Effects of Soil and Water Conservation Practices on Selected Bio-physical, andLivelihood Attributes and Farmer`s Perception at Akusti Micro Watershed, Northwest Ethiopia

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Abstract: Soil and Water conservation practices are widely practiced in Akusti Micro Watershed (AMW).The main purpose of this study was to assess the effects of soil and water conservation practices (SWCP) on selected biophysical, livelihood attributes and farmer`s perception at AMW, Northwestern Ethiopia. Field survey using questioner was conducted to assess the perceptions of farmers about SWCP. Data was also collected through key informant interviews, focus group discussions, field observations and field measurements and using Google Earth with 30 meter resolution. Data was analyzed using qualitative and quantitative analytical methods using SPSS software. Yield increments were evaluated by using the quadrant measurement 1m×1m (1m²) method. Yields before construction of SWCP were assessed using questioners. The results indicated that about 168.5 hectares of land were covered by vegetation and crop yields were increased, although the increments differed from farmer to farmer as the soil management practices differed. According to the respondents, the productivities of teff, wheat, maize and potato before construction of SWCP were 460 kg/ha, 240 kg/ha, 400kg/ha and 500kg/ha, respectively. After construction of soil and water conservation measures, yields of teff, wheat, maize and potato increased up to 6800, 3500, 12000 and 16000 kg/ha, respectively. According to survey results, 84.2% of the respondents practiced land restoration activities while the remaining 15.8% were not. Farmers who perceived SWCP more effective in controlling soil erosion and ensuring sustainability of crop yields adopted modern conservation methods. In Akusti micro watershed, lands are sloppy and thus soil erosion is very high that removes all the top fertile soils, applied fertilizers and sown seeds. Cultivating these vulnerable lands without proper management may result no or very low harvest. Therefore, it is recommended to integrate the use of agricultural inputs with Swept increase crop yields.

Keywords: Bio-physical, Crop yield, Livelihood, Perception, Soil erosion, SWCP

1. Introduction

Soil erosion and nutrient depletion considered as one of the major problems constraining the development of the agricultural sector in Ethiopia (Berhane *etal*., 2011). The problem is particularly severe on cultivated marginal and sloping lands because such area generally susceptible to soil erosion (Kassa *etal*., 2004).

As to international journal of environmental monitoring and analysis IJEMA's (2013) national level studies estimation, more than 2 million hectares of Ethiopia's highlands have been degraded beyond rehabilitation. Additional 14 million hectares of land have been severally degraded which is reflected by the reduction of cereal yields(< 1.2 t/ha) in most of the highlands. Avoiding such problem is badly needed to achieve food security.

To alleviate this problem, a number of policy measures have been taken by the government, although their success is highly questioned i.e. a limited success in addressing the problem. A range of conservation practices, which include stone-faced soil bund, soil bunds and area closures, have been introduced into individual and communal lands at massive scales. Understanding farmers' perception of soil erosion and its impact is important in promoting soil and water conservation technologies (Chizana *et al*., 2006).

Different SWCP implemented like bunds stabilized with grasses such as vetiver (*V.zizanioides*), *C. palmensis*, other leguminous plants and etc. brought changes on the nature of landscape. This signifies that, the integrated implementation of physical structures with biological/vegetative measures especially grasses are more effective in slope transformation and stabilization of the micro-ecosystem as compared to other soil and stone bund stabilization techniques (Demelash *et al.*, 2010).

The traditional agricultural land use and the absence of appropriate resource management often result in the degradation of natural soil fertility. Such activities haven egative implications on soil productivity, household food insecurity as well as on poverty of the people in different parts of the country (Teklewold *et al*., 2011). To mitigate soil degradation that is occurred due to soil erosion, deforestation and overgrazing and to enhance the productive potential of the farmlands someSWCPwerepracticed andpromotedbyBureauof Agriculture (BoA)and other concerned non-governmental organization in the study area.However, the effects of these interventions on biophysical and livelihood attributes were not evaluated and documented. Therefore, the objective of this paper was to evaluate the effects of SWCP on biophysical, and livelihood attributes in the study area.

2. Materials and Methods

2.1 Description of the study area

Akusiti watershed is located in Fagita Lekoma district of Awi Zone, Amhara Region. The watershed is geographically located at 10º59´30´´N to 11º1´30´´N Latitude and 36º53´0´´ to 36 º 55´0´´E Longitude. The total area of the watershed is 410.7 ha and the altitude ranges from1887 to 2902 masl. It is situated about 460 kmNorthwest of Addis Ababa and 105kmSouthwest of Bahir Dar, the capital city of Amhara National Regional State (ANRS).

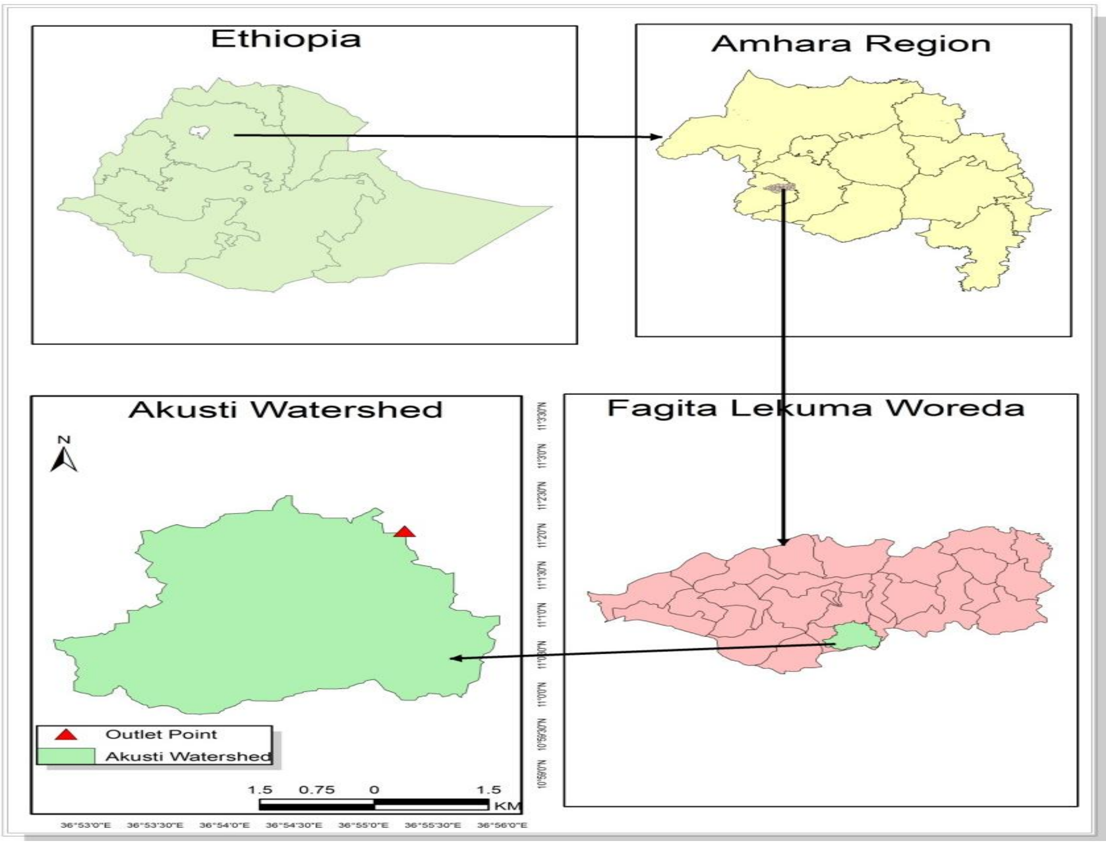

Figure 1: Location map of Akusiti watershed

2.1.1Climate

The study area mean annual maximum and minimum temperatures are 25°C and 11°C, respectively. The study area has annual rainfall of 2379 mm which is characterized by one long summer and one short spring rainy season (Alemayehu, 2015). The long summer rainfall is mostly started mid-June and ended mid-October which is the main rainy season for crop production while the short rainy season which called '*Belg*' is occurred between March and April.

2.1.2Topography and soil type

The topography of the Akusiti watershed consists of 62% plain, 23% mountains, and 15% others (Alemayehu, 2015). According to the same author, Nitosols with stony phase is the predominant soil type of the study area.

2.1.3Vegetation

Many indigenous tree species with very limited abundance are found in the area. They are found on some farmer's farmlands, around churches homesteads and the community woodlot. Major indigenous tree species found in the study area are Abalo(*Brucianti discentrica*), Yeabesha Girar (*Acacia abyssinica*), Weyra (*Olea africana*), Bisana (*Croton macrostachyus*) and Gesho (*Rahmnu sprinoides*). Exotics species Nech Bahir Zaf (*Eucalyptus globules*), Deccurence (*Acacia deccurence*) and Sesbania (*Sesbania sesban*) are also found in the study area.

2.1.4 Major agricultural practices

Rain-fed crop production during summer season is mostly practiced in the catchment area where intensive cultivation, sowing, weeding and other activities are performed. The livelihood of the community is mainly based on mixed farming system (Alemayehu, 2015). The dominant crops produced in the area are barley (*Hordeum vulgare*), wheat (*Triticumspp.)*, teff (*Eragrostis teff*), potato (*Solanum tuberosum*), maize (*Zea mays*) and others.

Moreover, livestock production plays a significant role in the livelihoods of the people in the study area. Livestock is also a source of foods and cash as well as the major source of draft power, fuel and fertilizer for crop production. The common types of livestock in the area include cattle, sheep, and poultry.

2.2 Methods of data collection

The sampling technique employed in this study was random sampling technique. Informal interview of the farmers was carried out using a combination of Participatory Rural Appraisal (PRA) techniques such as semi- structured interviews and group discussions. The interview and focus group discussions were supplemented with personal observation, secondary data and information from knowledgeable people in the Bureau of Agriculture. Since the target population is less than10, 000 (Cochran, 1977), the required representative sample sizes have been determined by the proportion sample size formula. The totalnumber of household in the watershed were 250 and 152 sample household were selected for structured questioner interviews.

Formula for sample size determination

$$n=\frac{no}{1+\frac{no-1}{N}} \text{ and } no= z^2 p\ q/d^2$$

Where:

no= the desired sample size

Z= standard deviate at require confidence level (1.96).

P= the proportion in the target population estimated to have a particular Characteristic (0.5)

N=target population (the total number of household in the watershed, 250)

q=1-p, (0.5)

d= Statistical significance (0.05)

Accordingly:

$no=1.96^2*.5*.5/.05^2 =385$

n=no/1+ (no-1)/N

n=385/1+ (385-1)/250 =152

To collect the existed SWCPs in the watershed, observations through transect walk from East to West and from North to South direction in the study area were carried out as well as questionnaires were used. Observation checklist related to the stated objectives was used in order to strengthen the reliability and validity of the data gathered. The existing vegetation in the study area was observed and their area was measured using GPS. Interviews and literature reviews/ secondary data have been used to collect data of the area before the intervention of SWCP.

To collect data on the effects of soil and water conservation practices on the livelihoods of the community; crop yields were estimated from eight households using the quadrant measurement (1m×1m) method. On the other hand, crop yields before SWCP interventions were assessed from three group discussions where each group has consisted four households. Moreover, secondary data were also used.

2.3 Methods of data analysis

Questionnaire data of the existing SWCPs as well as vegetation cover before the intervention of SWCPs were analyzed by SPSS version 20. The existing vegetation cover was analyzed using Google Earth 30 meter resolution 2015 / 16 as well as using GIS techniques.

3. Results and Discussion

3.1 Major soil conservation practice implemented by farmers in the study area

The survey result indicated the agreement of the respondents where soil conservation practices are important to minimize the rate of soil erosion on farm plots and communal grazing lands. In this regard, various physical soil conservation practices have been applied by the community farmers on their own farm plots and grazing lands. Based on the results of the field survey (Figure 2), about 8.6 %, 15%, 51.8% 12.5% and 11.8%of the household heads have been constructed stone and stone faced terracing, fanyajuu, soil bund, cutoff drains and waterway, respectively.

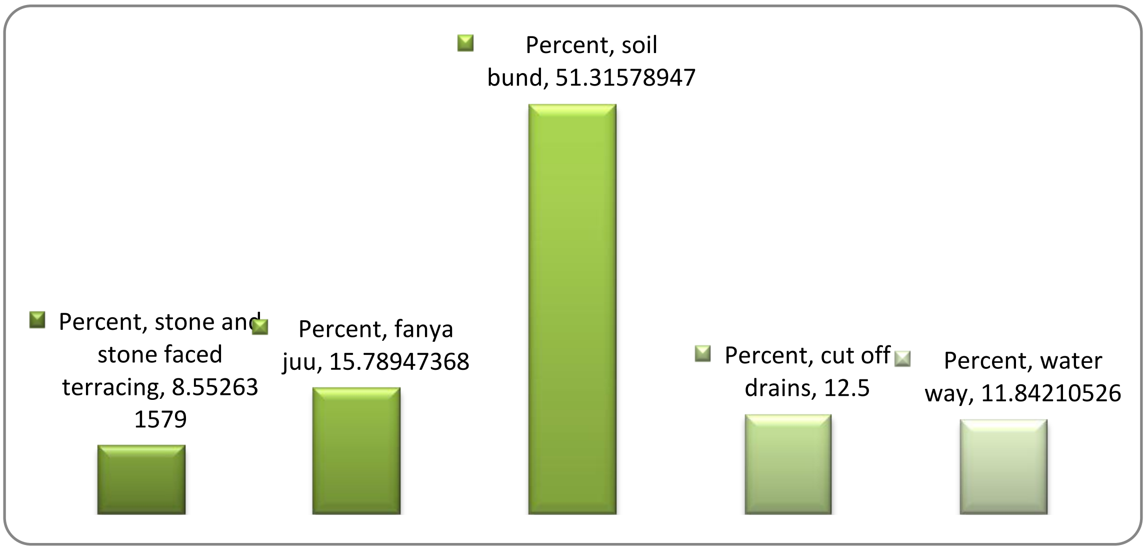

Figure 2: Major physical soil and water conservation structures practiced in study area

The respondents during the focus group discussion (Figure 3)revealed that soil and water conservation practices improved soil fertility of their farmland, increased water holding capacity of the soils, reduced runoff and erosion and increased land productivity. Soil and water conservation practices employed in the responsive settlement areas were fences of forage plants, agro-forestry and vegetable, and fruit production in at the garden.

Figure 3: Focus group discussion with farmers in the study area

The results of focus group discussion also indicated the positive effects of soil and water conservation practices on communal lands used for grazing which improved forage biomass quantity and increased rates of water percolation.

3.2 Effect of soil and water conservation practices on vegetation cover

Based on the results of Google Earth pro 2015/16, the study area which is covered by vegetation covers was about 168.5ha (Figure 4) which isabout 22% of the watershed area. The majority of vegetation that covered the watershed is *Acacia decurrens.* According to the respondents, the vegetation cover of the watershed before implementation of SWCPs was about 87 ha.

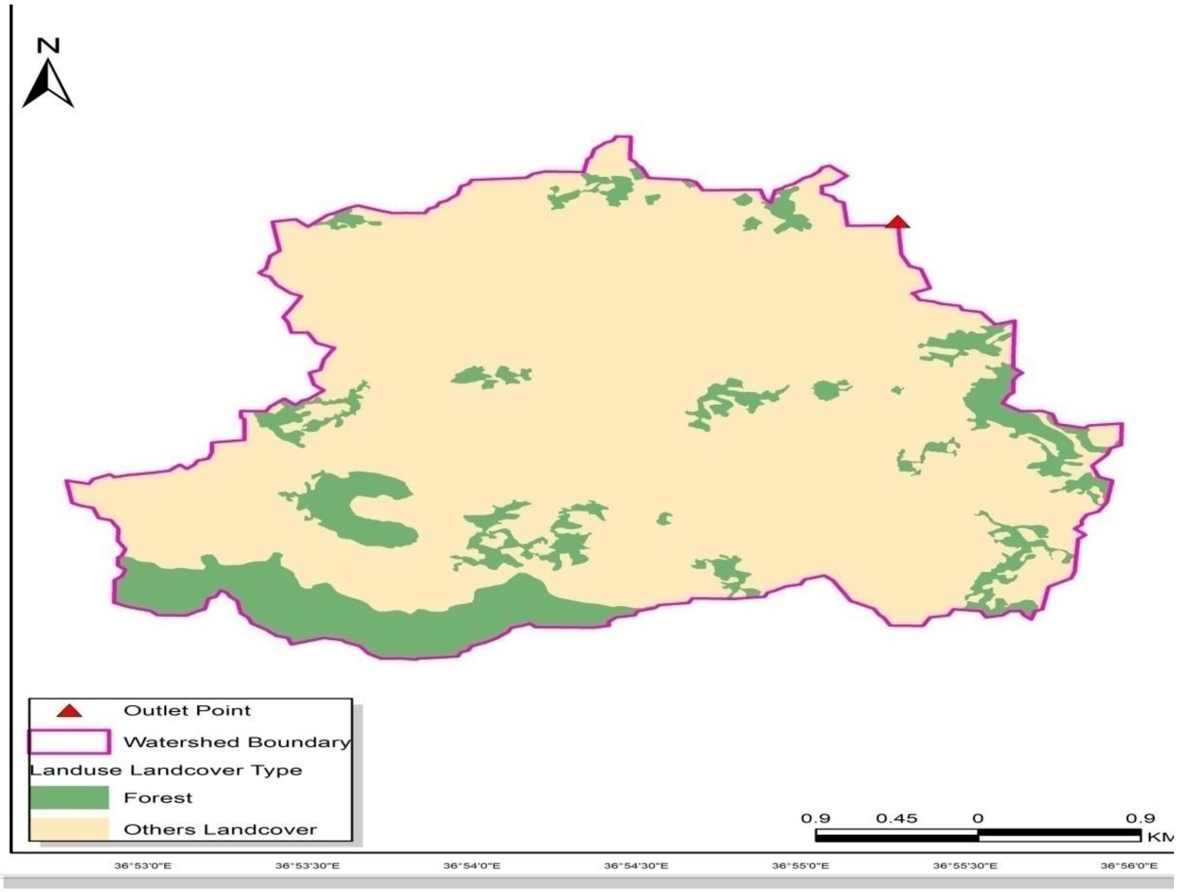

Figure 4: Akusti watershed vegetation cover map(2015/16)

The results of the present study is generally in agreement with the findings ofAlemayehu (2015) who found the increase of *Acacia decurrens* plantation in Fagita Lekoma district from time to time. This is because of the fact that the growth rate of the tree in degraded and infertile soil is high. Moreover, the tree is used for charcoal production in the district which improves the cash income of the farmers and thus their livelihoods. The fact that the tree is leguminous, it may help to improve the fertility of the soil and the yield of crops produced after cutting of the trees.

3.3Effect of soil and water conservation practices on livelihood condition

According to the survey results, 10.5, 25 and 64.5% of the respondents perceived that the intervention of soil and water conservation practices increased the crop yield very high, high and moderately, respectively, as indicated in Figure 5. In this regard, Tesfaye (2008) indicated that the introduced soil and water conservation measures, fanya-juu and soil bunds are widely acknowledged as being effective measures in protecting soil erosion and as having the potential to improve land productivity.

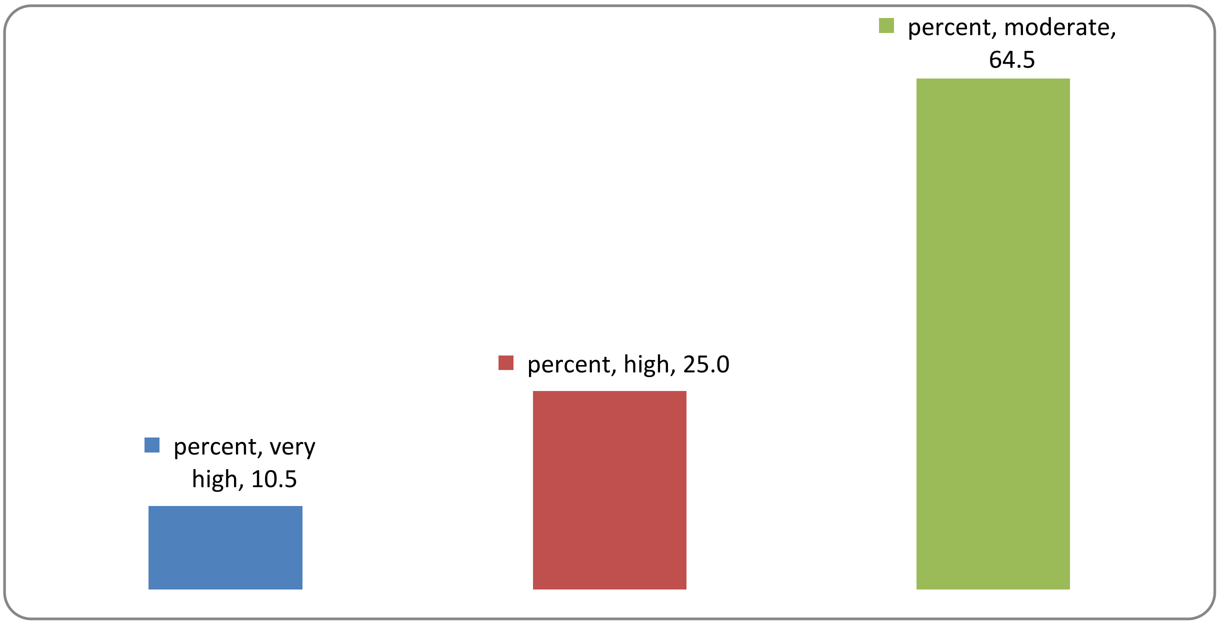

Figure 5: Proportion of respondents that preserve the increment of crop yieldsafterSWCPs

As per the respondents, the living conditions and purchasing power of the farmers was increased after the implementation of soil and water conservation practices. Before SWCP, the farmers ought to work in off-farm activities to buy clothes and get other services since their harvest was very small. After SWCP however, they could able to maintain seeds and reduce removal of top soil, seeds and fertilizer by erosion that in turn increased their crop harvest and able to buy the necessary materials by selling of the farm out puts. .

As shown in Table 1, crops yields were increased after construction of soil conservation structures, although the yield increment differedfrom farmers to farmers which is probably due to the differences in soil management activities of the farmers. According to the response of the farmers, the yields of teff, wheat, maize and potato were about 460 kg/ha, 2400 kg/ha, 4000 kg/ha and 5000kg/ha, respectively before construction of soil conservation measures. After construction of soil and water conservation measures however, the yields of *teff*, wheat, maize and potato increased up to 6800 kg/ha, 3500 kg/ha, 12000 kg/ha and 16000 kg/ha, respectively.

The findings of the present study were supported by Ayalew (2011) who observed low yields of crops in Gununo area before construction of soil conservation structures, even with application of fertilizers. According to him, the yield of teff in different farms increased from 300 kg/ha to 800 kg/ha after construction of soil conservation structures and that of haricot bean increased from 180 kg/ha to 400 kg/ha in different farms. Similarly, the yield of wheat was increased from 200 kg/ha to 800 kg/ha. Moreover, maize yield was increased four folds, from 400 kg/ha to 1600 kg/ha and that of potato was increased from <400 kg/ha to 1600 kg/ha.

Table 1: Crop yield before and after construction of soil conservation measure

Crop	Estimated crop yields before SWCP (kg/ha)	Estimated crop yields after SWCP (kg/ha)
Teff(local seed)	460	6800
Wheat (danifei)	240	3500
Maize	400	12000
Potato	500	16000

3.4Farmers' perceptions about soil and water conservation practices

Table 2 shows the distribution of sample household heads by age group. The age of respondents was categorized in to different age groups. Accordingly , the average age of rural households of Akusti micro watershed was between the ranges of 20-30, 31-45, 46-55 ,56-65 and >65 which is 11.2 %, 34.2%, 23.7% 21.1% and9.9%, respectively. Age is one of the demographic characteristics that influence the perception of farmers to soil and water conservation practices. Most of the HHH were in the age ranges of 31-64 and 46-55 years. Farmers in these age groups are assumed to have a good understanding towards soil erosion problems due to their access to information about soil and water conservations practices. The proportion of elderly farmers above the age of 65 years was lower in percentage, as old age affects their participation in soil and water conservation practices due to their inability in terms of labor. However, these farmers especially the elderly age groups usually implement and accept soil and water conservation practices because of their access to money for rented oxen as well as hired labor compared to the young age group.

Table 2: Distribution of sample household heads by age group

Age	Frequency	Percent
20-30	17	11.2
31-45	52	34.2
46-55	36	23.7
56-65	32	21.1
>65	15	9.9
Total	152	100

The findings of the present study are in agreement with that of Assefa (2009) who found that most of the farmers between ages of 20-64 yearsparticipated insoil and water conservation practices. This group of people seems to have better understanding for soil and water conservation practices. Moreover, this group of people is effective labor forces to implement soil and water conservation practices. Few elder people implement soil and water conservation practices through hiring laborers of young age group.

3.5Sex, marital, and educational status of household heads

The sex distribution of sample household heads was about 17.8% female and 82.8% male (Table 3). The great difference in male and female household heads in the present study clearly shows gender difference in the implementation of SWC measures. As indicated in the survey results, most of the female household heads managed their land through share cropping or renting their land male headed households and contracting for ploughing of the land for which they paid.

Table 3: The demographic characteristics of respondents

Characteristics of HHH	Respondents	
	Frequency	Percent
Sex		
Female	27	17.8
Male	125	82.2
Marital Status		
Single	26	17.1
Married	126	82.9
Education Status		
Illiterate	109	71.7
Literate	43	28.3

The results of the present study are similar with that of Kibemo (2011) where the majority of the people who participated in SWCP were male headed. According to him, marital status of household head determines the access to information and resource that intern to soil and water conservation measures. Getting the household head married is adventitious to share information among members about the SWCP which is in line with the findings of Tesfaye (2015) who found the majority of the respondents participated in SWCP measures.

With regard to the educational back ground of the respondents, as can be seen in (Table 3), about 71.7 % household heads cannot read and write (illiterate) and 28.3% of household heads can read and write (literate). The majority of the household heads participated in the survey were illiterate which is difficult to create awareness on the importance of SWCP. To bring a positive perception as well as to implement soil and water conservation measures, it is necessary increase the educational background of the people as indicated by Ermias (2014).

3.6Family size of household heads

As illustrated in Table 4about 19.7%, 62.5% and 17.8% of the household heads had 1-3, 4-7 and 8-10 family members, respectively. Accordingly, the majority of household heads participated in the survey had 4-7 family members. Generally, household heads with large number of family members have positive influence on the implementation of SWC practices.

This is because household heads with large number of family members may help to effectively adopted several SWC measures in their farm land.

These findings are generally supported by Ayalew (2014) and Kibemo (2011) who found that household heads with large family member have positive influences on practicing soil and water conservation measures. This means household heads with high working capacity may positively correlate with soil and water conservation practices. Therefore, it is possible to conclude that family size has significant role in the construction of physical conservation measures.

Table 4:Family size of sample household heads

Family size	Frequency	Percent
1-3	30	19.7
4-7	95	62.5
8-10	27	17.8
Total	152	100

3.7Households` perception on maintenance of SWCP

Soil and water conservation measures have to be regularly maintained for their sustainable benefits. The effort of the farmers to maintain soil and water conservation structures indicate their acceptance. As shown in Table 5, about 56.57% of the respondents maintained soil and water conservation structures while 43.42% did not maintain the conservation structures. Regarding to the reasons not to maintain the conservation structure, about 18.18% of the respondents said that the work is very tedious work while 51.51% of the respondents claimed loss of land due to the bund. Moreover, about 30.3% of the respondents did not maintain the structures due to inadequate labor for maintenance.

The results indicated that although different soil and water conservation measures have been practiced, the structures were not maintained my most of the respondents in the study area. This was mainly because of the tediousness of the work and lack of labor of the respondents. According to development agents (DA) and model farmers, soil and water conservation practice were done especially by public participation with help of government and non-governmental organization to control soil erosion as well as to enhance agricultural productivity. However, their maintenance is not done in the study area. The results of the present study are in agreement with the observation of Tesfay (2015) where soil and water conservation measures practiced in the study area were not maintained mainly because of shortage of farm land and lack of awareness.

Table 5: Distribution of issues related to the maintenance of SWC structures

Description	Response	Frequency	%
Doing maintenance on SWC structures	No	66	43.42
	Yes	86	56.57
	Total	152	100
Reasons for no Maintenance	Work is very tedious	12	18.18
	Because of loss of land to the bund	34	51.51
	Labor shortage	20	30.30
	Total	66	100

3.8Access of information and training on soil erosion and conservation practices

According to the survey results, about 74.3% of the respondents got training on the importance and implementation of soil and water conservation practices while the remaining 25.7% did not had any types of trainings. Frequent training and appraisal onthe importance of soil and water conservation practices, land use and soil fertility management is paramount important to maximize crop production. Moreover, accessing of information about SWCP from different sources is also important for their implementation. Accordingly, about 73.7% of the respondent household heads accessed information through trainings by DAs and non-governmental organizations while 19.7% and 6.6% got information from media and traditional information exchanges (neighbor) as indicated in Figure 6.

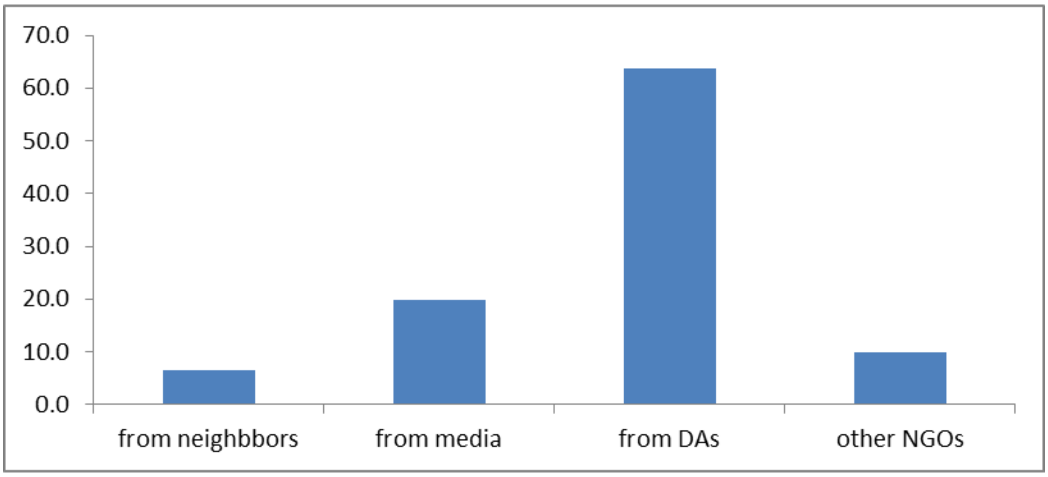

Figure 6: Source of information about soil and water conservation practices

3.9Soil fertility improvement practices

Farmers at individual level practice different land management activities mainly to increase agricultural yields and conserve the farming plot. Based on the results of the present study, about 44.7% of the respondents used chemical fertilizer while 33.6 % used crop rotation to improve soil fertility and conserve soils of soils of cultivated fields. On the other hand about 19.7% of the respondents applied manure and only 2% practiced fallowing to improve the fertility of soils as indicated in Figure 7. Application of chemical fertilizer is the common and important soil fertility management practice to improve land productivity as indicated by Berhe (2004).

Crop rotation is one of the most important soil fertility managements. This method becomes more important when leguminous crops are part of the rotation system to improve the nitrate content of the soil. According to the information of agricultural office of the district, the rotation system mostly consists of cereals, legumes (haricot bean) and root crops like potatoes in the farm land in different seasons and years of cultivation.

Manure is also used for promoting the fertility status of the soil. Its application to farmland raises the nutrient level of the soil, increases water infiltration and reduces soil erosion (Ermias, 2014). Currently, application of manure on farm lands has decreased from time to time as the number of livestock per household significantly declined for various reasons. Participants of focus group discussions indicated that manure is used only for homestead area because of shortage of manure. In addition, the use of cattle dung as source of fuel rather than as organic fertilizer is another contributing factor for low application of manure for soil fertility improvement practice in the study area.

The contribution of fallowing as soil improvement strategy is very small. This is because of the fact that cultivation of the farmland year after year is necessary to satisfy food requirements of the ever increasing population density.

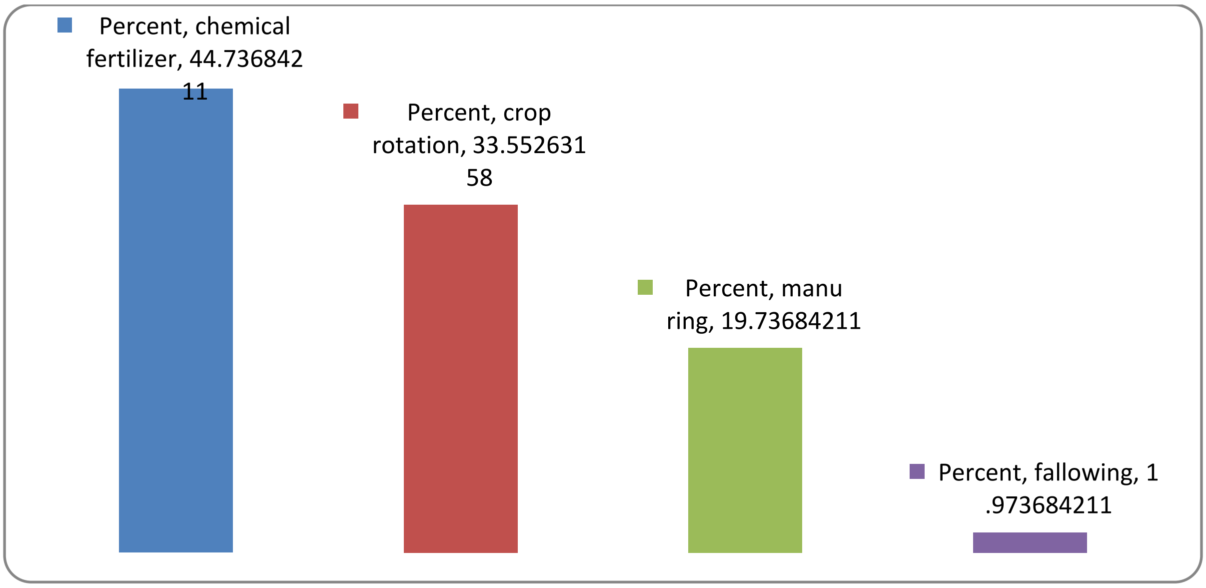

Figure 7: Soil fertility management strategies followed by the respondents

3.10Measures of the respondents for declining of land productivity

Land productivity is essential to increase agricultural production on a given plot of land. Therefore, appropriate measures for improvement of land productivity should be taken if the fertility of the soil is declining. Accordingly, about 80.3% of the respondents will try to use appropriate measures to improve the soil fertility if its status declined while the remaining 11.2% shifting to other fertile plot (Figure 8). From the field observation, it was noticed that varieties of fruits and vegetables including tomato, cabbage, carrot, banana, apple etc. are growing along the farm land using ground water and boring water holes which are mostly produced for self-consumption and local markets.

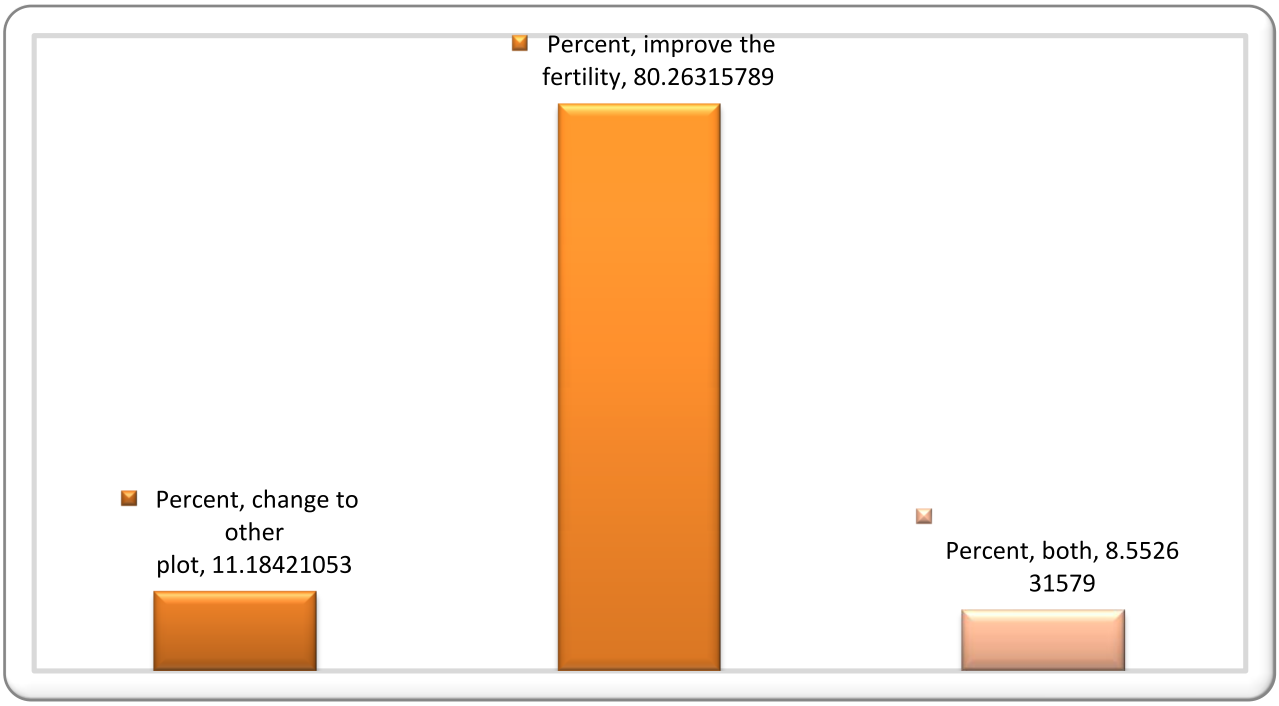

Figure 8: Measures under taken when the productivity of plot declines

3.11Efforts of projects in the restoration of degraded land in the study area

Sustainable land management (SLM) is widely involved in environmental restoration works.The main activities of SLM areestablishment of nursery and production of seedlings, plantation and distribution among the societies. In addition distribution of fruits and tree seedlings in order to introduce agro forestry practice is part of the activities. Moreover, soil and water conservation structures are practiced on individual lands to minimize soil loss and to increase productivity of farm land. With the involvement of the society and government cooperation extremely degraded areas around hill side are enclosed to protect from encroachment of livestock. In the study area, sustainable land management is working on alternative energy sources to minimize pressure exerted on natural vegetation. Among these activities, trainings on construction and distribution of biogas and fuel saving stove are the main ones. To restore gully lands, they are working different types of check –dam practicing plantation of degraded lands, establishing nursery and selling trees to increase the incomes of the respondents. These findings are supported by Ermias (2014) who found that NGOs are involved in the restoration of land sensitization and mobilization of the society through panel discussion, workshops and trainings for establishment of nursery, seedling production, and plantation on degraded land.

4. Conclusion

This study was conducted to evaluate the effects of SWC on selected biophysical, livelihood attributes and farmer`s perception at Akusti Micro Watershed (AMW), Northwestern Ethiopia. The results indicated that about 168.5 hectares of land were covered by vegetation and crop yields were increased, although the increments differed from farmer to farmer as the soil management practices differed. According to the respondents, the productivities of *teff*, wheat, maize and potato before construction of SWCP were 460 kg/ha, 240 kg/ha, 400kg/ha and 500kg/ha, respectively. After construction of soil and water conservation measures, yields of *teff*, wheat, maize and potato increased up to 6800,3500, 12000 and 16000 kg/ha, respectively. According to survey results, 84.2% of the respondents practiced land restoration activities while the remaining 15.8% were not. Farmers who perceived SWCP more effective in controlling soil erosion and ensuring sustainability of crop yields adopted modern conservation methods.

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