Evaluating Indigenous Structural Technologies of Konso People, Ethiopia

Barako Belachew[1], Alemayehu Hailemicael Mezgebe (PhD)[2]

[1]*Biology Department, Jinka University, Ethiopia*
[2]*Assistant Professor, Department of Biology, Arba Minch University, Ethiopia*

---***---

Abstract – *Indigenous Structural technologies are common practices to conserve soil and water globally. The main objective of this study was to evaluate the efficiency of the indigenous structural technologies of Konso people in protecting soil from erosion. In this study, quantitative method of research design was employed. The quality of existing soil and water conservation structures, current land use types and depth of the soil were analyzed. The results were evaluated against treatment oriented capability classification. In addition the quality of the physical structures was compared with computed recommended standards using standard parameters. The data obtained were summarized using SPSS software and means were compared using one sample student t-test and ANOVA. The findings of this study revealed that the existing conservation practices from four sampled sites (kuttele, kashalle, laka- Gaho and Pishelle) do match with the recommended structure considering the topography of the catchment. But Qolmale and Amaritta sites do not match with the recommended ones. This was because the recommended forest and pasture land for these sites were cultivated with extensive terrace. The mean back side height, top terrace width, and vertical interval between successive terraces has shown significant differences from the recommended standard values with better quality than the recommended values in much of the parameters. Generally, the traditionally engineered soil and water conservation structures were found to be well beyond the recommended standards set for quality structures. This is quite uncommon in modern structures where there is no continous monitoring for mentainance and sense of ownership. Hence, development of road maps that encourage such community wealth would contribute for sustainable conservation of the landscape resource.*

Key Words: Konso, Indegenous structural technology, Stone Terrace.

1. INTRODUCTION

Many areas of the Ethiopia's top soil are under high erosion pressure and degradation. Among the different forms of land degradation processes, soil erosion by water is the most widespread and critical problem (Woldeamlak, 2003). The problem became worst in areas where there is undulating hilly landscape with harsh environmental condition. (Mezgebe, 2011). The Konso people are among those who live in inhospitable harsh environment on steep slope landscape and high susceptibility of soil erosion. This has provoked the people to develop efficient coping up strategies. Because of this fact, the inhospitable Konso terrain was transformed by people into remarkable traditionally engineered physical structures capable of conserving soil and water. The people are known for their stone-based terracing, unique mixed agriculture and well integrated agro-forestry (Beshah, 2003). They are known for indigenous and intensive agricultural landscape that has been maintained for hundreds of years despite the social changes (Tadesse, 2010). The soil and water conservation structures of Konso have been built for more than four hundred years (Beshah, 2003). It has been retained and continuously maintained as the result of knowledge passed down from one generation to the next. Thousands of kilometers long interweave water systems across the landscape to conserve available moisture and protected soil were unique indigenous talents. Terraces are built with stone walls (Forch, 2003). The Konso are unique in their investment in their environment with terrace and other soil and water conservation structures (Watson, 2009). The practice has got recognition and was inscribed as the World Heritage Site by UNESCO on June 27, 2011, However, the existing indigenous physical structure were not evaluated against the standard treatment oriented capability classification and quality standards so far. Moreover, scaling up of the practices has been largely constrained by lack of methods to evaluate and test them for wider scale applicability. Hence, this study bridges the existing knowledge gap so that evaluation results on its effectiveness could help for future adjustments and recommendations. Therefore, the main objective of this study was to evaluate the efficiency of the indigenous structural technologies of Konso people in protecting soil from erosion. Specifically the study was designed to: measure the indigenous soil and water conservation structures; compare the results with the recommended treatments standards; and recommend appropriate measures to bridge efficiency gaps.

2. MATERIALS AND METHODOLOGY

2.1 Description of the study area

Konso is located in the Southern Nations, Nationalities and Peoples Region in South-Western Ethiopia, 600km South of the capital Addis Ababa (Figure1). The people occupy a rugged area formed as a result of early Miocene volcanism which created the basaltic hills. The Konso area is generally dry with mean annual rainfall of 551 mm) (Beshah, 2003). The average maximum temperature is 32.7^{0}C

(February and March); and lowest minimum temperature is 12.2^{0}C (June to August).

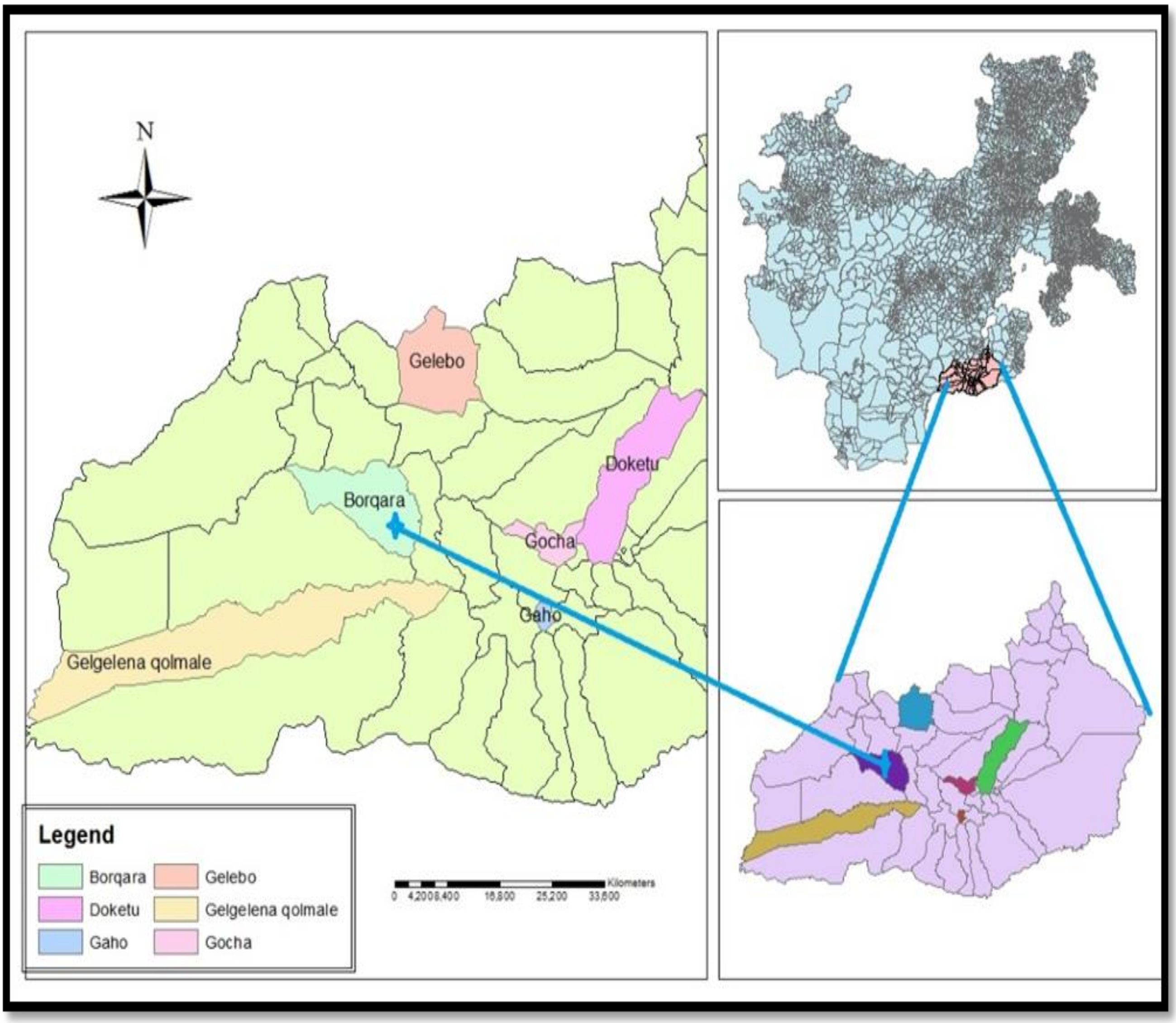

Figure-1: Location map of the study area, Konso.

2.2 Methodology

Data collection procedure: Before sampling and site identification, a reconnaissance was undertaken. During the survey, physical land management practices were observed. Quantitative method of research design was employed to evaluate the land use types and existing physical structures using Treatment oriented capability classification. The fitness and quality of these structures were compared using recommended standards for different kinds of structures in specific relief.

Determination of treatment oriented capability classification: First specific watersheds were identified purposefully. The reason was to make them agro ecologically representative (Table 1). Following this, the plots were identified through random sampling from the identified watershed for measurements like Soil depth, the type of soil and water conservation structure and current land use type (Table 2; Table 3; Table 4).

Table-1: Sample site identification

Sites	Specification (clustering)	Soil type	Slope measured	Specific watershed sampled
1	Karat one	Amata	Strong slope (36%)	Dokatu-kuttele
2	Kolme one	Amata	Steep slope (54%)	Gelgelena-kolmale-Qolmale area
3	Turo	Tahayta	Moderate slope (17%)	Gelabo-kashalle
4	Fasha	kalkalayta	Moderate slope (12%)	Gaho-laka
5	Karat two	Borbora	Gentle slope (3%)	Gocha-Pishelle
6	Kolme two	Tahayta	Strong slope (30%)	Borkora-Amaritta

A rectangular plot was drawn to identify whether all the employed biological and physical treatment structures does fit with the recommended treatments standards (Figure 2). To do this, slopes and soil depth were taken using clinometers and auger, respectively. The slope was measured among points, C—A, D---B, and G---F, as one of the three positions and taken from bottom slope to top slope. Soil depth was measured from points G, E and F and then average was taken from each sites (Figure 2).

Table-2: A modified treatment oriented capability classification scheme.

Moderate slope 12-26% (7-15)0	Strong slope 27-36% (15-20)°	Very strong slope 36-47% (20-25)⁰	Strong slope 27-36% (15-20)°	Very strong slope 36-47% (20-25)⁰	Steep 47-58% (25-30)⁰	Very steep >58% (>30°)
Deep (>90cm)	C2	C3	C4	C2	FT	F
Moderate deep (50-90cm)	C1	C2	C3	P	FT/F	F
Shallow (20-50cm)	C1	C2/P	C3/P	P	F	F
Very shallow(<20cm)	P	P	P	P	F	F

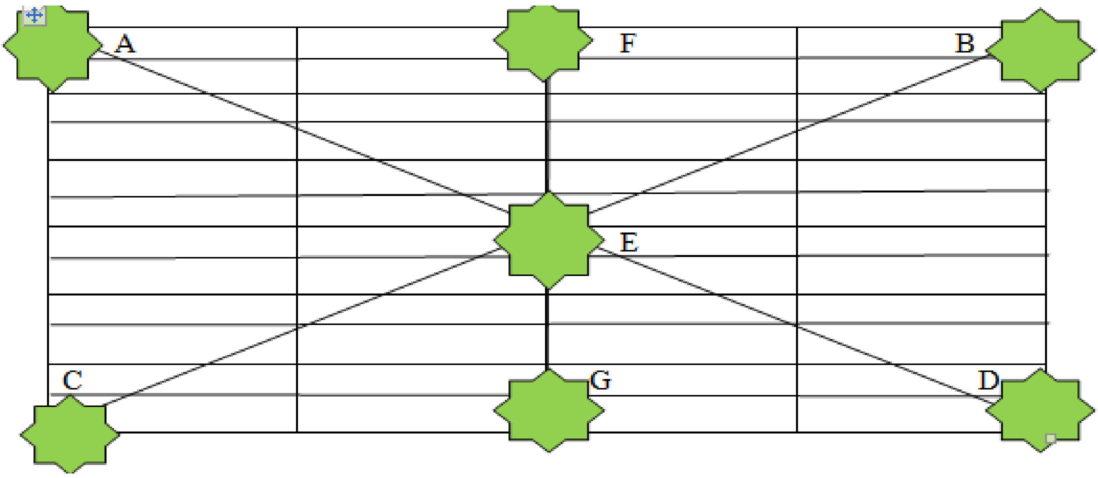

Figure-2: Pictorial representation of sampling plots for treatment oriented capability classification.

Table-3: Characteristics and Recommendation Treatments (Source: Belay, 2003).

Group	Class	Characteristics and Recommended Treatments
Suitable for tillage	C1	Cultivable land; up to 70(12%) sloped; require no or few intensive conservation measures ,e.g. contour cultivation and strip cropping vegetative and rock barriers and broad based terrace e
	C2	Cultivable land slopes up to 150 (12-27%)with moderately deep soil; need more intensive conservation i.e. bench terracing hexagons mini convertible terracing ,conservation measures can be constructed by small sized bull dozers
	C3	Cultivable land; slopes 15-200; bench terracing ;hexagons mini convertible terracing on deeper soils and hill side ditching ;individual basin on less deep soil; conservations are constructed by small bulldozers.
	C4	Cultivable land; slopes 20-25%(27-36)o; bench terracing, hexagons mini convertible terracing; all conservation treatments can be done by manual labor
	P	Pasture; slopes approaching 250(47%); soil depth too shallow for cultivation; uses for improved or managed pasture and rational grazing; zero grazing where land is very sleep and too wet
	FT	Food/fruit trees on slopes of 25-300 (47-58%); soil depth over 50cm use for tree crops with orchard terracing ;inter terraced areas in permanent grass; contour planting; diversion ditches; mulching
	F	Forest land; slopes over 300 (>58%); or over 250 (47%); where soil is too shallow for any of the treatments
Wetland liable to tillage	P	Wetland; slope below 250(47%); use as Pasture
	F	Very stony land ;slopes over 250(>47%); maintain as forest
Gully land		Maintain as forest land

Table -4: Rating the Fitness of Structures

Kinds Recommended Measures in Number	Kinds and Status of Practiced Measures in Number		Rating in Percentage
	Not Damaged	Damaged	
1	0	0	0
	0	1	50
	1	0	100
2	0	0	0
	0	1	25
	0	2	50
	1	0	50
	1	1	75
	2	0	100
3	0	0	0
	0	1	16.6
	0	2	33.3
	0	3	50
	1	0	33.3
	1	1	50
	2	0	66.6
	2	1	83.2
	1	2	66.6
	3	0	100
4	0	0	0
	0	1	12.5
	0	2	25
	0	3	37.5
	0	4	50
	1	0	25
	1	1	37.5
	1	2	50
	1	3	62.5
	2	0	50
	2	1	62.5
	2	2	75
	3	0	75
	3	1	87.5
	4	0	100

Note: Not damaged =SWCS or practices that are not dismantle demolished or degraded. Damaged =SWCS or practices in which part of it is dismantled if a certain structured is Damaged, it is given 50% or its efficiency in the rating column.

.

Assessing quality of the structure: The quality of the soil and water conservation structures was assessed using parameters like back side terrace height, top terrace width, vertical interval between consecutive terraces, slope and number of dismantled spots. A total of four sites were selected purposefully, two of the sites were among those sites that are fit to the treatment oriented classification scheme and the other two not. To measure the structure, bench terraces within the identified rectangular plot were grouped into three consecutive teraces. The sample sites were identifid as shown in figure 3 (as A, B, C, D and E). Then, three of them were randomly selcted and measured for the quality of the structures. And hence, we have four sites to sample, 3x4 = 12 terraes were identified and measured. The actual rsults were compared with recommended standards of WFP/MOE(2000) schemes. The recommended standard vertical interval between the terraces was computed according to Nguai et al. (1978), cited in Belayneh (2005), using the following formula:

$$VI = 0.3\left[\frac{average\ \%\ slope}{4} + 2\right]$$

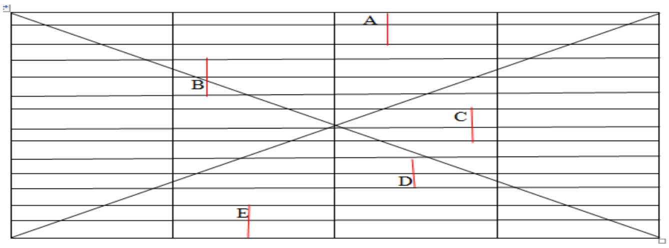

Figure-3: Pictorial representation of sampling plots (structural quality)

3. RESUTS AND DISCUSSION

3.1. Evaluating the Indigenously Engineered Structures of Konso Landscape

The indigenous soil and water conservation structures of Konso People were evaluated against the recommended treatment oriented capability classification standards of the modified scheme for Ethiopia cases (Belay, 2003). Accordingly, the current land uses of Kuttele, Kashalle, Laka-Gaho, and Pishelle were found to be in match with the recommended cultivable land uses (Table 5). The constructed structures of Qolmale and Amaritta doesn't fit with the recommended treatment oriented capability classification with fitness rating value of 100% and 75%, respectively(Table 5).

Table-5: Actual Indigenous Structures Versus Recommended Treatment Oriented Classification

Sites	Slope %	Soil depth (cm)	Actual (existing)		Recommended		Recommended versus existing land use	Rating fitness of existing soil conservation practices (%)
			Land use	Soil conservation measures	Land use	Soil conservation measures		
Kuttele	36% /20°	35	C	Bt CC	C3/P	Bt Nbt	Match	100
Qolmale	54% /28°	40	C	Nbbt CC	F	Forest land	Not match	100
Kashalle	17% /10°	20	C	Bt CC SC	C2/P	Bt Nbt	Match	83.2
Laka Gaho	12% /7°	>90	C	Bt CC	C2	Bt Bbt	Match	100
Pishelle	3% / 2°	>90	C	CC Btr	C1	CC Bbt SC Vegetative barrier	Match	100
Amaritta	30% /17°	15	C	Bt CC	P	Pasture land	Not match	75

C=Cultivable land, Nbt= Narrow based terrace, Bt=Bench terrace, Nbbt= Narrow based bench terrace, CC=Contour Cultivation, SC=Stripe Cropping, Bbt= Broad based terrace, Bt r=Banded tide ridges in the form of terrace.

In the study, soil erosion, aggravated by ox-plough on strong sloping, and week structure of bench terraces dismantled by plough-ox in Amaritta could have contributed to a major reduction in soil depth. Accordingly, the Amaritta area, which is strong slope and very shallow soil depth, was recommended to be preserved for pasture land. The other site, Qolmale, was characterized as an area with steep slope and shallow soil depth. Hence, the scheme proposed to be preserved as forest land. It was observed that the Pishelle site that has black soil with high water holding capacity even under time of water stress was better protected. This site has deep soil at gentle sloping, where soil is bundled to 1m high and 1.20 m width with band interval ranging up to 8m long. The sites, Kuttele, Kashalle and Laka-Gasho existing treatment were found fit and evaluated as beyond the required recommendations set by treatment oriented capability classification scheme. The results obtained were found to be different from studies undertaken in Woybla and upper Chena catchments of South Gondar where there was significant inefficiency to meet recommended standards (Walie, 2016; Belayneh, 2005).

3.2. Evaluating the Quality of Traditionally Engineered Structures

To evaluate the quality of the structures, the mean vertical interval, mean top width and mean backside height were computed for each terrace. Then, these mean values were compared with the World Food Program or Ministry of Agriculture (WFP/MOA) (2000) recommended standard value using one sample t-test at 95% confidence interval. The average measurments for each parameter was assessed in each study site. Accordingly, the following results were obtained.

Kutelle site: The mean terrace height was measured and analysed at Kutelle site. Accordingly, the back side height of the terrace was calculated as 1.14 + .085 m. The standard height recommended for such landscape was a terrace height of 0.85 m. the existing measured value (1.14 + 0.085 m) was found to be by far higher than the recommended standard height (0.85 m). The significancy of the existing average terrace height was computed against standard using one sample student t-test. Hence, the height of the terrace was found to be significantly well above the recommnded standard at 95% confidence interval with P=0.028. Similarly, the mean terrace top width in Kutelle site was found to be 0.46 ± 0.02 m. This value wass still greater than the recommended standard, which is 0.35 m. Theresult significantly differes at 95% confidence interval with P= 0.012. In addition, the average vertical interval between terraces of Kuttele site was measured and found to be 2.71±0.076 m. The recommended vertical interval in kuttele site was calculated as 3.12 m interval. The vertical interval of the constructed terraces has shown significant difference with 95% confidence interval at p= 0.012. Thus, it can be concluded that, under this slope (33.7%), the constructed terraces have good efficiency to protect soil erosion. This result was unlike the results obtained in studies conducted in northen part of the country where meeting standards was unthinkable (Walie, 2016; Belayneh, 2005). The reason could be attributed to the cultural commitment of the community and sense of ownership of konso people.

Table-6: Summary of average measurments of structural quality parameters in selected sites

Sites / Quality parameters		Kuttele	Qolmale	Laka-Gaho	Amaritta
Slope%		33.7 ±3.21	53.6 ±1.52	13.7 ± 1.52	30 ± 1
Backside Terrace	Actual Height	1.14 ±.09	1.18±0.05	0.87±.08	1.24± 0.08
	Recommended Height	0.85	0.85	0.85	0.85
	P - value	0.028	0.008	0.705	0.016
Top Terrace Width	Mean Actual Width	0.46± .02	0.57±0.03	0.41±.06	0.59± 0.02
	Recommended Width	0.35	0.35	0.35	0.35
	P - value	0.012	0.005	0.203	0.006
Vertical Interval between Consecative Terraces	MeanActual VI	2.71±.08	2.63± 3.2	3.5± .5	2.76±0.25
	Recommended VI	3.12	4.62	1.62	2.85
	P - value	0.012	0.009	0.023	0.624
Average Number of Dismantled Spots		4	3	4	0

NB: Source for recommended standards was computed using (WFP/ MOA, 2000; Belayneh, 2005)

Qolmale site: in Qolmale site, the actual mean height of terraces in this site was found to be 1.18 ± 0.05 m. this value was much higher than the recommended height by WFP/MOA which was 0.85. the one sample t- test value(p= 0.008) showed a significant differenrence at 95% confidence interval. Simlarly, the terraces top width was analysed for its quality. The actual terraces top width at Qollmale was 0.57±0.026 m. This result was found to be greater than the recommended standard value 0. 35 m. According to the one sample t-test result,the average actual top width differs significantly to the standard at 95% confidence interval with p= 0.005 (Table 6). In addition, the vertical interval between terraces was also evaluated for its correctness. Accordingly, the terraces were found built at an average distance of 2.63±0.32m. The interval width was compared fot its fitness at 95% confidence interval. The resut revealed that the vertical interval of the constructed terraces had significant difference (p= 0.009) from the recommended (Table 6). From the results it could be concuded that in steep slopes, the vertical terrace interval between consecutive terraces has to be narrower in order to accommodate more soil loss and enhance infiltration. In this regard, the constructed terraces have better efficiency to protect soil from erosion.

Laka-Gaho: The mean height of terraces at Laka-Gaho site was 0.87 ± 0.08 m. This value was equevalent to standard height recommended (0.85 m) for the specific site. To evaluate whether the existing average terrace heights fit with the recommended, one sample student t-test was computed and revealed absence of significant difference at 95% confidence interval with p= 0.705. This could be attributed to the moderateness of the slope (13.5%) in Laka-Gaho site. In addition, the mean terraces top width in "Laka-Gaho",was measured as 0.41±0.06 m. This value was higher than the recommended standard (0.35 m). However, the actual and recommended values were not found significantly different at 95% confidence interval with p = 0.203. The distance between the terraces is one of the criterion to evaluate the landscape soil and water conservation structures. Accordingly, the actual vertical interval between terraces was computed as 3.5 ±0.5 m. The recommended standard vertical interval between the terraces for such topography was 1.62 m. The arrangment of terraces of the existing structures were wider than the recommended standard. Its broadness was significantly higher at 95% confidence interval with p= 0.023.

Amaritta site: the actual mean height of terraces in Amaritta site was assessed. The mean backside height of terraces was 1.24 m ± 0.08 m. This actual value was found to be statstically significant with the recommended standard of mean terrace height (0.85m) at 95% confidence interval with p= 0.016. Similarly, the mean top terrace width was computed for the same site. The result was 0.59±0.015 m. This value was compared with the standard recommended terrace width (0.35 m). Accordingy, the difference in mean top terrace width was found to be statistically significant at 95% confidence intercal with p= 0.006. In addition, The mean terrace vertical interval was also computed for Amaritta site as 2.76 ±0.25 m. This result was found to be equivalent to the recommended standard (2.85) vertical interval between terraces. Hence, there was no statstically significant difference between the actual and recommended vlaues at 95% confidence interval with p= 0.624. This result was completely different from studies conducted on different parts of the country where there was not more than 50% of fitness with recommended standards (Walie, 2016; Belayneh, 2005).

4. CONCLUSION

The land use types, existing soil and water conservation structures and soil depth do fit with treatment oriented capablity classification schemes set for Ethiopia. In addition, the quality of traditionally engineered soil and water conservation structures were found to be fit and even well beyond the recommended standards set for quality of soil and water conservation structures. This is quite uncommon in modern structures. The skill and work culture that pass through generation has paved the way for continous monitoring and sense of ownership in Konso.

REFERENCES

1) Belay, T., 2003. Combining Land Capability Evaluation, Geographic Information Systems and Indigenous Technologies for Soil Conservation in Northern Ethiopia. Eastern Africa Social Science Research Review, **19**(2) 23-53, 2003.

2) Belayneh, A., 2005. Land Degradation Assessment and Evaluation of Current Land Uses and Soil Conservation Structures at Upper Catchement, South Gondar, Ethiopia. MSc. Thesis. Addis Ababa University, Ethiopia.

3) Forch, W., 2003. The agricultural system of the Konso in South-Western Ethiopia. FWU

4) Water Resource Publications: University of Siegen.

5) Mezgebe A.H., 2011. Indigenous talents of Konso people to cope with climate change susceptibility, Ethiopia. A paper presented in International workshop on Indigenous Peoples, Marginalized Populations and Climate Change, United Nation University, From 19 - 21 Jul 2011 Mexico City, Mexico

6) Tadesse, M., 2010. Living with adversity and vulnerability.Adaptive strategy and the role of trees in Konso, southern Ethiopia. Faculty of natural science and agricultural science department of

urban and rural development, Uppsala. Doctorial thesis Swedish university of agricultural science.

7) Walie, S. D., 2016. Evaluate the Quality of Physical Soil and Water Conservation Structures in Wyebla Watershed, Northwest Ethiopia 2016. Journal of Environment and Earth Science Vol.6(3).pp 66-73.

8) Watson, E. E., 2009. Living Terraces in Ethiopia: Konso Landscape, Culture and Development. Woodbridge and New York: James Currey (an imprint of Boydell and Brewer) East Africa Series.

9) Woldeamlak B., 2003. Land degradation and farmers' acceptance and adoption of conservation technologies in the Digil watershed, Northwestern Highlands of Ethiopia.Social Science Research Report Series no. 29, OSSREA, Addis Ababa, Ethiopia. 65 pp.