



Research Paper

Assessment of indigenous soil and water conservation practices of East Hararghe Zone, Ethiopia

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ABSTRACT

Ethiopia is regarded as the roof of eastern Africa and is considered water tower of the region. Indigenous knowledge of soil and water conservation practices are common in many parts of the country. It is common to see slope lands brought into cultivation where land pressures are high. In many instances in the past, SWC mechanisms were built without proper design. Thus, it is common to see different forms of soil and water conservation practices across the country. Hence, many area of the country's top soil is under severing condition of erosion; however, the East Hararghe people have indigenous SWC mechanisms which enable them to save the soil from erosion. The objectives of this study were to identify indigenous SWC practices physically and socio-economically to harness and promote its use and to characterize indigenous soil and water conservation practices of the study area for further improvement. In this study, both primary and secondary data collection techniques were used. This includes physical SWC structure parameters: (Land Slope (LS), Vertical Interval (VI), Horizontal Interval (HI), Length of the structure (L)), interview, focal group discussion, observation, document analysis and other data source. The finding of the study shows that the indigenous SWC mechanisms in the community are developed over a very long period of time. The overriding solutions to soil erosion problems include options ranging from single mechanical or agronomic practice to watershed scale. Some of the common indigenous SWC practices identified in the study area were: Mechanical SWC practices (soil bund, stone bund, terrace, micro-basin and tied ridge) and biological SWC practices (grass for structure stabilization and tree plantation). Agroforestry practices (algae check dam, sifting cultivation) consistent with similar practices found in different parts of the country. Bunds and terraces are widely used in the study areas and appreciated by all the farmers. Bunds and terraces constructed by farmers were measured for comparison with scientific value, the measured and calculated parametric value were different from each other; these indicated that, farmers construct these structures without any scientific calculation, which leads to farm land fragmentation and labor intensive. Therefore, these indigenous practices need governmental or non-governmental organizations attention for further improvement.

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Key words: Indigenous knowledge, characterization, identification, soil and water conservation practice.

INTRODUCTION

Accelerated soil erosion is one of the major threats to sustainable agricultural production in many parts of the

East African highlands (Gachene et al., 1997; Kaihura et al., 1999). Soil erosion in these areas causes loss of soil fertility,

low crop yields, food deficiency and off-site effects such as siltation of waterways and damage to various structures. In Ethiopia, soil and water are the most critical natural resources. Nearly, 85% of the population depends on subsistence agriculture. One process that threatens the resource base is soil erosion. Studies have shown that billions of tons of soil are lost annually (Teshome, 1995) cited in Samuel (2014).

Ethiopia is one of the most environmentally troubled countries in the Sub-saharan belt. The principal environmental problem in Ethiopia is land degradation in the form of soil erosion, gully formation, soil fertility loss and severe soil erosion (Hurni, 1993).

The Ethiopian land mass is generally categorized into the highland (above 1500 m.a.s.l.) and the lowland (below 1500 m.a.s.l.). The highlands comprise about 44% of the total landmass and accounts for 95% of the cropped land. About 88% of the human population, at an average density of 64% per km² and two-thirds of the livestock is accommodated in the highlands (Kruger et al., 1996).

Serious erosion is estimated to have affected 25% of the highland area. According to some estimates four percent of the highlands are now so seriously eroded that they will not be economically productive again in the foreseeable future (Kruger et al., 1996). The Soil Conservation Research Project (SCRIP) has estimated an annual soil loss of about 1.5 billion tons from the highland. According to the Ethiopian Highlands Reclamation Study (EHRS), soil erosion is estimated to cost the country 1.9 billion US\$ between 1985 and 2010. These call for external interventions based on the local socio-economic and technical potentials if the country is to continue as a nation. Many generous international donors assisted the program. Since 1960s various conservation strategies have been introduced to enhance agricultural development and rural livelihood (Aklilu, 2006).

During the 1980s, the Government of Ethiopia launched a massive program of soil conservation and rehabilitation. Hence, to grapple with the problem of soil erosion massive reforestation and soil and water conservation schemes were launched in Ethiopia. The effort, which involved heavy external support culminated in the mobilization of peasant associations with over 30 million workdays per year (Hurni, 1986).

During this period, it was normal to follow any technical guideline developed and tested elsewhere without integrating it into the local socio-economical or environmental conditions. Nevertheless, the achievements fell far below expectations and the country still loses a tremendous amount of fertile topsoil and the threat of land degradation is alarmingly broadening.

These SWC measures are expected to reduce soil loss from water erosion, retain more moisture and nutrients effects of which increase crop yields. However, there is not

much information as to what extent these SWC measures achieve the expectations (physical effectiveness) so as to enable proper planning and convincing the farming community to invest in SWC. The little information available has been delivered from very diverse methodological approaches and many different underlying assumptions, thus, making it difficult for generalized application (Lal, 2001; Stroosnijder, 2003). This information often report the effects of soil erosion or the effectiveness of SWC measures in terms of soil loss (ton ha⁻¹) or surface run-off (m³ t ha⁻¹). The value of such information can be added by translating the loss due to soil erosion or the gain from SWC measures into crop yields or monetary terms which are of primary importance to farmers.

Furthermore, the effects of soil erosion and hence, SWC practices can vary according to the soils, crop and other management practices (Kruger et al., 1996; Johansson, 2001).

Knowledge and preferences of farmers have also not been adequately considered in planning and implementation of SWC programs (Kruger et al., 1996; Tenge et al., 2004; Conte, 1999; El-swify and Hurni, 1996). Consequently, the adoption by farmers of the most recommended SWC measures is minimal and soil erosion continues to be a problem (Wenner, 1988; Mbaga-Semgalawe and Fomer, 2003; Tejuwani, 2004; Tenge et al., 2004).

There are two main types of erosion: geologic and accelerated erosion. Geologic erosion is a normal process of weathering that generally occurs at low rates in all soils as part of the natural soil-forming processes. It occurs over long geologic time horizons and is not influenced by human activity. In contrast, soil erosion becomes a major concern when the rate of erosion exceeds a certain threshold level and becomes rapid, known as accelerated erosion (Humberto and Rattan, 2008).

Anthropogenic activities involving deforestation, overgrazing, intensive cultivation, soil mismanagement, cultivation of steep slopes and urbanization accelerate the soil erosion hazard in the selected area. As a result, the following study exemplifies the widespread nature and degree of sophistication of indigenous soil conservation mechanisms. Thus, indigenous knowledge on soil conservation at East Hararghe will provide a more detailed account, description and analysis of indigenous soil and water conservation practice. The study also serves to illustrate and reinforce the value of indigenous soil and water conservation as the basis for improved conservation of soil and water resources.

The important issue should thus be the integration of indigenous practices and the western scientific technologies in such a way that the positives sum produces optimum outputs. This study is therefore aimed at identifying the

local knowledge and practices of farmers on soil and water management for further improvement that was bench mark for the future development work. The objectives of the study were to identify indigenous SWC practices physically and socio-economically to harness and promote its use in soil and water conservation and to characterize indigenous soil and water conservation practices of the study area for further improvement.

MATERIALS AND METHODS

The adoption of improved SWC technologies in developing countries has attracted much attention from scientists and policy makers mainly because land degradation is a key problem for agricultural production (De Graaff et al., 2008). In Ethiopia, prior to 1974, the importance of conserving farmland was largely neglected. The problem attracted the attention of policy makers only after the devastating famine problem in 1973/74. After the 1973/74 famines that coincided with and/or triggered a change of regime in the country, the government has initiated a massive program of afforestation and soil conservation with the support of international countries (Wagayehu and Lars, 2003). Packages of soil and water conservation programs were prepared for implementation through Food-For-Work schemes (Wagayehu and Lars, 2003). The method consists of a participatory community planning process with actual planning of SWC measures at farm level. Since its introduction, the catchment approach has given positive results in the improvement of soil productivity together with reduced resource degradation and is now adopted by six East African countries (Kamar, 1998; Kizunguto and Shelukindo, 2002). However, a critical review of the method lamented the low rate of SWC adoption and highlighted the lack of proper tools for soil erosion assessment (Pretty et al., 1995).

Location and description of the study area

The study was conducted in three districts (Fedis, Kersa and Kombolcha) of Eastern Hararghe Zone of Oromia (Figure 1). The study areas are located around 536, 475 and 525 km from Addis Ababa, capital city of Ethiopia, respectively. The study encompasses two peasant associations (PA) from each district. Iftu-Dada and KeransaLencha, YabataSalama and Galemirga and Sibilu and Simergel peasant associations were selected from Fedis, Kersa and Kombolcha districts, respectively. Fedis, Kersa and Kombolcha districts are situated between 08°55'41"N to 09°17'59"N and 42°00'42"E to 42°20'26"E, 09°20'50"N to 09°32'53"N and 41°4'00"N to 41°58'15"N and 09°25'50"N to 09°22'53"N and 42°20'00"N to

42°43'15"N, respectively. Fedis, Kersa and Kombolcha districts are situated in average elevation of 1418, 1983 to 1851 m.a.s.l. respectively. These districts are characterized by diversified topography features such as undulating to rolling plains and flat plains. They have bimodal rainfall pattern with average annual amount ranging from 500 to 750, 498 to 866 mm and 500 to 900 mm Fedis, Kersa and Kombolcha, respectively. The first rainy season is short from March to April and the second rainy season is long from July to end of September. The second rainy season is more reliable and contributes to agricultural crop production in the areas. The annual temperature amount ranges from 14.10 to 27.7°C, 11.40 to 25.2°C and 12.5 to 26.7°C with mean minimum and maximum temperature in Fedis, Kersa and Kombolcha.

Soil type

There are five types of soils in Fedis district. The dominant soil type in the area is Cambisols which cover an area of 67.20%. Leptosols, Gleysols, Luvisols and Nitisols cover 22.43, 5.35, 3.70 and 1.32% of the area respectively. Table 1 and Figure 2 shows the soil type of the catchment presented. The dominant soil type in Kombolcha district is Cambisols which cover an area of 56.29%. Leptosols, Gleysols, Luvisols and Nitisols cover 29.45, 8.31 3.72 and 2.23% of the area, respectively. The soil type of the catchment is presented in Table 1 and Figure 2. There are five types of soils in Kersa district. The dominant soil type in the area is Cambisols which cover an area of 71.23%. Leptosols, Gleysols, Luvisols and Nitisols cover 22.40, 4.35, 1.70 and 0.32% of the area respectively. Table 1 and Figure 2 show the soil type of the catchment.

Land use/land cover and farming system

The GIS output of land use/cover of Kombolcha district shows that intensively and moderately cultivated agricultural land (covered with maize and sorghum) covers 96.73% of the entire study area followed by open and dense shrubs land that takes 2.91% and the least is 0.36% covered by open grass land. Fedis district shows that intensively and moderately cultivated agricultural land (covered with maize and sorghum) covers 41.33% of the entire study area followed by open and dense shrubs land that takes 34.81% and the least is 23.86% covered by open grass land. Kersa district shows that intensively and moderately cultivated agricultural land (covered with maize and sorghum) covers 38.83% of the entire study area followed by open and dense shrubs land that takes 31.91% and the least is 29.26% covered by open grass land. The area coverage by each land use type is presented in Table 2

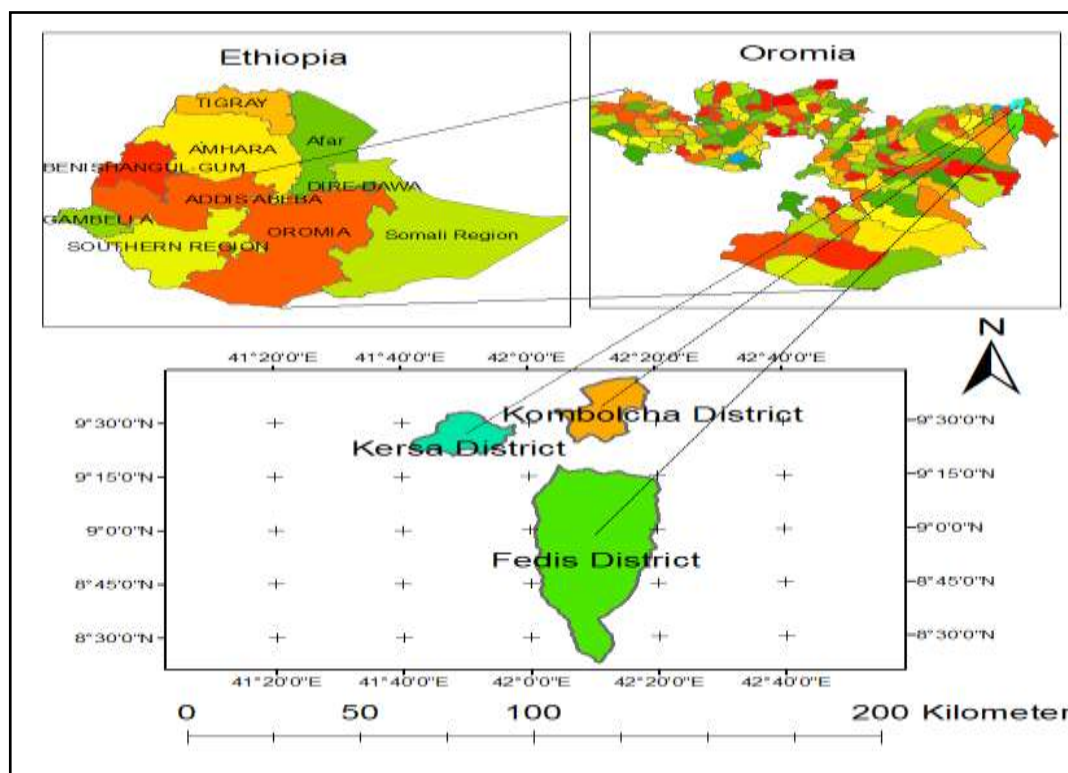


Figure 1: Location map of the study area.

Table 1: Soil distribution of the study area.

Districts	Soil type	Areal coverage (ha)	Areal coverage (%)
Fedis	Cambisols	144.522	67.20
	Leptosols	48.239	22.43
	Glyesols	11.506	5.35
	Luvisol	7.957	3.70
	Nitisols	2.839	1.32
	Total	215,063	100
Kersa	Cambisols	33.033	71.23
	Leptosols	10.388	22.40
	Glyesols	2.017	4.35
	Luvisol	788	1.70
	Nitisols	148	0.32
	Total	46,375	100
Kombolcha	Cambisols	24.830	56.29
	Leptosols	12.990	29.45
	Glyesols	3.666	8.31
	Luvisol	1.641	3.72
	Nitisols	984	2.23
	Total	44,110	100

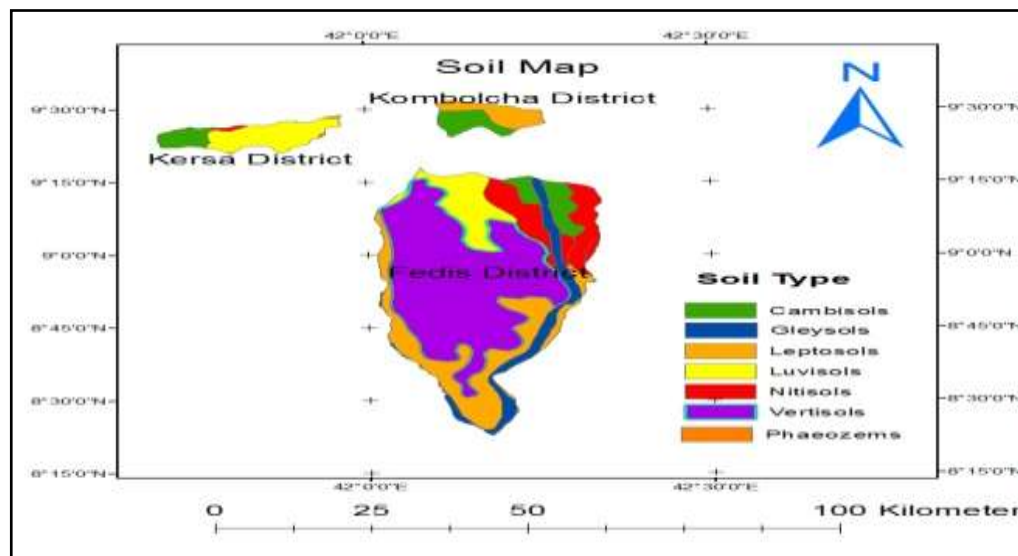


Figure 2: Map of the study area.

Table 2: Land use/cover of study area.

Districts	Land use	Areal coverage (ha)	Areal coverage (%)
Fedis	Cultivated land	88,885.54	41.33
	Shrubs land	74,863.43	34.81
	Grass /grazing land	5,131.40	23.86
	Total	215,063	100
Kersa	Cultivated land	18,007.41	38.83
	Shrubs land	14,798.26	31.91
	Grass/grazing land	13,569.33	29.26
	Total	46,375	100
Kombolcha	Cultivated land	42,667.60	96.73
	Shrubs land	1,283.60	2.91
	Grass/grazing land	158.80	0.36
	Total	44,110	100

and Figure 3. The current situation in the site was observed as cultivated land encroached the shrubs and grazing land due to mainly agricultural land use.

The study area is characterized by a mixed-farming system, whereby farmers are involved in rain-fed agriculture, traditional irrigation in valley bottoms. Among these activities, rain-fed agriculture is the most important, followed by irrigated agriculture.

Major cash crops are Chat (*KattaEdulis*) and vegetables while sorghum and maize are major food crops. Major cropping systems are Chat-sorghum intercrop with different trees species, maize-chat intercrop and patches of

sweet potatoes and tomatoes.

On average, a household has 0.25 ha (undp-eue@telecom.net.et) for rain-fed agriculture. Soil erosion is one of the major constraints to agricultural production. Survey results indicated that the most erosion prone land use fields are those of sorghum followed by maize.

RESEARCH METHODOLOGY

In this study, both the primary and secondary data collection techniques were used. This includes observations,

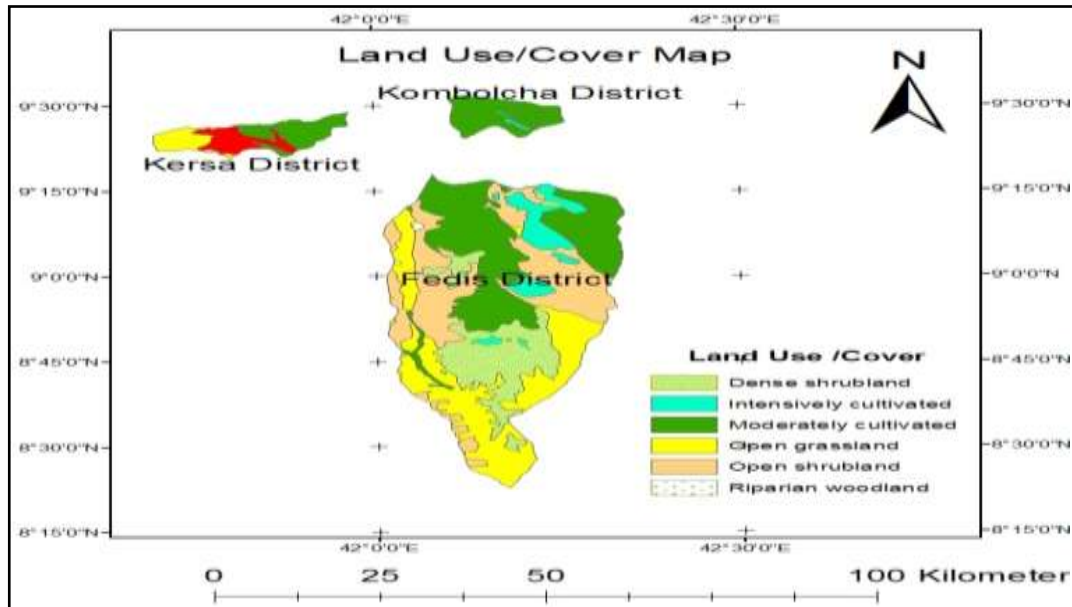


Figure 3: Land use land cover map of the study area.

interviews, focus group discussions, document analysis and other data sources. The applicability of some of these instruments is highlighted.

Observations: Personal observations were conducted together with taking field notes on the behaviors and activities of individual farmers on their interest for the application of different indigenous soil conservation mechanisms and associated factors. These observed facts are further investigated and consolidated through interview and focus group discussions.

Interviews: In this research, many interviews were carried out with the intention of collecting the maximum data until saturation was reached. The researcher conducted face-to-face interviews with farmers, experts in the field, district agricultural officers on the issue of indigenous soil conservation mechanisms and its effectiveness. In this interview, different sections of a society were put into account. Some to mention were farmers and their families (men, women, sons and daughters) etc.

Focus group discussions (FGDs): Focal group discussions with fifteen discussants in each group were carried out on different issues of indigenous soil conservation mechanisms of the local people. These discussions involved unstructured and generally open ended issues of indigenous and modern soil conservation mechanisms that are intended to elicit views and opinions from the participants.

Document review and analysis: During the process of research, we reviewed related literature on indigenous soil conservation mechanisms of the different parts of the world and general back ground of the East Hararghe people. These documents were reviewed both from government official reports and private documents (personal article). Accordingly, data analysis was carried out through interpretation, summarization and description of meanings, views and perceptions of the community.

Site selection and identification of indigenous knowledge

Three districts were selected based on diversity of farmers' indigenous knowledge. Accordingly, Fedis, Kersa and Kombolcha districts were selected. Representative areas investigated were selected based on secondary information on agro-ecologic zone, soil type, topography, rainfall, land cover and past experience (indigenous knowledge and practices on SWC). Based on the aforementioned criteria two peasant associations from each districts were selected. For each district highland, mid-land and low-land agro ecologies were identified.

Participatory Rural Appraisal (PRA) technique was employed with farmers to elaborate on soil and water conservation and soil resource use and management practice and also guided group discussions were made with groups of fifteen farmers from each peasant association (PA).

Farm selection for characterization

Based on data obtained from group discussions, six key informants from each PA under study who have great depth of knowledge about the study area were selected in consultation with the local development agent (DA), local leader and district agricultural office experts with the aim to obtain general information of the selected farm.

Based on information obtained from the key informants and direct field observations (transact walk), six farms from each district that were treated with different indigenous SWC practices were selected. Systematic sampling technique was used to select the farms. The criteria used for selection was: farm size greater than 0.5 ha, each identified belonging to different household and there was no technical intervention of any organization (Governmental or Non-governmental) during the construction of the SWC structures.

After these farms were selected average slope of each of the identified farms were measured using Clinometer and ranging pool and categorized into different slope classes based on FAO, 2006 slope classification system. Each selected farm for all districts was named F₁, F₂, F₃, F₄, F₅ and F₆.

Soil and water conservation measures and criteria for selection

A list of ISWC measures and farmers' priorities was done through different participatory methods which included group discussions and household surveys (Chambers, 1992; Defoer and Hilhorst, 1995; Graaff, 1996; Lyamchai et al., 1998). The aim was to identify the most important SWC options and understand farmers' preferences for certain SWC measures.

Fifty (50) farmers from each district were interviewed. Household surveys were employed followed by group discussions with key informants to get general information and their views on SWC measures. During the household surveys and group discussions, farmers were asked to mention different SWC measures used on their fields and their criteria to select appropriate measures for implementation.

The relative importance of the selection criteria mentioned was ranked. Each SWC measure was assessed by giving a rank on each criterion. The rank was on a scale ranging from 1 to 9, 1 for first choice and 9 for the last selection criteria. A measure with the first choice was considered as the most preferred option (Belton and Reeves, 2002; Tenge et al., 2004).

Adoption of soil and water conservation measures were analyzed in terms of the proportion of farmers undertaking the measures and in terms of the area covered. Generally, this survey was held to collect specific and quantitative

information from the representative farmers.

Characterizing indigenous soil and water conservation practices of the study area

Average ground slope% (GS), average vertical interval (VI), average horizontal interval (HI) parameters of each indigenous soil and water conservation practices were measured with the aim of identification and characterization of SWC practices on selected farm and for each slope class scientific value of the aforementioned parameters were calculated for comparison with farmers practice as:

Spacing of the bunds: The basic principles adopted for deciding the spacing of bunds are: (1) the seepage zone below the upper bund should meet the saturation zone of the lower bund; (2) the bunds should check the water at a point where the water attains erosive velocity and (3) the bund should not cause inconvenience to the agricultural operations. For determining the spacing of the bunds (Murthy, 1994), the formula used is:

$$VI = \frac{S}{a} + b$$

Where, VI = vertical interval between consecutive bunds (m), S = land slope (%), a and b are constants; a = 3 and b = 2 for medium and heavy rainfall zones a = 2 and b = 2 for low rainfall zones.

The bund spacing: The horizontal interval (spacing) can be easily measured on the land surface. For this purpose, the relationship between horizontal and vertical spacing is important and calculated as:

$$HI = \frac{VI}{S} * 100$$

Where, HI=horizontal Interval of the bund (m) and VI = vertical interval (m).

Length of bund: The length of bund was determined by calculating the horizontal interval of the bund formed. The length of bund (m) per hectare area of land was calculated as:

$$L = 100 \left[\frac{S}{VI} \right] \text{ or } \left[\frac{10,000}{HI} \right]$$

Terrace width: The horizontal distance between two terraces was determined based on the formula. However, two meter depth of cut is required for ploughing using bullocks (DSCWM, 2005). The formula used to calculate the width of the terrace is given by (DSCWM, 2005):

$$W = \frac{200 \times d}{s}$$

Where, W = width of the terrace in (m), d = maximum depth of the cut (m) and S = slope of land (%).

Vertical interval: The spacing is the vertical interval (VI) between two terraces. The terrace spacing depends on the soil type, slope, surface condition, gradient, depth of cut and agricultural use. The depth of cut and fill have to be balanced, thus, the interval is equal to double the depth of cut. The depth of cut must not be so deep as to expose the bed rock. The spacing is also linked to the terrace width. The soil depth limits the maximum depth of cut and the maximum possible vertical interval. At the same time, the width of the terrace should permit economic agricultural operation. Therefore, the spacing of vertical interval of the terrace was calculated using the formula (Mal, 1999):

$$VI = \frac{S \times W}{100 - S}$$

Note: For a given slope, the greater the VI, the greater the width.

Length: The length of the terrace is determined by several factors including the shape and size of the land, degree of dissection of the land and permeability and erodibility of the soil. Longer terraces are more efficient for agriculture and cost less to install, but they may increase the velocity of surface run-off, thus, increasing erosion (DSCWM, 2005). In our case the length of the terrace was calculated as bund lengths.

The type of data collected

Farmers idea from group discussion and key informant, Farmers house hold, household characteristics, farming system and farm household resource availability, size of the farm, average ground slope (GS) in %, vertical interval (VI), horizontal interval (HI), length of each practice (LS) of SWC measures and farmers' reasons for preferences of different SWC were all collected.

Sampling procedure

Systematic sample technique was employed to select representative district. The house hold sampling frame consisted of lists of heads of households obtained from the selected farmers for identity criteria of selected SWC. These lists were further stratified according to high, middle and low income groups as established during an earlier

participatory rural appraisal (Lyamchai et al., 1998). Generally, from 150 farmers, only 18 farmers were selected for characterizing SWC based on farm size.

Data analysis

Both qualitative and quantitative statistical techniques were applied in data analysis. Data was analyzed with Microsoft Excel in order to answer the following research questions: (i) Household type that reside in represented area; (ii) what are the major farming systems in the study area; (iii) options of SWC measures farmers use in the research area; (iv) what are the farmers' criteria in selecting SWC measures for implementation?

RESULTS AND DISCUSSION

Site selection and identification of indigenous knowledge

For site selection and household survey two-stage cluster sampling was applied: firstly districts were selected and subsequently peasant associations were selected within these districts. The twenty one districts of East Hararghe Zone were divided into three groups, according to their agro ecology zone: from lowland, midland and highland agro ecology of the study area. Three districts were nominated for the study from these twenty one districts. From these three districts six Peasant Associations were selected for the identification and characterization of indigenous SWC practices. This stratification by location was undertaken, since it seemed likely that these districts would be affected in a different way by soil erosion, with on-site and off-site effects.

Fedis, Kersa and Kombolcha districts were selected based on primary and secondary data of zonal agriculture office. The data indicated that indigenous knowledge of SWC was more diversified in the three districts of the zone. These selected districts have different agro ecologies. Fedis, Kersa and Kombolcha districts represent lowland (arid and semi-arid), midland (semi-arid and semi-humid) and Highland (humid) agro-ecology of the study area, respectively. Iftudada and KerensaLenca PAs represent Fedis district. YabataSalama and Galemirga PAs represent kersa district as well as Sibilu and Simergel PAs represent Kombolcha district.

The stratified sampling frame at the second stage consisted of lists of heads of households obtained from the leaders of the PAs. From the stratified sampling frame, systematic sampling was subsequently undertaken in such a way that representative samples of male and female headed households were included in the sample (Table 3).

In this way, a sample of 150 farmers was obtained, that was representative with regard to some characteristics that were hypothesized to affect adoption of SWC measures.

Farming systems and farm household types

Farm household types were distinguished on the basis of household characteristics, such as age, sex, education, marital status and family composition and also on the basis of resource availability, such as farm size, land tenure, possession of livestock, farm income, labor availability and involvement in off-farm activities. Farmers were asked to group the households in the districts and mention criteria they used. Cluster analysis was then used to group farmers and examine the conditions which can make them interested to implement SWC measure. Farming system analysis involved the identification and ranking of major crops, land uses, soil types, erosion status and climatic features. Crops were ranked according to the number of farmers who cultivate them. Table 3 shows household survey data.

Male-headed household: The result of the study indicated that 79% of households are male headed. This group includes the most influential people and decision makers at the PA and household levels. While it is important to consider this influential group, care needs to be taken during planning of SWC so that other groups are not marginalized.

Female-headed household: Survey results indicate that 21% of the household heads are women. These household headed by females are either widowed or divorced. Fedis district have relatively many women-headed households. Followed by Kersa, and Kombolcha was the last female headed household district. This may have negative effects on the adoption of soil and water conservation measures because female-headed households have limited access to information on SWC and to land and other resources, due to traditional social barriers. Women are also more involved in regular household activities than men (Lyamchai et al., 1998).

Education level groups: Four education level groups were distinguished in the study area: Lower primary school (grade 1 to 4), upper primary school (grade 5 to 8), secondary school (grade 9 to 12) and non-formal education (less than grade 1) in school. About 50, 59 and 62% of Fedis, kersa and Kombolcha districts households have primary school education (lower and upper primary school), respectively. Fedis, Kersa and Kombolcha districts have only 5, 7 and 5% secondary school education, respectively. The rest 45, 44 and 33% is without any formal

education for Fedis, Kersa and Kombolcha, respectively. Fedis district have relatively many households without any formal education. Educated households, expected to understand soil erosion problems, have more access to information related to SWC and hence, can more easily adopt different SWC measures.

Age groups: Family household age was categorized based on 2017 CIA world fact book age category: Children (0 to 14 years), young (15 to 24 years), middle (25 to 54 years), old (55 to 64 years) and very old farmers (65 years and over). About 78% of the farmers in the study area were between 15 to 54 years. This is the youngest generation involved in agriculture, with a longer planning horizon, more understanding of soil erosion problems, and thus more interested in soil and water conservation. Fedis district have a higher proportion of farmers aged over 54 years. This may imply labor shortage for implementing SWC measures. Also, old farmers tend to be conservative, sticking to their traditional way of farming.

Farming system

The major economic activity in study areas were agriculture, on which over 80% of its population depends on their living (Zone Agricultural office report, 2015). Sorghum and maize are major food crops while chat (*chataedulis*) and vegetables are cash crops. Cattle, goat, sheep, camel and chickens are the main livestock in the study areas. The study area was characterized by a mixed-farming system, whereby almost all farmers were involved in rain-fed agriculture. 55.66% of the sampled farmers are involved in animal fattening. During the dry season only 9.63% of farmers used traditional irrigation (Table 4). Most vegetables and chat are produced by ground water based traditional irrigated method. Major cash crops were chat and vegetables while maize and sorghums are major food crops grown by rain-fed agriculture. Sometimes, irrigation is used as supplementary for production of cash and food crops. Major cropping systems were sorghum-soya bean and tomato, maize- soya bean and tomato, sorghum-sweet potato, maize-sweet potato, inter crop with different trees species, chat and mango.

Farm identification

Farm selection was based on information obtained from the key informants and direct field observations. Six farms from each district and from each district two Peasant Associations Iftu Dada and Kerensa Lencha, Yabeta Selama and Galemirga and Sibilu and Simergel were selected from Fedis, Kersa and Kombolcha, respectively as shown in Table 5.

Table 4: Major economic activities and involvement of farmers in study area.

Activity	Districts			Average	Gender	
	Fedis	Kersa	Kombolcha		Male	Female
Rain-fed Agriculture (%)	100	100	100	100	15	85
Traditional irrigation (%)	0	4.08	25	9.63	14	86
Animal fattening	60	56	51	55.66	20	80

Note: All farmers involved in rain-fed agriculture at the time they were also involved in irrigation and animal fattening.

Table 5: Farm slope class of Fedis district.

Districts	Farm code	Area in (ha)	Slope class in (%)					Structure	
			<5	5-14	15-25	26-30	>30	Bund	Terrace
Fedis District	F ₁	1	-	-	-	28	-	-	-
	F ₂	0.72	2.50	-	-	-	-	-	-
	F ₃	0.54	-	7	-	-	-	-	-
	F ₄	0.67	2	-	-	-	-	-	-
	F ₅	0.56	-	-	20	-	-	-	-
	F ₆	0.7	1.50	-	-	-	-	-	-
Average		0.70	1.67	7	21	28	-	-	-
Kersa District	F ₁	0.98	-	-	23	-	-	-	-
	F ₂	0.45	2.1	-	-	-	-	-	-
	F ₃	0.37	-	-	-	27	-	-	-
	F ₄	0.38	2.7	-	-	-	-	-	-
	F ₅	0.25	-	13	-	-	-	-	-
	F ₆	0.25	-	-	-	29	-	-	-
Average		0.45	2.4	13	23	28	-	-	-
Kombolcha District	F ₁	0.44	-	-	19	-	-	-	-
	F ₂	0.38	-	-	-	27	-	-	-
	F ₃	0.25	1.9	-	-	-	-	-	-
	F ₄	0.35	-	12	-	-	-	-	-
	F ₅	0.25	-	-	-	27	-	-	-
	F ₆	0.32	1.7	-	-	-	-	-	-
Average		0.33	1.8	12	19	27	-	-	-

Soil and water conservation options and proportion of farmers for implementation

Six common SWC practices were identified in the study areas that were common in all representative districts. These SWC measures were used for the criteria listed in Table 7. Table 6 shows a total of 18 farms selected with the proportion of farmers for each measure and the extent of coverage. Six common ISWC practices were identified as implements in the three districts which are: Soil bund, stone bund, bench terraces (Figure 4), tree plantation, tied

ridge and grass for stabilization of soil bund are common identified soil water conservations.

Forty percent (40%) of the sample farmers used soil bund for soil and water conservation purpose that was most important to conserve soil and water, followed by stone bund (32%) of the farmers considered for soil and water conservation purpose. 21% of the farmers used bench terrace for soil and water conservation. Only 8% used tree plantation, tied ridge and grass for soil bund stabilization; these SWC practices are preferred for simple implementation and minimum maintenance requirement

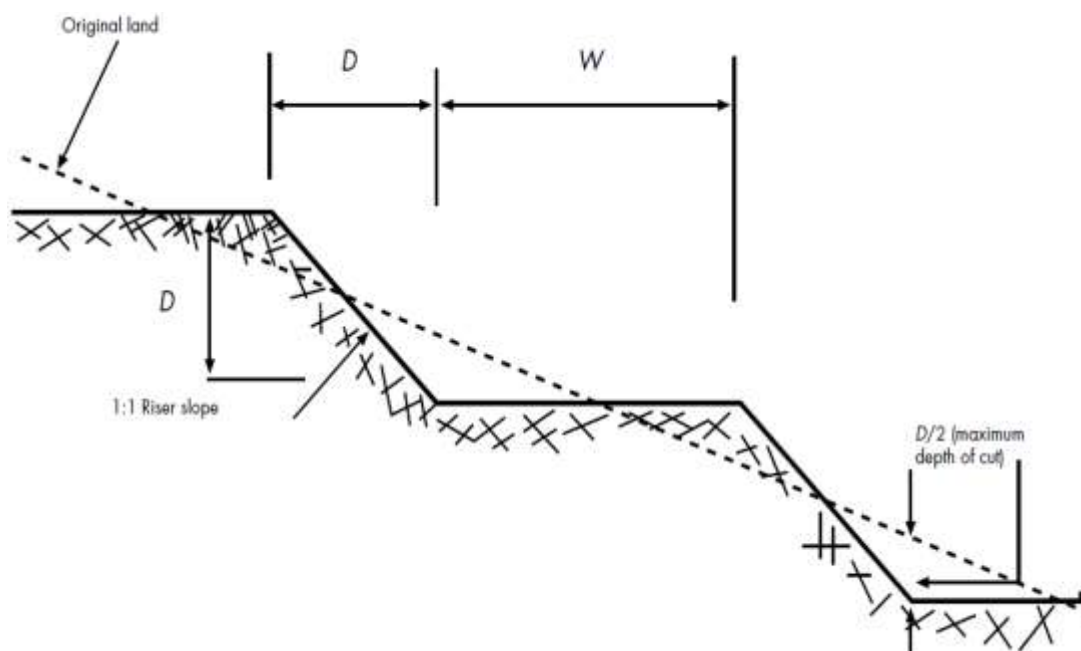
Table 6: Proportion of farmers for implementation of SWC and the extent of coverage.

Conservation measure	Farmers (%)
Soil bund	40
Stone bund	32
Bench terraces	21
Tree plantation	3
Tied ridges	3
Grass for stabilization	2

Sources: (Field data, 2015).

Table 7: Farmers criterion for SWC measures in Fedis, Kersa and Kombolcha.

Selection criteria	Ranking and percentile of respondent (N=150)						Average percentile
	Fedis		Kersa		Kombolcha		
	Rank	Percentile	Rank	Percentile	Rank	Percentile	
SWC	1	21	1	25	1	20	22.00
Fertility improvement	2	18	2	22	2	18	19.33
Increase soil productivity	3	15	3	13	3	16	14.67
Fodder (soil bund stabilizer)	4	12	4	11	4	13	12.00
Low labor intensive	5	10	5	9	5	10	9.67
Simplicity	6	9	6	7	9	3	6.33
Low material input	7	7	7	6	8	5	6.00
Material availability	8	5	8	5	7	7	5.67
Minimum maintenance needs	9	3	9	2	6	8	4.33

**Figure 4:** Schematic view of bench terrace.

(Table 6).

Criteria for selection of indigenous soil and water conservation measures

Important criteria for the preference of different SWC measures by farmers were effectiveness in reducing soil and water losses, fertility improvement, increase in crop yields, low labor, material inputs and provision of fodder for livestock. Important criteria for preference and evaluation of different SWC by farmers are indicated in Table 7.

Soil erosion in study areas causes soil and water losses, loss of soil fertility, low crop yields, food deficiency and off-site effects such as siltation of water harvesting structures from finding of key informant dissuasion and field visit. These problems were enforced in order for farmers to adopt different indigenous SWC in the area. Perception of soil erosion as a hazard to agricultural production and sustainable agriculture is the most important determinant of effort at adoption of conservation measures. Theoretically, those farmers who perceive soil erosion as a problem having negative impacts on productivity and who expect positive returns from conservation are likely to decide in favor of adopting available conservation technologies (Semgalawe and Folmer, 2000; Gebremedhin and Swinton, 2003). On the other hand, when farmers do not acknowledge soil erosion as a problem, they will not expect benefits from controlling erosion and it is highly likely that they will decide against adopting any conservation technologies.

Twenty two percent (22%) of the sample farmers believed that soil and water conservation structure was the most important to conserve soil and water followed by 19.33% of the farmers considered for soil fertility improvement. Only 4.33% found that SWC practice was preferred for minimum maintenance requirement (Table 7). This finding confirmed that farmers have awareness towards SWC practices to conserve soil and water, increase soil fertility and productivity consistent with findings of Abebe (2015). The reasons behind the adoption of soil and water conservation were reduced soil erosion and improvement of soil fertility, the two major expectations of adopting soil and water conservation.

Characterization of identified SWC measures

A total of 150 farms were selected based on methodology for identification and characterization of SWC practices implemented in selected districts. A total of 18 farms were selected based on methodology for characterization purpose that holds different SWC measures. Bund and terrace

SWC practices are common in all of the three districts and the characterization of these identified SWC structures were based on average ground slope% (GS), vertical interval (VI), horizontal interval (HI) and length of each practice (LS) of each practices were collected during field measurement as indicated in Table 8.

Soil bunds

The measured and calculated scientific value vertical interval of bund in Fedis, Kersa and Kombolcha districts were 1.3 and 1.09 m, 1.05 and 0.96 m and 1.23 and 1.38 m (Table 8) and (Figure 5), respectively. This indicated that the measured and calculated VI of the bund had different value. In generally the farmers of Fedis and Kersa construct high height of bund than scientific recommended value which needs high labor and more construction cost but the farmers of Kombolcha construct less height of terrace.

The measured and calculated scientific value horizontal distance of bund in Fedis, Kersa and Kombolcha districts were 23.25 and 40.64; 23.50 and 40.40 m and 28.00 and 38.96 m (Table 8) and (Figure 6), respectively. This indicated that the measured and calculated HI of the bund had no relationship. The major problems related to conservation structures mentioned by the inconveniency during ox ploughing, reduction of farmland, labor intensiveness, difficulty in implementation, and costliness (Murthy, 1994). In generally the farmers construct less bund spacing than scientific recommended value which leads for farm land fragmentation.

The length of measured and calculated value of bund in Fedis, Kersa and Kombolcha districts were 447.22 and 271.17 m; 427.27 and 249.08 m and 370.85 and 304.51 m (Table 8) and (Figure 7), respectively. This indicated that the measured and calculated value of bund length had differences. This difference comes from improper design of horizontal distance.

These are embankments constructed from soil along the contour with water collection channel or basin at its upper side. They were constructed by throwing soil do from basin down slope. They were constructed to control runoff and erosion from cultivation fields by reducing the slope length of the field which ultimately reduces and stops velocity of runoff. Usually they are constructed in fields that have slope less than 10%. According to WFP (2005), soil bunds are effective in controlling soil loss, retaining moisture and ultimately enhancing productivity of land. Farmers in the study area were construct level bund in the slope class from 0 to 13% which is not recommended for land slope of greater than 5%.

These structures were installed at vertical interval (VI) of 1-1.2m depending on the slope of cultivation field. The height and width of embankments varied from PA to PA of

Table 8: Characteristics soil and water conservation practices of the study area.

Districts	Parameters		Type of structure									
			Bund					Terraces				
			Slope class			Average		Slope class			Average	
Fedis	GS %	M	2.50	2.00	1.50	7.00		-	20.00	28.00	-	
	VI (m)	M	1.20	1.20	1.30	1.50	1.30	-	2.00	3.00	-	2.50
		P	0.98	0.90	0.83	1.65	1.09	-	5.00	5.56	-	5.28
	HI (m)	M	20.00	30.00	25.00	18.00	23.25	-	14.00	13.00	-	13.50
		P	39.00	45.00	55.00	23.57	40.64	-	20.00	14.29	-	17.14
	L (m)	M	500.00	333.33	400.00	555.56	447.22	-	714.29	769.23	-	741.76
		P	256.41	222.22	181.82	424.24	271.17	-	500.00	700.00	-	600.00
Kersa	GS %	M	2.10	2.70	-	-		13.00	23.00	27.00	26.00	
	VI (m)	M	1.10	1.00	-	-	1.05	2.50	2.00	3.00	2.80	2.58
		P	0.92	1.01	-	-	0.96	4.60	5.19	5.48	5.41	5.17
	HI (m)	M	22.00	25.00	-	-	23.50	17.00	12.00	15.00	14.00	14.50
		P	43.57	37.22	-	-	40.40	30.77	17.39	14.81	15.38	19.59
	L (m)	M	454.55	400.00	-	-	427.27	588.24	833.33	666.67	714.29	700.63
		P	229.51	268.66	-	-	249.08	325.00	575.00	675.00	650.00	556.25
Kombolcha	GS %	M	1.70	1.90	12.00	-		16.00	27.00	27.00	-	
	VI (m)	M	1.00	1.30	1.40	-	1.23	2.00	2.20	2.70	-	2.30
		P	0.86	0.89	2.40	-	1.38	4.76	5.48	5.48	-	5.24
	HI (m)	M	33.00	30.00	21.00	-	28.00	20.00	15.00	16.00	-	17.00
		P	50.29	46.58	20.00	-	38.96	25.00	14.81	14.81	-	18.21
	L (m)	M	303.03	333.33	476.19	-	370.85	500.00	666.67	625.00	-	597.22
		P	198.83	214.69	500.00	-	304.51	444.44	574.47	574.47	-	583.33

Note: VI = vertical interval, HI = horizontal interval, GS: Ground slope, L: length of the structure.

the studied area. However, the maximum height was limited to 1.20 cm. Farmers that construct bunds with height of embankments less than 60 cm on their fields, construct bunds having

embankment with height of 60 cm at the top of their cultivated field prior to constructing subsequent bunds. According to key informants, this is in order to minimize the risk of breakage that arises

from accumulation of water from the upland on embankments. The measured horizontal distance between two consecutive bunds were not the same to that of predicted one because, farmers construct

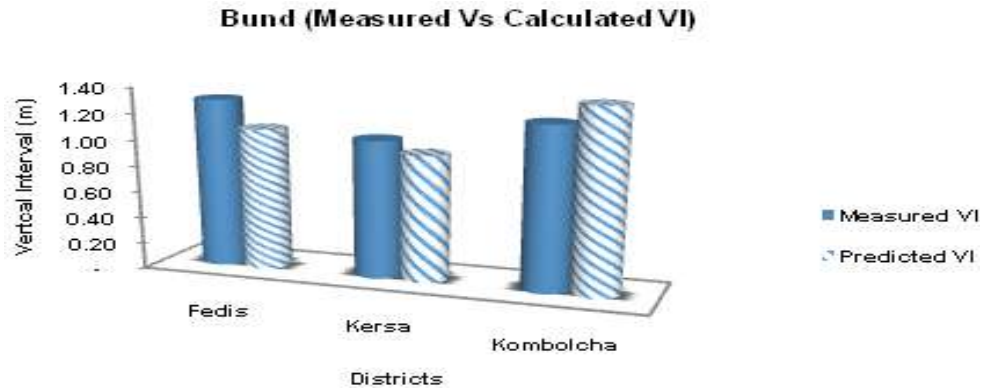


Figure 5: Comparison of measured and calculated VI of bund.

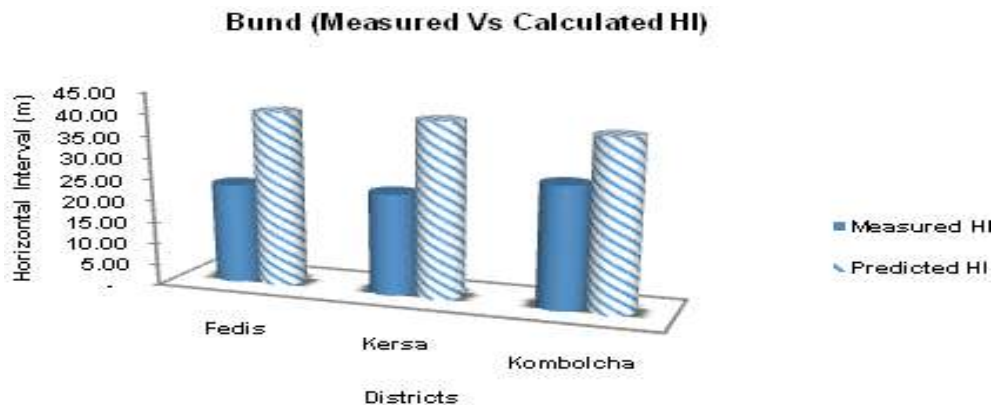


Figure 6: Comparison of measured and calculated HI of bund.

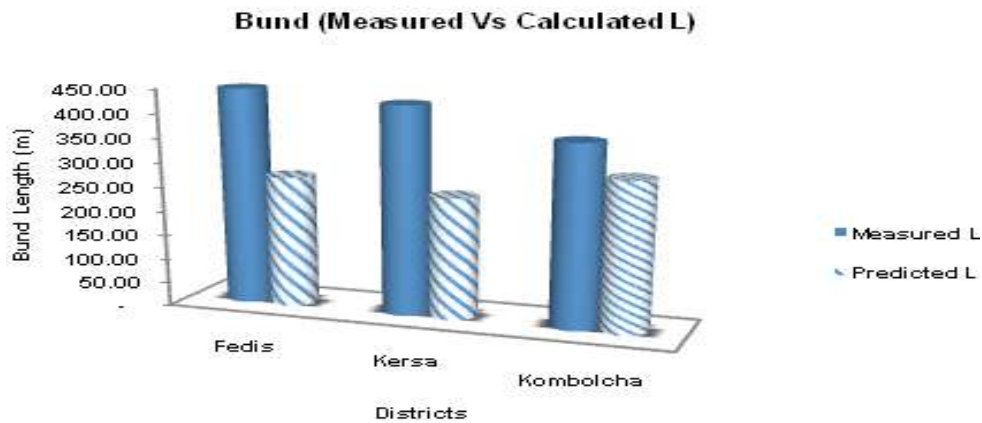


Figure 7: Comparison of measured and calculated L of bund.

soil bund without any scientific measurement (Table 8 and Figures 5, 6 and 7). The embankments of soil bunds

constructed in the study area were traditionally laid along the contour because of technical ease in lying out

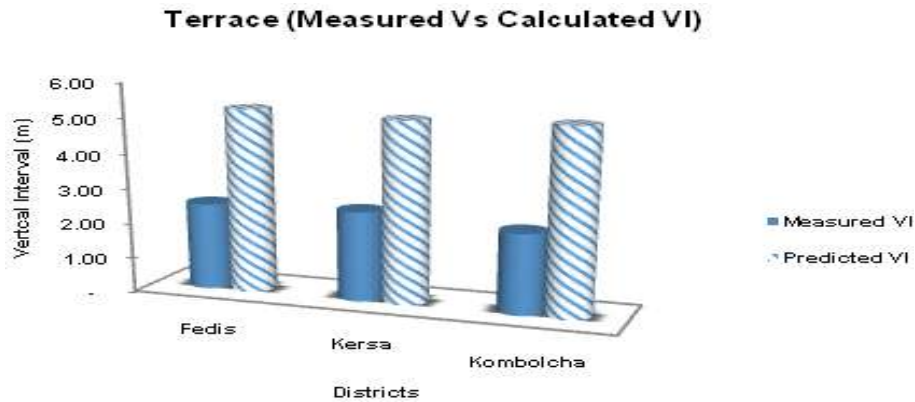


Figure 8: Comparison of measured and calculated VI of terrace.

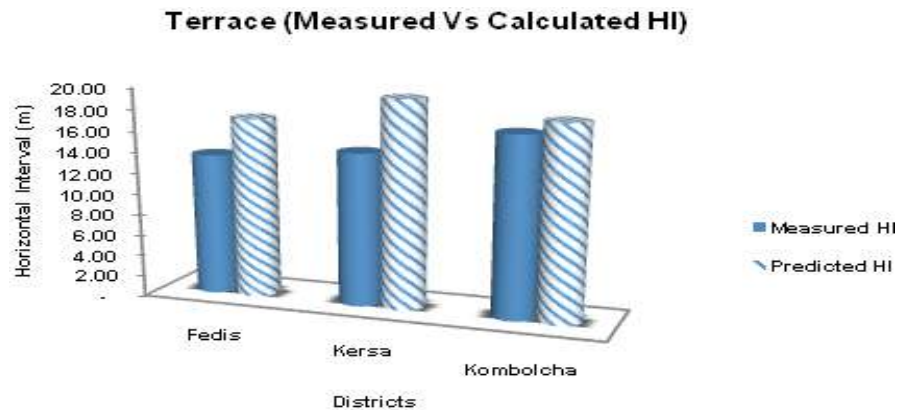


Figure 9: Comparison of measured and calculated HI of terrace.

and to avoid complication of constructing graded bunds.

Bench terraces

Bench terraces consist of a series of level or nearly level platforms built along the contour line at suitable intervals. They are suitable for farms on steep slopes with deep soils, and for intensively cultivated fields. Bench terraces are recommended on slopes between 35 and 55% (Shelukindo, 1995). Farmers in the study areas construct bench terraces on slopes between 13 and 28%. According to farmers, bench terraces are labor intensive, it reduce cultivable areas and may decrease crop yield in the initial stage unless there is high fertilization. However, farmers in the study area preferred to construct bench terraces due to their effectiveness in erosion control and potential increase in yields and this structure was done in most part of all districts but from these districts, Kersa and Kombolcha there were more practices than Fedis as a result of the high

land slope gradient. The lists of SWC options in the all districts cover a wide range of SWC measures that are applicable elsewhere.

The measured and calculated scientific value vertical interval of bench terrace in Fedis, Kersa and Kombolcha districts were 2.5 and 5.28 m, 2.28 and 5.17m and 2.3 and 5.24m (Table 8 and Figure 8), respectively. This indicated that the measured and calculated VI of the bench terrace had different values. In general, the farmers construct less height of terrace than scientific recommended value, which leads to overtop and structural breakage.

The measured and calculated scientific value horizontal distance of bench terrace in Fedis, Kersa and Kombolcha district were 13.5 and 17.14 m, 14.5 and 19.59 m and 17.00 and 18.21 m (Table 8 and Figure 9), respectively. This indicated that the measured and calculated HI of the bench terrace had no relationship. In general, the farmers construct terraces nearest each other, but less than scientific recommended value thereby leading to farm land fragmentation.

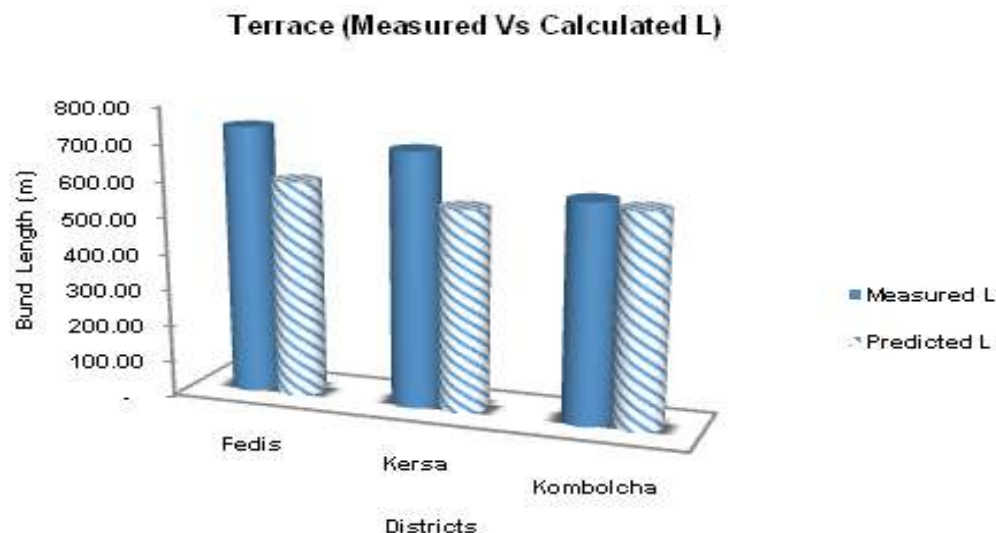


Figure 10: Comparison of measured and calculated L of terrace.

The length of measured and calculated value of terrace in Fedis, Kersa and Kombolcha district were 741.76 and 600 m, 700.67 and 556.25 m and 597.22 and 563.33 m (Table 8 and Figure 10), respectively. This indicated that the measured and calculated value of bench terrace length had differences. This difference comes from improper design of horizontal distance.

Other ISWC in the study area

Agro forestry

Agro forestry refers to land use practices where perennial trees are deliberately integrated with crops and animals on the same land management unit. Trees provide timber and fuel wood; fruits and some trees can provide fodder for livestock and improve soil fertility. If appropriate tree species are planted in macro contour-lines together with grasses in rows, this system act as soil and water conservation measure by reducing the speed of surface run-off and retaining the sediment carried by the surface run-off (Shelukindo, 1995). Farmers in the study areas had good practices on use of integrated agro forestry. Mango, Guava, Papaya and other fruit tree species and grass species are planted traditionally based on contour line in small plots of land with integration of animal fattening. According to farmers in the study area, these practices help their economy and requires little labor for implementations and also easy for management. With related soil and water conservation the practices have different advantages such as the roots holding soil, reducing erosion and maintaining soil fertility.

Grass for stabilization of bund

Farmers sow different grass type on SWC structures for stabilization embankment. Besides stabilization of the structure, grass is provided as a fodder for livestock and improves soil fertility as farmers' perception; the grasses are cheap and simple to make.

Micro basin

Micro basins are small structures constructed by excavating half circle shaped basins for tree planting. In the study districts there was the practice of micro basins for cultivation of fruit trees but the practice is very limited in number. The constructions of micro-basins in the study areas excavated soil in specific diameter to conserve water for plantation. The spacing between basins along contour line is determined by plant spacing and the distance along the slope (distance perpendicular to the contour line).

Brush wood and algae check-dams

These are vegetative measures constructed from small wood branches and poles, interwoven together by sisal. Most of observed brush wood check-dams were constructed from plant species that can regenerate easily such as *Vernonia amygdalina*. These are structures that have short life span and easy to construct using cheap materials. These are constructed in small gullies due to the short life span of structures.

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