107 t/year to Gilgel Gibe I and this amount could cover 3.75 × 107 m3/year of the dam volume. The authors concluded that the Gilgel Gibe dam would be filled up in 24 years whereas it was planned to serve for 70 years. The Soil and Water Assessment Tool (SWAT) model by [1] similarly confirmed a drastic increase in sediment flux to Gilgel Gibe dam I if business as usual continued.

1.3. The objectives of this study

The general objective of the research was to assess the impact of SWC measures on social, environmental, and economic aspects in Mizraf watershed in Tigray, Northern Ethiopia**.**

Specific research questions are:

- What are the success or failure of previous conservation measures?
- What is the positive effect of SWC measures on land Degradation, Spring source, Gully size, Status of the surrounding cultivated land and crop production productivity?
- What are the major lesson learned and recommendations for up-scaling successful practices?

II. Materials and Methods

*2.*1. Background of the study area

This study was carried out from August 2017 to June 2018 to assess the various impacts of SWC measures implemented in the Mizraf watershed in the Tigray region, northern Ethiopia. It was selected for the study due to its representativeness concerning intensive SWC practices such as stone bunds, hillside and bench terraces, trenches, gabion check dams and exclosure with enrichment of plantations have been carried out. SWC interventions have been started before 15 years ago in this watershed, but they have not been evaluated scientifically;

Elevation varies between 2002-2600 m above sea level and the watershed has a total area of 385 ha (i.e from this about 22 ha is cultivable land and the rest 363 ha is hillside. The number of households and the total population in the watershed were 26 and 140 respectively. The landholding size of most farmers in the study area was less than one ha. The rainfall is unimodal but erratic in variability and amount within and among seasons. The main rainy season is very short and extends from June to the first week of September. The mean annual rainfall is 650 mm and the mean monthly temperature during the growing season ranges between 17-29^{o}C (Ethiopia National Meteorological Service Agency, 2016, Unpublished). Mizraf watershed is categorized by different landscapes that range from flat or undulating plains and rolling land to steep mountains and very steep escarpments. Topography affects the type and concentration of SWC measures to be used. The degradation of landscapes also varies as one moves from flat to steep areas. The soil types vary according to the landscape. The chief soil kinds are cambisols on undulating plains and rolling land, vertisols on hilly and steep to very steep lands, and vertisols on flat and plateau landforms. The farming system is predominantly crop-oriented. Teff cultivation (Eragrostis tef) is the dominant cultivated land followed by wheat (Triticum Vulgare). Other crops such as barley (Hordeum vulgare) and maize (Zea mays) are also imperative crops. Irrigation is also extensively practiced in the study site. Despite the high crop diversification in the watershed, yet we observed that there is a need for crop productivity to be improved by appropriate cropping systems and soil and water management practices. Livestock husbandry is also vital in the farming system, but stock numbers are being declined because of fodder shortages. The vegetation is scant and has been overgrazed for centuries and comprises of shrubs and small trees with little economic value.

2.2. Data collection

Primary and secondary data were collected related to the environmental, economic, and social impact assessment of SWC measures in the watershed. Primary data were gathered from farmers' semi-structured questionnaire interviews, group discussions, field measurements, and observations. Before and after comparisons of indicators of environmental, economic, and social impact were used during data collection. Secondary data such as climate, demographic, and other related data in this study were collected from the Bureau of Agriculture. The topographic transect walk method was employed for the assessment of natural resources and existing SWC measures in the watershed.

The major data collection instruments were semi-structured questionnaires interviews, field measurements, and observations to investigate the impact of SWC measures on social, environmental, and economic aspects in Mizraf watershed in Tigray, Northern Ethiopia. During the field measurements and observations appraisals of the vegetation and density, the impact of the existing SWC measures, level of erosion before and after the SWC program, and levels of SWC measures at different parts of the landscape were recorded.

2.3.Data analysis

Quantitative data was analyzed using Statistical Package for Social Sciences (SPSS) and the result was presented in tables. Qualitative data obtained through interviews were analyzed by using content analysis. It followed the following steps: identification of the main themes, assignment of codes to the main themes, and classification responses under the main themes. Finally, the information from key informants was categorized into themes that were used to cement the findings of the study.

III. Result and Discussion

3.1.Socio-demographic Characteristics of Sample Households

The study result shows the key demographic and socioeconomic characteristics of the surveyed households. A large percentage of household heads (65.1%) were males whereas females constituted the remaining proportion (34.9%). Family sizes ranged from one to 8 persons, with an average family size of 4.9 persons. About 32.2% of respondents had between one and five household members, while a majority (67.8%) of them had six or more members in the family. Most of the surveyed households were engaged in mixed farming activities (85.3%), and some of them (2.5%) were engaged in some form of off-farm activities like petty trading and informal labor,. The landholdings of households in the study area varied from 0.5 ha to 1.1 ha with an average holding size of 0.8 ha per household. A large number of households were aware of land degradation particularly soil

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erosion, soil nutrient depletion, and development of gullies as major problems in their localities.

3.2. Impact of SWC Measures on Social, Environmental and Economic aspects in Mizraf watershed in Tigray Region, Northern Ethiopia

For the last two decades, the problem of soil erosion has been of great concern in the Tigray region in general and the Mizraf watershed in particular. This is because inappropriate land management practices coupled with intensive rainfall and steep terrains resulted in big gullies, topsoil erosion, and poor soil fertility. To minimize the effects of soil erosion, the governments of the region and country have allowed the implementation of SWC programs at a watershed level. The consequences of different measures were assessed in this study in different land uses to evaluate the positive impact on soil, water (moisture), fertility, biomass, and reduction of soil and water losses with run-off by comparison with the situation before/after the program.

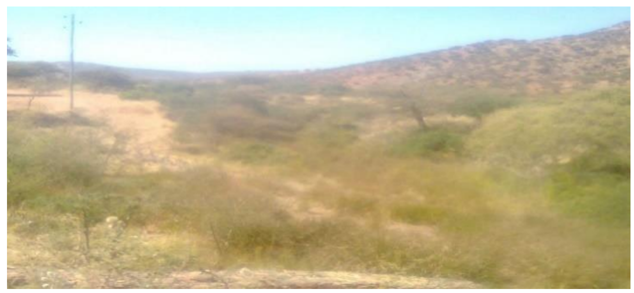
3.2.1 Environmental Impact

One watershed is selected to see the environmental impact of “Mizraf”, watershed. The watershed is almost completely treated with different soil and water conservation structures mainly deep trench, percolation ponds, and stone-faced trench integrated with gabion check dams and biological SWC plants like Elephant grass, Vetiver grass, poplus tree, “Leusnia”, “Sasbania Sasban” e.t.c.seen photos below.

Comparing between pre-and post-implementation of the SWC measures according to farmers’ qualitative evaluation gully

A) The photo was taken in Dec. 2009

B) The photo was taken in Dec. 2011



C) The photo was taken in September 2019.

Figure 1: The impact of SWC measures on gully reclamation (Photo A, B, C)

Table 1: Shows the general changes on gully reclamation before after the implementation

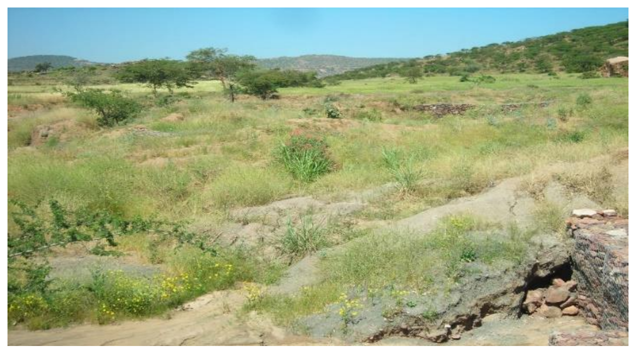
Degradation Status before implementation	Degradation Status after implementation	Spring source Status before implementation	Spring source Status after implementation	Gully size before implementation	Gully size after implementation
It was fragmented, very deep, highly exposed to erosion	It is highly reduced & all most 80% of it is reclaimed.	It was very dry fragmented, very deep, highly exposed to erosion	The water sprout out on the gully stays till December &January. One hand pump constructed from the developed water service for the community throughout the year. Some ponds around the banks of the gully also for their animals.	The depth of the gully was about 3m deep, 12m wide & it was actively expanding.	The gully depth is now averagely about 1m deep& it is all most dead (reclaimed).

Source filed measurement (2019)

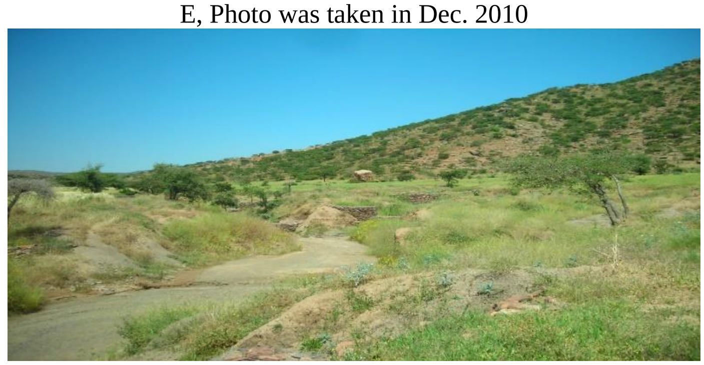
Figure 2: Biological SWC activities integrated with physical SWC activities in gully reclamation

3.2.1.1. Degradation Status before and after implementation

D, The photo was taken in September 2008 before implementation



E, Photo was taken in Dec. 2010



The photo was taken in Dec. 2011

F, Photo was taken in Dec. 2011

Figure 3 Degradation Status before and after implementation (D, E, F)

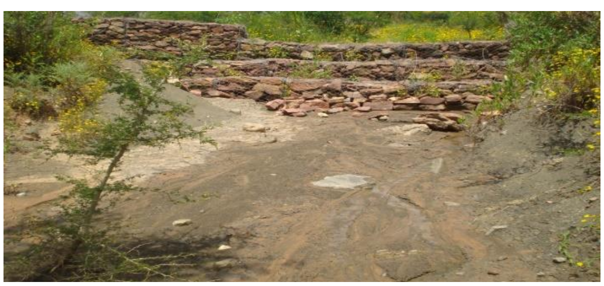
The above photo shows before the implementation of SWC activities, there was a big degradation process. That is the cultivated land was fragmented into different segments and it was very difficult to perform activities such as cultivating the land, crossing the gully for both the animals and even for human beings. But now different gabion check dams (i.e. about 16) and loose rock check dams (about 9) were constructed and integrated with different biological conservations. Therefore; the degradation status is now reduced by more than 75% and almost the gully is reclaimed (relieved).

Sample photo that shows comparing and contrasting the previous and present status of the gully and the gabion check dams are filled with sediments and covered by biological plants like vetiver grass, elephant grasses.

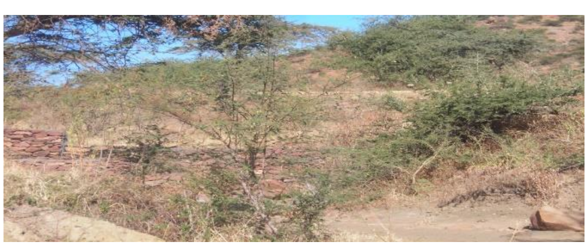
In the above consecutive pictures illustrating different photos taken at different times. As it is observed, the big stone taken as a reference frame is now covered with forests. And the area is showing the gradual change from time to time.

3.2.1.2 Spring source Status before and after implementation

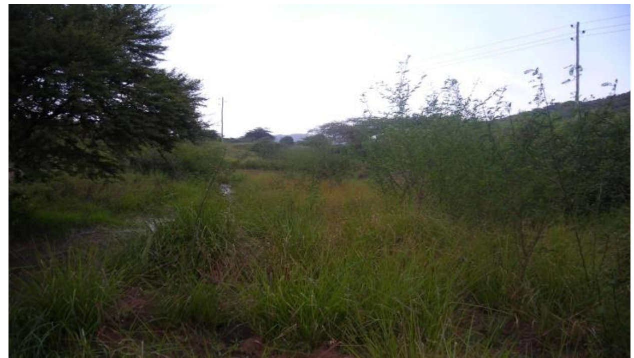
Before the intervention of the project soil and water conservation, the gully was completely dry. And the top part of the soil that is very important and fertile for crop production was completely eroded. Hence, the bed of the gully was left with a hard internal argillaceous black rocky structure that looks hard and smooth during the rainy season but during the dry season it fractures from time to time, and while the heat of the sun in the day time and cooled condition during the night varies it easily weathered. Therefore; the bed of the gully breaks down and it was aggravating degradation. As can be observed from the photo below.



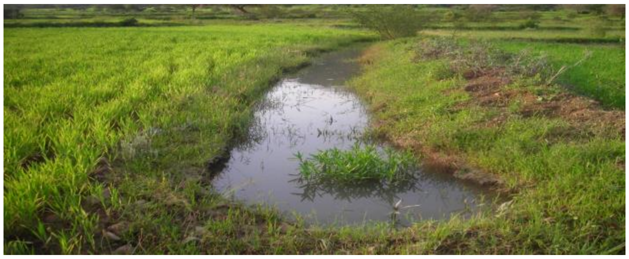
The photo was taken in October 2009



On the contrary; after the implementation of different techniques of soil and water conservations on the catchment treatments and gully reclamations integrated with biological soil and water conservation was done; the groundwater table of the hillside area is recharged. And the water sprouts out as spring and new spring water developed. And its discharge was measured **42.3 lit** per second water was measured on September 27, 2011. and this water stays till **December** regularly running and on some parts of the gully as pond form ponded till **June.** It is easy to compare the two photographs taken in different years, the previous one is dry and the plantation of the biological plants very young. While the recent one with matured biological and spring developed.



This shows children washing their body from the spring developed and hand pump photo at the downstream. Deep trench Photo taken in September15/2011& seasonal spring developed



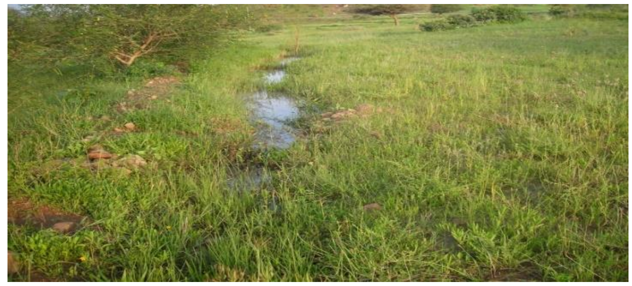


Photo: demonstrating water status at the downstream

Figure 4, Spring source Status before and after implementation

3.2.1.3. Gully size status before and after implementation

The size of the gully before the construction/implementation/ of different SWC techniques was illustrated in the table below.

Table 2. The size of the gully before and after SWC

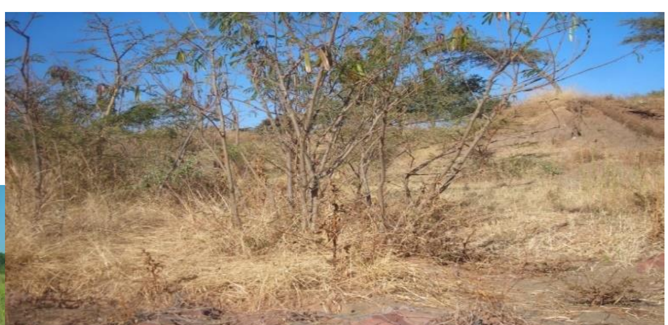
S.n	Previous status (size of the gully)			Current status (size of the gully)			Remark
	Gully depth	Gully Width	Gully length	Gully depth	Gully Width	Gully length	14,000m^3
	3m	12m	975m	1m	12m	956m	sediment accumulated

Source filed measurement

As it is observed in the above table, many parts of the gully are all most filled. The average gully depth is changed from 4 m to 1m (i.e the difference of two meters is filled with soil that comes via the flood). But on some specific areas/parts/ of the gully there are all most 100% reclaimed. The total area of the gully is about 0.78ha and this all is serving as a source of forage production to the animals (no any part of the gully is free).

After the implementation of different techniques of physical soil and water conservations on the catchment treatments and gully reclamation activities integrated with biological soil and water conservation activities, observe photos bellow.

The photo was taken:- in September 20/2009, gabion check



biologically treated gully taken in 2010 dams filled with sediment accumulated

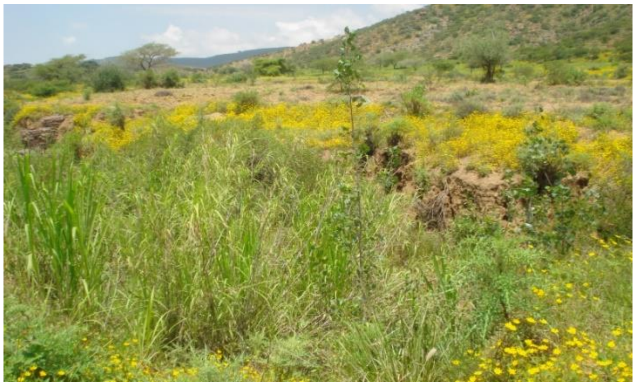
The photo was taken:- in September 26/2011

3.2.1.4. Status of the surrounding cultivated land before and after implementation

Before the implementation of the soil and water conservation activities, the surrounding cultivated land was diminished by the expanding gully degradation. Different tunneling erosions were formed at the bank of the gully as the gully was actively expanding. That is big holes were formed or developed at a distance of 3m to 10m far from the bank of the gully to the center of the surrounding cultivated land. As a result of this, the product of the land was declined from time to time. And is, therefore; the cultivated land as a whole was under risk condition unless those treatment activities were implemented. However; after implementation of these activities discussed above, the tunneling, rill, and sheet erosions are ceased out. There fore; the land is now in good condition due to different physical SWC techniques on catchment treatment, on gully reclamation integrated with biological conservation activities. Hence in July and at the beginning of September, different temporary springs at different plots that did not appear previously have been developed. In other words, moisture is conserved **in situ** after the

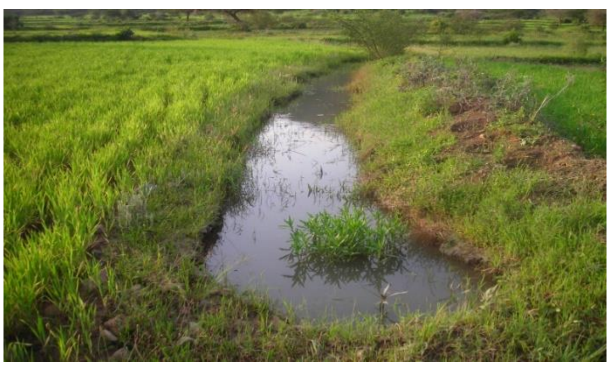
implementation of integrated SWC activities emphasized biological plantation practiced
Photo Status of gull in the cultivated land Seasonal spring water developed at the cultivated land

As it is observed from the above photos, the rain is highly harvested and left on the ground. These types of techniques and others like percolation ponds, deep trenches, simple trenches, hillside terraces, e.t.c. retained the water that comes from the upper catchment and reduces the runoff that aggravates degradation. Hence, in turn, reduces degradation and results in land stability, sprig development as seen in different photos under different subheadings.



3.2.1.5. Societies/community/ benefit before and after implementation

Before the implementation of activities of the project SWC, the members of the community have no benefit from the gully. However; after the implementation of different interventions, the community's benefit is increasing from time to time. Some of the major benefits are:-



a) Forage development: - before the implementation of the gully reclamation, the gully was bare land or free rocky spaces. But after the implementation of these activities, different grasses like vetiver grasses, elephant grasses, and other mono plats like "Leuceania" and "Sesbania " are developed inside the gully. Hence; these all are serving as a source of forage for the animals in addition to conservation purposes.

The photo was taken in January 2009 Photo taken in Dec. 2011

b) *Water availability*: -previously, the gully, and the surrounding land did not have any water availability. But after the gully reclamation activities are done, the community gets benefits of water inside the gully as ponds for their animals and one hand pump for the community as drinking water source respectively. These all are the results of the rain harvested at different parts of the catchment recharges the groundwater and this makes shallow the water table and easily available the water for human and animal benefits. The hand pump bellow was constructed in 2009

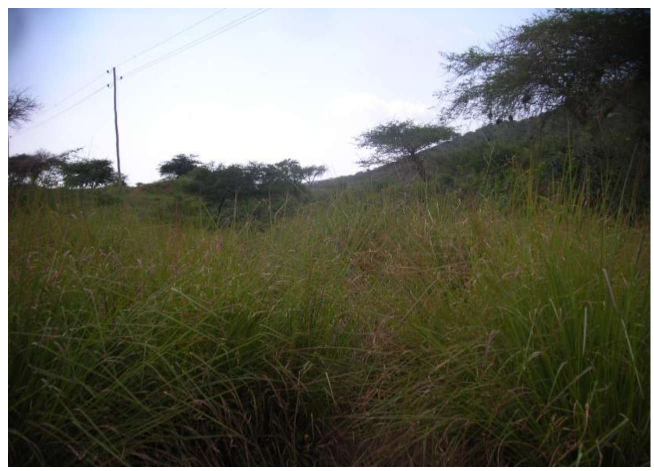


Photo of a hand pump for drinking water Photo of ponds developed & serving as a water source for cattle developed

3.2. Economic Impact

Here the impact of soil and water conservation structures on yield status was assessed in tabia E/Chiwa (Mizraf watershed). In the watershed in concern; the yield of the cultivated land on crop production in the previous three successive years 2006,2007,2008 farmers told their experience barley and wheat were 18Qtl / Ha, Teff 16 Qtl / Ha; whereas on the other recent years(i.e. in 2009 and 2010) improved their land productivity to 26Qtl / Ha Barley and wheat, to23Qtl/Ha Tef .15.5Ha of land was taken in the year 2010 to assess the impact of the terraces on yield product improvement with in the same catchment characteristics around the gully reclamation treated on both sides. And 12 farmers were interviewed to see the amount of yield they harvested before and after the implementation of different SWC structures.

3.2.1 Crop production

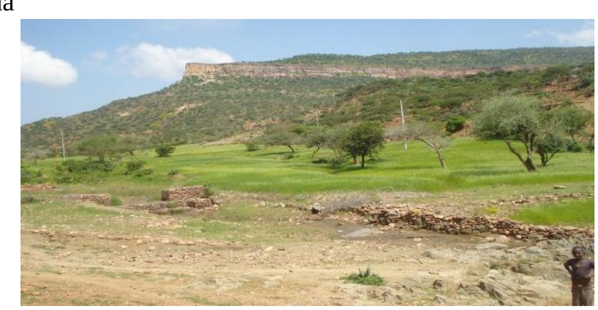
The impact of SWC on grain yield before the implementation of the SWC structure and after implementation was assessed. And its effect is discussed in the table below.

Tables 3: Impact of SWC structures after the construction of terraces.

S/n	Sowed crop type	Before implementation of SWC 2007		After the implementation of SWC in 2010					Yield difference In Qtl	
		Amount harvested		Amount harvested		Ha covered	Total harvested			Straw(bale)
		in Qtl/ Ha grain	Straw(bale)	in Qtl/ Ha grain	Straw(bale)		Grain	Straw(bale)	Grain Qtl	
1.	Wheat	18	40	28	84	3	84	252	30	132
2.	Barley	18	32	28	65	6	168	390	60	198
3.	Teff	16	45	25	92	6.5	162.5	598	58.5	306
	Total	52	117	81	241	15.5	414.5	1240	148.5	636

the above table tried to compare the productivity difference and there is an assumption that the crop type sown and harvested in 2010 may or may not be sown in 2007. But crop types sown in 2010 were taken as initial for assessment. In addition to this 6.5 ha of land from the cultivated land was also under fallowing process and there was also in the year 2007 some part of the cultivated land may or may not be fallowed, the products of 2007 are also an assumption the farmers themselves told but there is no recorded data. It has these types of limitations

Photo of crop production statuses taken in August30/2011



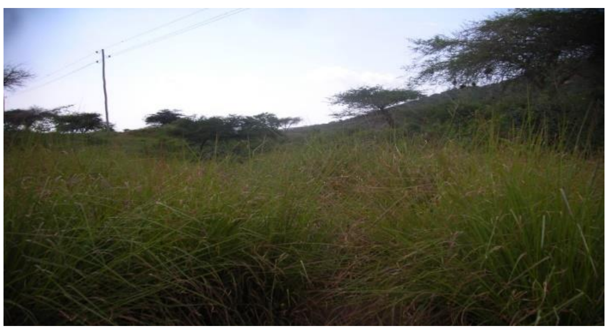
3.2.2. Forage Development

Forage grasses, shrubs, and trees have been planted and sowed to reclaim the gully (i.e. vetiver grasses, elephant grasses, S.sesban, e.t.c.). Now the community using the reclaimed gully, as a source of feed for their livestock through the cut and carries or controlled grazing system.

In addition to the above ideas discussed physical appearance investigation was performed and some farmers interviewed if there are changes on the size of their animals (i.e. comparing and contrasting the size or weight of the livestock before and after gully treatment) there is much difference in weight and physical appearance; because they feed their livestock forage from the treated gullies. Besides that the farmers harvest grass three times a year including the summer products in September, February and June; and about 45 bales of grass were collected per a period and distributed 20 beneficiaries. Hence, each farmer feeds two months per year from the grasses harvested.

Table 4: Amount of forage collected and distributed per House Hold

s/n	No of grass collection time	Amount of forage collected (in Bales)	No of forage bales distributed per House Hold	No of beneficiary (Households)	Remark
1.	September	140	7	20	Including grasses collected from the area closure
2.	February	45	2.25	20	From gully forage
3.	June	40	2	20	From gully forage
	Total	225	11.25	20	



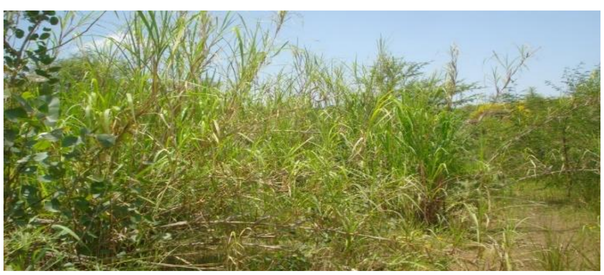


Figure 5: The above biological treated gully used as a source of feed for livestock

3.3. Social impacts

People have changed the cultural outlook on conservation interventions. Before the intervention of SWC activities, people were reluctant to work on closing the land and animal control mechanisms on free grazing. This is because they hesitated and believed that the government would have owned, and will take in the future time. However; now a day people participating in closing the land from animals and discus themselves, do SWC activities in almost 20-24 days per month. Now, they capacitated and they carry out SWC activities by themselves**.**

IV. CONCLUSION AND RECOMMENDATION

This study assessed the impact of various SWC measures implemented for land Degradation, Spring source, Gully size, Status of the surrounding cultivated land, and crop production productivity in Mizraf watershed, northern Ethiopia. The study indicated that there has been a success in maintaining and improving land resources, viz. soil, water, vegetation, and moisture due to the implementation of SWC measures. Many issues need to be improved on the existing SWC measures, such as continuous maintenance and follow up of physical SWC structures, appropriate spacing. Additionally, stabilizing physical SWC structures by planting multi-purpose grasses/plants and integrating SWC practices with biological conservation measures, in all parts of the watershed landscape to restore degraded land to its full potential and to be sustainable. More efforts should be directed towards increasing the water retention capacity and improving the organic matter content of the soil, along with the restoration of flora and fauna for ecological and economic benefits in many parts of the watershed.

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