

Assessment of Farmers' Perception towards the Adoption of Soil and Water Conservation Practices and Soil Quality in Kechabira Woreda; Southern Ethiopia

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Abstract – Study on assessment of farmers' perception towards the adoption of soil and water conservation practices and selected physicochemical properties of soil were carried out in Kechabirra woreda, southern Ethiopia. The aim of the study was to investigate farmers' perception towards the adoption of soil and water conservation practices in the area. Descriptive survey design method was used. Thus, a total of 302 households from three *kebeles* (The lowest administrative unit) were randomly selected for the study. Experimental work has also been carried out to determine physicochemical properties of soil in the study area. A total of 18 plots among these, 9 plots were from farmlands treated with 5 and above years old fanaya juu and various physical and biological soil conservation structures as treated and other 9 plots were with no soil and water conservation (SWC) practices as a control with the same land use system. Moreover, soil samples were taken at three slope gradients lower slope (3-8%), middle slope (8-13%), and upper slope (13-18%). The samples were analyzed for soil moisture, soil pH, total nitrogen, available phosphorous, soil organic carbon, and basic cation exchange capacity (Ca^{2+} , Mg^{2+} , K^+ , Na^+). The study revealed that among indigenous soil and water conservation measures practiced in the study area, application of manure (81.8%), indigenous tree planting (79.5%) and crop rotation (77.2%) were most preferred by the farmers. On the other hand, grass strips (70.4%) and fanaya juu (46%) were among the most preferred modern soil and water conservation methods practiced in the study area. Farmers' adoption of soil and water conservation measures in the study area was influenced by demographic (gender, family size, educational status and age) and bio-physical (farmland size, farmland fertility and distance of farmland from residence) factors. The mean of soil moisture content (MC), hydrogen ion concentration (pH), Soil Organic carbon (SOC), total nitrogen (TN), available phosphorus (Av.P) and basic cations exchangeable capacity (BCEC) except the exchangeable Na^+ showed significant variation between treated (experimental) and non-treated (control) farm plots ($p \leq 0.05$). Hence, farmland treated with soil and water conservation measures showed high mean values of the analyzed soil nutrients. Similarly, the mean values of analyzed soil nutrients were higher at lower slope (3-8%) position in both treated and untreated farmlands with the exception exchangeable Na^+ .

Formulating appropriate plan and strategies for creating suffices awareness about different SWC techniques in the study area is very important.

Key words: Adoption, Ajacho, Farmers perception, Watershed, SW

1. INTRODUCTION

Land degradation is an important global problem because of its adverse impact on agricultural productivity, food security and the quality of the environment. Due to land degradation in most developing countries, particularly agricultural productivity reached the level beyond the subsistence requirement of a household (Antenah Gebremariam, 2010). The economic development of developing countries depends on the performance of the agricultural sector, and the contribution of this sector depends on how the natural resources are managed. Unfortunately, in the majority of developing nations, the quality and quantity of natural resources are decreasing resulting in more severe droughts and floods (Fikru Assefa, 2009).

Inappropriate land management practices in areas with high population density and fragile ecosystem further increases loss of productivity of resources. These in turn affect food security and livelihood. According to Getachew Adem and Demele Yismawas (2000) large areas of sub-Saharan African soils in particular are affected by various types of degradation, which directly cause the decline in soil fertility. Consequently, yields are relatively low. For instance, the productivity of some land in Africa has declined by 50% because of soil erosion and desertification (Dregne, 1990). Further, yield reduction in Africa due to past soil erosion may range from 2% to 40% with a mean loss of 8.2% for the continent (Lal, 1995). The most pressing environmental problem in the least developed countries are prevalent in rural areas, where large number of population live and whose livelihood depend on agriculture and related activities (Getachew Adem and Demele Yismaw, 2000).

Ethiopia is among the least developed countries that survival and livelihood of majority of the people is based natural resources such as land, water and forests. Therefore, there is a strong and direct link between the basic needs such as food and shelter and natural resources in Ethiopia (Mitche, 1991). Declining land productivity, natural resource degradation, high population growth and food security are major challenges facing Ethiopia (Alemneh Dejene, 2003). In particular, small scale farmers that depend on the resources face severe constraints related to intensive cultivation, overgrazing and deforestation. Thus, for environmentally sustainable development, there is an urgent need of identifying the serious problem of soil erosion which directly results with land degradation, land productivity and food security.

The present study area, Kechabira Woreda, is located in Kembata and Tambaro Zone, southern region of Ethiopia. According to the Woreda (Administrative unit higher than Kebele) office report (2017), there is high population density in the area. Farmers in this locality are mainly small land holders that are engaged in subsistence agriculture. The current agricultural activities of farmers coupled with rapid population growth in the area resulting land degradation. Due to lack of appropriate soil management practices, a number of agricultural and grazing lands are seriously degraded. Even though modern technological soil and water conservation practices area applied in most places, land degradation problems still persists that need further research and investigations. Therefore, the present study is towards this end that assessing farmers' perception towards the adoption of soil and water conservation practices and selected physicochemical properties of soil in the study area.

2. MATERIALS AND METHODS

The study area is located between 7°10' 30"N -7° 10' 00"N latitude and 37° 31' 30"E - 37° 45' 30"E longitude with the altitude range from 1800-2400 m.a.s.l. (Figure 1) The area covers three agro-ecological zones namely; 'Dega' (wet highland and relatively cold), 'Woina-dega' (moderately warm midland) and 'Kolla' (low land and relatively hot) which accounts for 24%, 72% and 4%, respectively. Regarding the land use pattern of the study area, 17161ha Crop land, 7506.4ha forest land, 748ha grazing land, 440ha degraded land and the rest 89ha is fallow land (Kechabirra Woreda Agricultural Office Report, 2018). Descriptive survey design method was used. Both qualitative and quantitative data were collected using questionnaires, interviews and focus group discussions. Experimental work has also been carried out to determine physicochemical properties of soil in the study area. Among 20 kebeles in the study area, three kebeles namely - Mesafe, Kachabirra and Wrerama were randomly selected. The total number of households in the selected kebeles was 1234. Thus, to determine the sample size, Yemane (1967) sample size determination formula was used and it has become 320. Later on sample size per study sites (Kebeles) was determined following Kothari (2004).

For soil sampling, a total of 18 plots were selected from three kebeles. Among these, 9 plots were from farmlands treated with 5 and above years old fanaya juu and various physical and biological soil conservation structures as treated (experimental plots) and the other 9 plots were with no SWC practices as a control plots (cultivation land adjacent to each structure) with the same land use system. Even though the structures were common between 3 to above 30% slope, the samples were collected from 3–18% slope based on land use practice. Accordingly, the farm land was divided into three slope classes as lower slope (3-8%), middle slope (8-13%), and upper slope(13-18%) and soil samples (0-20cm depth) were taken from each layer following Dejene Teressa (2017). On the other hand, soil samples for control plots were collected from the 0-20 cm depth at four corners and center of a plot of 10m x10m size using "X" sampling design (Marges and Schinner, 2005) using sharp edged and closed circular auger pushed manually down the soil profile. Therefore, based on the terrace site position, soil conservation practice and study kebeles, 18 composite soil samples (3 replication * 2 treatments * 3 slope gradients) were collected. Then after, the samples mixed thoroughly in clean plastic bucket to form a composite sample and analysis was made in the laboratory for selected physicochemical properties of soil. Data analysis was employed by combining both qualitative and quantitative methods. Rate of adoption, constraints and farmers' of SWC technologies were analyzed using descriptive statistics. Microsoft excels, SPSS (Version 22.00) and SAS (Version 9.4) were used for data analysis. Statistical tests such as, correlation, standard error, means for mean separation of each soil parameters, and analysis of variance (ANOVA) were computed. Soil samples were air dried, crushed with mortar and pestle, mixed well and passed through 2 mm sieve for the following selected physicochemical propriety analysis; total nitrogen, available phosphorus, Soil Organic carbon, soil basic Cation Exchange Capacity, soil moisture and soil PH. Total nitrogen was determined following the Kjeldelhal procedures (Hamagaki and Panbingbatan, 1988) for converting organic nitrogen to ammonium-nitrogen that can be readily estimated. Available phosphorus of soil samples were determined by measure absorbance on UV- visible spectrophotometer following the Olsen method (VanReeuwijk, 1992) at pH 7.0. pH of soil samples were measured from a soil suspension solution prepared with 1:5 (5gm soil with 25ml distilled water) soil to water ratios using conventional glass pH meter. Soil moisture was estimated by taking undisturbed soil core from the surface of the soil by driving a metal cylinder /core sampler, samples then dried in the oven at a temperature of 105°C for 24 hours.

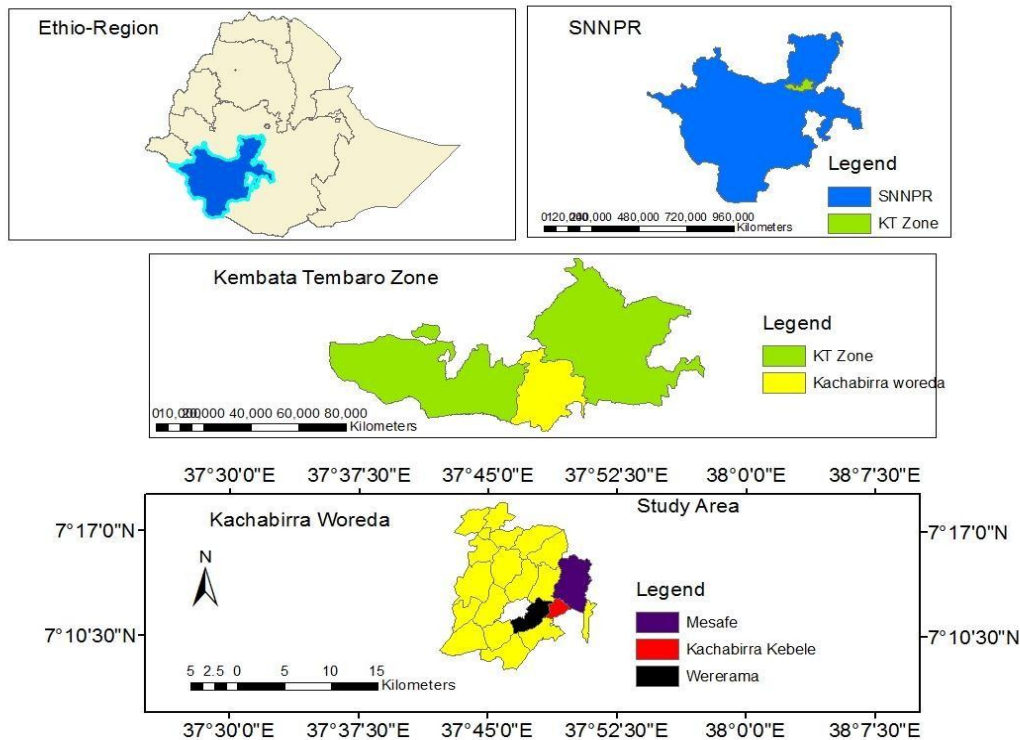


Figure-1: Location map of the study area.

3. RESULTS AND DISCUSSION

3.1. Soil and water conservation practices

3.1.1. Indigenous SWC practices

Indigenous soil and water conservation management practices are broadly grouped as physical, vegetative and agronomic methods of soil management practices. These practices also emerge from a detailed understanding of local conditions, and are modified in response to changing socio-economic, political and ecological conditions. In the present study, it has been revealed that many indigenous SWC methods such as traditional stone bunds, traditional ditch, crop rotation, fallowing, cut-off drains, tree planting, contour farming, traditional terrace, application of manure, mixed cropping and inter-cropping were practiced in the study area. However, their level of application in the area was varied. Hence, according to respondents, the top three known indigenous SWC practices in the study area were application of manure (81.8%), indigenous tree planting (79.5%), and crop rotation (77.2%); whereas the least practiced were fallowing (5.1%), terracing (10.8%) and traditional stone bunds (15.9%) (Table 1). Similarly, per study kebeles also, application of manure, indigenous tree planting, and crop rotation were the dominant indigenous SWC practices. Application of organic manure has become the most preferred agronomic indigenous soil fertility management practice in the study area. Farmers used manure mainly on the homestead farm rather than the distance plot presumably to reduce transport and/or labor cost. Focus group discussions with development agents and farmers (who have very low income) have also confirmed the same. Major sources of organic matter are manure, household refuse and thrash lines. Tree leaves and branches of harvested trees also provide organic matter. Manure is obtained from animals raised at home, and community garbage. Unlike in Northern part Ethiopia, animal dung is not used as fuel and in the past decades farmers in study area used to apply dried human and poultry farce to their field as the best sources of organics than manure (Hallpike, 1972).

Indigenous tree planting was the second most used indigenous SWC practice in the study area. Biological (vegetative) measures can prevent soil erosion by slowing down water flowing over the land and it allows much of the rain water to flow into the ground and thus prevent it from being removed away. Moreover, plants break the impact of a raindrop before it washes the soil, thus minimizing its ability to erode soil. The loss of protective vegetation through deforestation, over-grazing and ploughing makes soil vulnerable to being removed away by wind and water erosion. In the study area, trees

such as Korch (*Ehretia abyssinica*), kulkual (*Euphorbia ampliphylla*), Kinchib (*Euphorbia tirucalli*), Wanza (*Cordia africana*), Bisana (*Croton machrostachus*) are commonly planted. Besides, enset (*Enset ventricosum*), Coffee tree (*Coffea abyssinica*), local grass strip and others are also played significant role in protecting soil moisture, controlling fast run-off and flood, breaking wind as well as to increase soil fertility with their decomposing leaves. During FGD, it has been mentioned that planting of trees is important conservation activity to combat soil degradation and rehabilitating degraded lands since it does not cost that much. Plants break the impact of a rain drop before it hits the soil, thus reducing its ability to erode soil. Indigenous trees and shrubs are planted on eroded lands to rehabilitate land degradation. In certain areas, communal highly degraded lands are closed off to livestock to protect it from grazing and planted with trees for regeneration (Lal, 2008).

Crop rotation was the third most preferred indigenous SWC practice in the study area. It was applicable in all parts of the study area where terraces were not built that the slope was not the problem. Farmer's choices of crops to grow in rotation were largely based on their personal preference, agro climatic condition and suitability of the soil type of farm plot for the chosen crops. According to the key informant discussion, major crop rotation system practiced by farmers in the study area were from cereals to cereals (Maize - Teff - Maize or Maize - Wheat or Wheat - Teff - Wheat), from legumes to cereals (Haricot bean - Teff or Maize - Beans - Maize) or from cereals to root crops (Maize-Sweet potato or Wheat - Sugar potato or Teff -Yam). Planting of different crops on the field in rotation can increase soil nutrients and crop yields. On the other hand, if the same crop is grown on the same land frequently, the planted crop develop the root at the same depth of soil profile and thus the propagation of the root systems in the same depth results in strong competition for moisture and nutrients. Teklu Erkossa and Gezahegn Ayele (2003) reported that in east Wollega region, major cereals after legumes or oil crops are rotated mainly for soil fertility maintenance, weed and disease control. Moreover, a study in Konso area showed that to improve soil fertility farmers' use alternating high residue producing crops with the growing low residue producing crops (Yeshambel Mulat, 2013).

Fallowing, a conservation technique which involves the practice of leaving the land out of production for 3-5 years for the purpose of restoring soil fertility and minimizing soil loss, was the least practiced indigenous SWC technique in the study area. As FGD revealed, despite the fact that farmers have good knowledge about this conservation practice, due to shortage of farmland and high population pressure in the study area, the method has become rarely practiced. During field observation in the study area, it was observed that farmers applied fallowing in the formerly degraded farm and grazing lands. A study conducted at Digil watershed in East Gojam indicated that fallowing was used to be the most important way for improving soil fertility (Michael Shiferaw, 2002). Therefore, fallowing is effective measure in restoring degraded farm and grazing lands in the study area, though it is less practiced.

3.1.2. Modern soil and water conservation practices

Modern soil and water conservation practices were recently introduced but widely applied methods in the study area. Of the total sampled households, 94% of them used modern soil and water conservation practices such as *fanaya juu*, soil bunds, grass strip, improved cut-off drains plantation of trees, check dams, and basins (Table 2). However, grass strips were highly practiced (70.4%) conservation activities in the study area. This is in agreement with Lan *et al.*, (2009) that grass strips create barriers that minimize soil erosion and runoff. Silt builds up in front of the strip, and within time benches are formed. Types of grasses planted in the study area included elephant grass and bushes (Figure 2). Furthermore, key informants reported that there are different types of strips used along with grass stripes such as banana, gravillea, and coffee. According to respondents, the major reasons for using grass stripes were due to its low cost and could be used as forage for their cattles. Besides, in some cases, they earned money from the sale of grasses.



Figure-2: Grass strips used in the study area.

On the other hand, check dams and basins were the least practiced (6.8% each) conservation activities in the study area. Gully erosion was one of the serious problem in the study. Hence, according to respondents, check dams are important structures constructed by woods and rock fragments across the gully to reduce the velocity of run-off and prevent deepening and widening of the gully. In order to overcome the problem, different gully stabilization measures were implemented in the study area. Basins are normally small semi-circular shaped or holes constructed to capture and hold rainwater and soil. They constructed along the contours on the eroded bare lands and communal lands which used to trap rapid run-off and flow of rain water. According to respondents, constructed basins enhanced the infiltration capacity of water and nutrients in the ground. In the study area, basins were constructed in different shapes (Figure 3).

Table-1: Indigenous soil conservation measures practiced in the study area

Indigenous soil management practices	Kebeles						Total	
	Mesafe		Kachabirra		Wererama			
	No	%	No	%	No	%	No	%
Traditional stone bunds	18	16	15	18	13	13	48	15.9
Traditional ditches	53	46.9	36	42	63	61.6	153	50.5
Crop rotation	77	68.1	65	76	91	88.3	233	77.2
Following	5	4.5	3	4	7	6.6	15	5.1
Cut-off drains	82	72.7	64	74	70	68.3	216	71.6
Tree planting	89	78.7	71	82	81	78.3	241	79.5
Contour farming	49	43.9	53	62	62	60	164	54.5
Terraces	10	9	14	16	9	8.3	33	10.8
Application of manure	84	74.2	76	88	87	85	247	81.8
Mixed cropping	48	42.4	60	70	72	70	180	59.6
Inter cropping	32	28.7	39	46	38	36.6	110	36.6



Figure-3: Basins on degraded land in wererama kebele

Table-2: Soil and water conservation techniques.

Types of modern soil management practices	Kebeles						Total	
	Mesafe		Kachabirra		Wererama		No of HHH	%
	No of HHH	%	No of HHH	%	No of HHH	%		
Fanaya juu	53	47	36	42	46	45	135	46
Improved cut-off drains	38	34	32	38	36	35	107	35.7
Check dams	5	4.5	9	10	7	7	21	6.8
Soil bunds	37	33	32	38	29	28	99	33
Basins	5	4.5	7	8	8	8	21	6.8
Plantation of trees	53	47	36	42	46	45	135	44.8
Grass strip	89	79	67	78	57	55	212	70.4

3.2 Farmers' perception on the significance of modern SWC practices

Farmers and focus group informants were interviewed to understand their perception upon the effectiveness of modern soil and water conservation practices in retaining soil erosion on their farm. Thus, 66.5% of respondents perceived that application of modern soil and water conservation practices such as grass strips, improved cut-off drains, *fanaya juu* and others are highly effective and widely used in their locality (Table 3). The level of perception on modern SWC practices per study kebeles was also relatively the same. Similar study that has been carried out in southern Ethiopia at Gununo area confirmed that farmers in the area have good perception about SWC practices (Abay Ayalew, 2011)

Table- 3: Farmer's perception on the effectiveness of modern soil and water conservation practices

Effectiveness of modern SWC Practices	Kebeles			Overall total	
	Mesafe	Kacha birra	Wer era ma	No of sample HHH	% of sam
Less effective	16	10	7	33	11
Moderately effective	21	20	27	68	22.5
Highly effective	76	56	69	201	66.5
Total	113	86	103	302	100

Regarding the length of time at which farmers practiced SWC techniques in their farmland, 66.5% of respondents mentioned that they used for more than 5 years. At study kebele levels also, 76%, 65.1% and 60% of respondents practiced the same at Kachabirra, Mesafe and Wrerama, respectively (Table 4). Different studies (Million Alemayehu, 2003; Fikru Assefa, 2009) have also shown that using of SWC techniques for prolonged periods would result improved crop yield.

Table-4: Time of length for application of SWC measures.

Variable	Duration (Years)	Kebeles			Total	
		Mesafe %	Kachab irra %	Wrera ma %	No	%
Time of length for application of SWC measures	More than 5	74(65.1)	65(76)	62(60)	201	66.5
	3 – 4	24(21)	9(10)	17(17)	50	16.5
	2 – 3	10(9.09)	5(6)	15(15)	30	10
	One	6(4.54)	7(8)	8 (8)	21	7

3.3 Factors affecting implementation of soil and water conservation practices

In the study area, it has been found that farmers' application of structural soil and water conservation practices were influenced by different factors such as, age, sex, house hold size, topography, educational status and farmland size. Besides, lack of information, labor cost, distance from the homestead, level of contact with DA's, and training on soil conservation techniques had significant influences on practicing structural soil and water conservation measures in the study area.

3.3.1. Gender

Of the total of 302 sampled household heads, 79.8% were males. These household heads were include a wide range of people, village elders, decision makers or local administrators, younger people, older people, farmers and so on. The remaining 20.2 % of the household heads were females. There is a positive relationship between gender and implementation of soil and water conservation measures. In most cases male households are more actively participated in the implementation of indigenous and modern SWC measures than female household heads. Analogously, Krishna *et al.*, (2008) and Eleni Tesfaye (2008), revealed that male headed house hold heads have a higher chance to be involved in continued use of SWC measures than female headed households in most women spent their time in domestic activities and responsibilities.

Majority (93%) of household heads among the sampled respondents were married. And the remaining households were single (2%), divorced (2%) and widowed (3%). Out of the total sampled household heads, 67.5% had family size of 5-7. The remaining 10.8% and 21.7 % of the household heads had 1-4 and > 8, respectively. Hence, majority of household heads (89.2%) had family size > 5. The minimum and maximum family sizes found in the present study were 3 and 13, respectively, with the average family size of 7. The result is greater than Ethiopian national average household size of 5 (MoH, 2014). This clearly indicates that there is relatively high population density in the study area that presumably have negative impact on SWC measures since to feed such large family, engagement in off-farm activities would be inevitable. Large family size influences the decision of farmers to undertake the conservation measures. Wagayehu Bekele and Lars, (2003) indicated that in the large families with greater number of mouth to feed, immediate food generate need is given priority and labor is diverted to off-farm activities that food.

3.3.2. Marital status and family size

According to the present finding, majority of the respondents were found at productive age between 20-29 (28.1%), 30-39 (46.1%) and 40-49 (16.1%). Age has influence on the acceptance and implementation of SWC practices. Usually farmers at younger age are not resistant to adopt different SWC techniques as compared to the older ones. Mulugeta Demalash *et al.*, (2001) mentioned that young farmers are often expected to engage in SWC practices because they assumed to have a better awareness and not resistant to change. Similarly, Goulson and Dillman (1983) pointed out that there is a negative correlation between age of farmers and adoption of erosion control practices. Wagayehu Bekele and Drake (2003) also found out that old-aged farmers are more likely to reject conservation practices. Of the total household heads in the survey, 13% were unable to read and write whereas the remaining 87% were literates at different levels that assumed to have a better knowledge of SWC practices in their locality. Generally, better-educated households have a more realistic perception and adoption about SWC practices ($r = 0.726$). Mulugeta Demalash, *et al.* (2001), explained that level of education has strong in fluency towards the adoption of any kind of technology. In similar fashion, Krishna, *et al.*, (2008) and Fikru Assefa, (2009) indicated that better educational level of the HH heads has strong and positive relationship with their adoption of SWC because of their ability to find new information and their understanding of new technologies.

3.4 Bio-physical characteristics

3.4.1. Farmland Size

Similar to most of the highlands of the country, the landholding size of farmers in the study area was very small. Majority (72.7 %) of farmers had farmland less than 0.5 ha. On the other hand, only 5.1% of the total sampled households had farmland size larger than 2 ha (Table 5). Reports from Zonal bureau indicated that majority of households in the study area cultivate in <2.0 ha of farmland (CSA, 2010). During FGD, discussants mentioned that due to the smallness of their farmland implementation of some SWC practices such as terracing would further narrowed the farmland. Thus, due to this reason either they do not use such practices or they would not let the constructed terrace for longer period. Similarly, Belay Tegene (1992) and Habtamu Ertiro (2006) showed that farmers having smaller farming land usually remove soil conservation measures such as terraces.

Table-5: Land holding size of sample household heads

Variables	Frequency	Percentage
<0.25 ha	17	5.7
0.26-0.5 ha	202	67
0.6-2.0 ha	68	22.2
>2.0 ha	15	5.1
Total	302	100

3.4.2. Soil fertility of farmland

The condition of soil fertility on cultivated farm land has been found another important factor that affected farmers' decision on the application of SWC practices in the study area (Table 6). Farmers with infertile farm land were more

involved in conservation work than those who had fertile land. This might be due to the reason that farmers with infertile farmland need to improve the productivity of the land by implementing various SWC techniques. Eleni Tesfaye (2008) mentioned that continuous use of soil management practices is important to enhance the productivity of a farmland.

The distance between farmland and farmer’s residence was also another factor which determines the implementation of SWC practices in the study area (Table 6). Generally speaking, as the farmland distance from the residence increases, the level of engagement in SWC practices decrease. This implies that distant farmlands are not well managed compared to near farm lands which are close to the homesteads. Labor cost due to time spent on travel might be the probable reason. Similarly, Kessler (2006) revealed that the level of engagement of farmers in practicing SWC measures is very high in fields situated near to the residences. According Shiferaw and Holden (1998) also, scattered and far away fields are determinant factors that discourage farmers from adopting SWC measures. They further explained that some farmers undertake SWC work during the evening, making it difficult to go to the fields that are located far from the residence.

3.4.3. Fertility Impacts on soil quality

Concerning the fertility status of soil in the study area, 84.7% of respondents confirmed that it is improving whereas 13% of respondents said it is declining. On the other hand majority of respondents (73.2%) have mentioned that the decline of agricultural productivity is one of the most important indicators for declining of fertility in the study area (Table 7). With regard to reasons for soil fertility decline in the study area, majority of respondents (55.7%) replied loss of top soil by erosion. Other reasons for soil fertility decline in the study area include over cultivation and over grazing. Habtamu Ertiro (2006) indicated that soil loss occur on unproductive land with less vegetation cover that was once under cultivation. He further explained that along with soil movement large amount of organic matter (OM), nitrogen (N), phosphorous (P), potassium (K) and other nutrients that are necessary for agricultural production are lost.

3.5. soil quality analysis

3.5.1. Soil moisture

Among analyzed soil quality parameters, soil moisture showed significant variation (p<0.05) with respect to treatment of soil (conservation practices). Higher soil MC (2.86±0.018) was recorded in terraced farm plots with

Table-6: Relationship between distance of farm land and soil fertility with soil and water conservation practices on farm lands.

Variables		Soil and water conservation practices			Correlation	
		Indigenous methods of SWC	Modern methods of SWC	Integrating indigenous with modern		
Location of farm plots		No of HHH	No HHH	No of HHH	Count	.849 **
		73	62	61	196	
	Far	37	34	35	106	
		110	96	96	302	
Fertility of Soil	Fertile	67	51	72	190	.773**
	Medium	24	26	37	87	
	Low	8	6	11	25	
		99	83	120	302	

** . Correlation is significant at the 0.01 level (2-tailed)

Table-7: Fertility of soil in study area (Based on respondents’ response)

CAM	Options	Frequency	Percentage
	Improving	256	84.7
	The same	7	2.3
	Declining	39	13

	Total	302	100
Indicators of fertility decline	The decline of agricultural productivity	221	73.2
	Devoid of vegetation cover	21	7
	Size and color of seedlings	60	19.8
	Total	302	100
Reasons for fertility decline	Losses of top soil by erosion	168	55.7
	Over cultivation	115	38
	Over grazing	19	6.3
	Total	302	100

different SWC measures as compared with non-Terraced farm plots (2.37±0.018). On the other hand, the interaction of treatment and slope effect was not statistically different (p>0.05) (Table 8). In conserved farm plots, the higher soil moisture (2.86±0.018) was observed in the lower slope gradients (3-8%) than in the higher and middle slope gradient (13-18% and 8-13%) (2.818±0.018 and 2.817±0.018) whereas in non- conserved farm plots, lower soil moisture with very small difference was observed at all slope gradients (2.363 - 2.375) (Table 9). The result of the study revealed that BPSWC practices highly improved the soil moisture capacity or contents. Soil MC, which is a key factor affecting agricultural production in water shortage problem having environments, was higher in farm plots with BPSWC practices compared to non-SWC practiced farm plots. Lewis (1982) reported that soils found at the middle and lower level receives high moisture than upper slope. The increase in soil MC also may be attributed to an additional water supply from upper slope to down slope direction as catchment area increase.

Table-8: summary of ANOVA for (MC pH SOC TN Av.P Ca²⁺ Mg²⁺ K⁺ and Na⁺)

Sv	df	MC		PH		SOC		TN		Av.P		Ca ²⁺		Mg ²⁺		K ⁺		Na ⁺	
		Ms	P	Ms	P	Ms	p	Ms	P	Ms	P	M	P	Ms	P	Ms	P	Ms	P
TR	1	.96	<.01	.6	<.001	.069	.032	.0018	<.0001	.000098	<.0001	1.3	<.0001	.43	<.0001	.67	<.0001	.039	<.0001
SP	2	.0013	.29	.024	.819	.00042	.0001	.00004	.12	.001	.0014	.002	.30	.0009	.116	.0022	.073	.00008	.2269
TR*SP	2	.0008	.47	.0025	.98	.00024	.79	.00005	.109	.000028	.057	.00065	.69	.0007	.178	.0007	.38	.00008	.2267
Error	10	.001		.119		.0018		.00001		.000007		.0017		.00035		.00067		.000046	
Total	15																		

TR-Treatment, SP-slope, TR*SP-Treatment with Slope, MS-Mean, P-value

Table-9: Soil properties of (MC pH SOC TN Av.P Ca²⁺ Mg²⁺ K⁺ and Na⁺) of the top soil (0-20cm) depth relation with conservation practice and slope gradients (mean±S.E)

Conservation	Slope	Parameters																	
		MC	PH	SOC	TN	Av.P	Ca ²⁺	Mg ²⁺	K ⁺	Na ⁺	MC	PH	SOC	TN	Av.P	Ca ²⁺	Mg ²⁺	K ⁺	Na ⁺
		Mean	S.E	Mean	S.E	Mean	S.E	Mean	S.E	Mean	S.E	Mean	S.E	Mean	S.E	Mean	S.E	Mean	S.E
Conserved	3-8%	2.86	±0.18	6.2	±.19	.637	±.024	.168	±.0024	.420	±.0015	1.60	±.024	1.81	±.0108	1.70	±.0149	.175	±.003
	8-13%	2.81	±0.18	6.15	±.19	.622	±.024	.158	±.0024	.411	±.0015	1.54	±.024	1.81	±.0108	1.68	±.0149	.179	±.003
	13-18%	2.81	±0.18	6.0	±.19	.607	±.024	.160	±.0024	.408	±.0015	1.58	±.024	1.77	±.0108	1.64	±.0149	.189	±.003
Non-conserved	3-8%	2.37	±0.18	5.0	±.19	.501	±.024	.142	±.0024	.400	±.0015	1.04	±.024	1.49	±.0108	1.29	±.0149	.274	±.003
	8-13%	2.37	±0.18	4.98	±.19	.496	±.024	.142	±.0024	.398	±.0015	1.027	±.024	1.48	±.0108	1.291	±.0149	.276	±.003
	13-18%	2.36	±0.18	4.95	±.19	.497	±.024	.141	±.0024	.396	±.0015	1.046	±.024	1.48	±.0108	1.278	±.0149	.274	±.003

3.5.2. Soil PH

Soil PH mean value showed significant variation with regard to treatment (p<0.05), however no variation observed at different slope gradients (p>0.05). Similarly, the interaction between treatment and slope effect was not statistically significant (p<0.05) (Table 8). The pH mean values of the study site at conserved and non-conserved plots were 6.23±0.19 and 4.96±0.19, respectively (Table 9). This difference may be due to leaching of cations in non-conserved farm lands due to lack of SWC measures. The results of the soil P^H content analysis revealed that traditional land conservation practices have significant role in controlling soil cover, soil organic matter and reduces soil erosion. Alemu Lelago *et al.*, (2016) mentioned that soil P^H(water) critical levels used for classifying soil fertility. As strongly acidic <5.5, Moderately acidic 5.6-6.5, Neutral 6.6-7.3, Moderately alkaline 7.3-8.4 and Strongly alkaline >8.4. Therefore, in the present study non-conserved farm lands were strongly acidic whereas conserved farm lands were moderately acidic.

3.5.3 Soil organic carbon

Laboratory results of SOC showed significant variation with respect to both treatments and slope gradients (p<0.05). However, the interaction of treatment and slope gradients did not show variation (p>0.05) (Table 8). The conserved farmlands (0.637±0.024) contained higher soil organic carbon than then on-concerned ones (0.497±0.024). This indicates that the BPSWC methods have significant role in conserving soil organic carbon. Tadele Amdemariam (2011) reported that SOC is higher in treated farmlands than untreated ones. Other similar studies (Million Alemayehu, 2003; Yihenew Gebreselassie, *et al.*, 2009; Worku Hailu, *et a.* 2012), have also pointed out that non-treated farm lands have significantly lower SOC than treated farm lands. With respect to slope gradient position, the lower slope gradient had higher SOC where as the upper slope gradients contained lower SOC (Table 9). The lower soil SOC content at higher slope gradient might reflect the decreasing width of horizon with uniform sheet erosion. Million Alemayehu (2003) and Gregorich (1998) reported that soil organic carbon content is higher in the lower slope position due to increasing in moisture (soil water content) and fertile soil deposition which higher crop biomass production. Moreover, Bot and Benites (2005) revealed that the accumulation of soil organic matter would be favored in the lower slope gradients due to soil moisture and transportation of soil organic matter through erosion.

3.5.4. Total nitrogen

Total nitrogen differed significantly between the treatments (p<0.05), but not for slope positions and, treatment and slope interactions (p>0.05) (Table 8). The overall TN content in soil under non-conserved farm lands was significantly lower (0.14) than conserved farmland (0.16). Abay Chall *et al.*, (2016) mentioned that the farm plots treated with SWC measures within the catchment was found to exhibit higher TN than the non-conserved farm plots in

the catchment. TN also correlated positively with SOC contents. Havlin *et al.*, (2002) explained that there is strong positive correlation between total soil nitrogen and soil organic carbon contents. Bezuayehu Tefera *et al.*, (2002) also confirmed that the availability of total nitrogen is dependent on soil organic matter content of the soil.

3.5.5. Soil available phosphorus

Soil available phosphorus differed significantly between the treatments and slope gradients ($p < 0.05$), but it was not significant for treatment and slope interactions ($p > 0.05$) (Table 8). The conserved farmlands had greater concentration of available phosphorus than non-conserved ones. With respect to slope gradient position, the lower slope gradient (0.42 ± 0.0015) showed higher mean of available phosphorus than both in the middle and upper slope gradient position (0.41008 ± 0.0015) and (0.39 ± 0.0015) (Table 9). This result implies that implementation of biophysical soil and water conservation (BPSWC) structures maintain soil fertility by reducing the removal of available phosphorus and soil organic matter through soil erosion. Furthermore, these variations could be happened due to washing of top soil and soil organic matter from the higher slope gradient position and accumulation at the lower slope gradient/accumulation zone. Phosphorus is normally strongly fixed with soil particles. Therefore, it is easily transported from higher slope position to down slope gradient position during erosion, giving higher amount of Phosphorus in the soil accumulation zone. As result of erosion is responsible for the reduction of soil available phosphorus in the upper slope gradient (Ohwoghere, 2012). Available phosphorus also showed positive correlation with SOC and TN. According to Press (1992) report, the amount of soil organic matter in the semi-arid region is the main factor of controlling available p and other soil fertility parameters. The higher soil organic matter content in treated farm land would result high availability phosphorus (Mulugeta Demelash and Stahr, 2010).

3.5.6 Exchangeable cations Ca^{2+} Mg^{2+} K^{+} and Na^{+}

The exchangeable Na^{+} ion showed significant variations at ($p < 0.05$) with treatments, however, it was not significant in slope gradients and treatment-slope gradient interaction their interaction ($p > 0.05$) (Table 8). Exchangeable Na^{+} under non-conserved farm land was significantly higher (0.274 ± 0.0039) than conserved farmland (0.175 ± 0.0039) (Table 9). Generally, Ca^{2+} Mg^{2+} and K^{+} concentrations in conserved farm lands were found to be significantly higher than non-conserved farm lands based on both treatment and slope gradient positions. This indicates that SWC measures have great contribution for improving soil quality with respect to the above mentioned basic cations. Unlike all other parameters measured in the present study, exchangeable Na^{+} was significantly higher in non-conserved farm land with higher slope gradient position. The mean value of Na^{+} in conserved soil were low the soil have good texture and high amount of Ca^{2+} and Mg^{2+} because of calcium and magnesium ions are very essential soil nutrients. When the Na^{+} is high amount in soil the sodas, salinity and electric conductivity of soil increase.

4. Conclusion and Recommendations

4.1 Conclusion

The study assessed awareness of the kechabirra woreda community about SWC practices in the locality. Thus, different SWC practices that include indigenous, modern and integrated approaches are practiced at various levels in the study area. Among indigenous SWC techniques farmers showed high degree of preference to application of manure, indigenous tree planting and crop rotation. On the other hand, grass strips and fanaya juu were among the most preferred modern SWC measures in the study area. Effectiveness of the methods towards farmland productivity, farmers' prior experience/awareness, and ease application in terms of cost and accessibility might contribute for such preferences. Different demographic factors such as gender, level of education, age and family size have influenced farmers' adoption of SWC practices in the study area. Besides, bio-physical characteristics such as soil color, farmland size, farmland fertility and distance of farmland from residence were also affected farmers adoption of soil and water conservation practices. Many prior studies that have been carried out at different regions also confirmed demographic and bio-physical characteristics as key factors affecting implementation of SWC practices. The physicochemical properties (MC, pH, SOC, TN, Av.P and BCEC) of soil analysis revealed high mean content for farm plots treated with SWC practices. At different slope gradients, variations have been observed for some soil physicochemical properties. In general, both the experimental and farmers perception assessment results confirmed that farmlands treated with different SWC techniques have better productivity than untreated ones.

4.2 Recommendations

Based on the findings of the present study, the following recommendations are forwarded:

- ☐ High population pressure forced local people to cultivate very sloppy areas that accelerate soil erosion, land degradation and loss of biodiversity in the study area. Therefore, minimizing population pressure by implementing wide resettlement program to low populated areas is advisable.
- ☐ Indigenous knowledge of farmers on soil and water conservation measures should be highly encouraged.
- ☐ Formulating appropriate plan and strategies for creating suffice awareness about different SWC techniques among farmers is very important

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