Novelty Journals

ISSN 2394-966X

International Journal of Novel Research in Life Sciences
Vol. 6, Issue 1, pp: (54-61), Month: January - February 2019, Available at: www.noveltyjournals.com

Evaluation of Soil and Water Conservation Measures on Physico-Chemical Properties of two Watershed in Humbo Woreda, Southern Ethiopia

[1]Meseret Melilo, [2]Dawit Dalga

[1]Humbo District Agricultural office, P O Box, 60, Wolaita Zone, Ethiopia

[2]Wolaita Soddo University, College of Agriculture, P O Box, 138, Wolaita Soddo, Ethiopia

Corresponding author email: dawitdalga9@gmail.com

Abstract: **Land degradation in Ethiopia is a serious constraints and causes for soil fertility depletion and results low production of Agriculture. However, it is possible to tackle such problem by using different SWC measures and knowing its status. Nevertheless, the performance of soil and water conservation structures has not been well studied in the study area. Therefore, this study was conducted in Humbo woreda of two Watersheds, southern Ethiopia to evaluate the effect of soil and water conservation structures in selected soil physiochemical properties. Cultivated fields treated soil bund, Fanyajuu and Trench structures were compared with non-conserved cultivated land (control). A total of 16 soil samples were collected from the top 20 cm soil depth replicated three times. The collected data from soil parameter was analyzed by using SAS soft-wares. The results of the experimental study showed that textural fractions of sand, clay and silt showed no significant variation ($p < 0.05$) with the conserved and non-conserved treatments. Soil organic carbons (SOC), total nitrogen (N), Available P, Exchangeable K and Bulk density (Bd) were significantly ($p \leq 0.05$) affected by the soil conservation measures. Soil organic carbon and total N were higher while bulk density was lower in soils of the conserved fields compared to fields without conservation structure. Similarly, all the treatments in the study area were showed non-significant difference among the mean values of exchangeable Ca^{++}, K^{+}, Mg^{++}, Na^{+} and sum of exchangeable bases. Soil properties were in good conditions in the conserved areas with higher SOC, N and lower BD which were indicators of a fertile soil compared to the non-conserved plots. Therefore, it could be concluded that Faynajuu SWC practice was better in low land area and Trench SWC practice was better in mid-high land of the studied watershed.**

Keywords: **Soil bund, Faynajuu, Trench and soil physiochemical properties.**

1. INTRODUCTION

The severity of land degradation process makes large areas unsuitable for agricultural production, because the top soil and even part of the sub-soil in some areas has been removed, and stones or bare rocks are exposed at the surface. Land degradation problem in Ethiopia is manifested mainly in the form of soil erosion, gully formation, soil fertility loss, and crop yield reduction (Safene *et al.*,2006). The excessive dependence of the Ethiopian rural population on natural resources, particularly land, as a means of livelihood is an underlying cause for land and other natural resources degradation (EPA, 2004). Some forms of land degradation are the result of normal natural processes of physical shaping of the landscape and high intensity of rainfall. The scale of the problem, however, dramatically increased due to the increase in deforestation, overgrazing, over-cultivation, inappropriate farming practices, and increasing human population. Removing vegetative cover on steep slopes for agricultural expansion, firewood and other wood requirements as well as for grazing space has paved the way to massive soil erosion (USAID, 2004).The economy of Ethiopia is mainly based on rain-fed agriculture which is the source of livelihood for the majority of its population (CSA, 2008).

International Journal of Novel Research in Life Sciences
Vol. 6, Issue 1, pp: (54-61), Month: January - February 2019, Available at: www.noveltyjournals.com

Considering the background problems enumerated above on soil and water management in Ethiopia, proper soil conservation becomes imperative when considering issues regarding soil fertility improvement. This becomes evident to the effect that the lives of a greater percentage of the population are directly connected to agriculture and agriculture based industries (Omotayo and Chukwuka, 2009). In order to mitigate land degradation problems in Ethiopia, the government has taken different soil and water conservation measures. Nevertheless, the rate of adoption of the interventions is considerably low. Space occupied by soil and water conservation (SWC) structures, impediment to traditional farming activity, water logging problems, weed and rodent problems and huge maintenance requirements are some of the reasons that cause farmers refrain from SWC works. In addition, top down approach in the extension activity, focusing mainly on structural soil and water conservation technologies, and land security issues contribute much to the failure of SWC works (Mitiku *et al*., 2006). Mechanical conservation structures are designed to control runoff and soil erosion in fields where biological control practices alone are insufficient to reduce soil erosion to permissible level and to support agronomic measures and soil management (Morgan, 2005).

Humbo district is selected purposively as a case study area for several reasons. Familiarity with the conditions of the study area in which the researcher has been working in the study area for the last eight years is one of the pre-reason for selecting the study area. In addition to that, the area is selected as the area characterized by high severity of soil erosion, high soil degradation and a lot of effort has been under taken by different stakeholders/MERET, World vision Ethiopia, PSNP and Government Initiatives/to reduce soil erosion. Moreover, the area is food insecure and recurrent drought occurrence is a common phenomenon. In addition to that high population pressure in highland areas`, shortage of farmland, low soil fertility and productivity. For this and other reasons Hamusse and Hamassa watershed in Humbo Woreda many soil and water conservation measures were practiced to improve SWC and enhance soil productivity. However, there has been not qualitative and quantitative evaluation takes place to compare among SWC measures. Therefore, this study was initiated with the objective of: to evaluate the effect of soil and water conservation measures on physico- chemical Properties of soil in conserved and non-conserved farm in the study watersheds.

2. RESEARCH METHODOLOGY

2.1. Description of the Study Area

The study was conducted in SNNPR State, Ethiopia, Wolaita zone at Humbo Woreda. Humbo Woreda is located in an elevation lowest point at Abaya lake range from 1100 meter peak 2335 at solko mountain meters above sea level and temperatures vary according to the season and elevation, but mean maximum range from 18 to 24^{o}c and mean minimum from 12 to 15^{o}c (Humbo Agricultural office, 2017) .

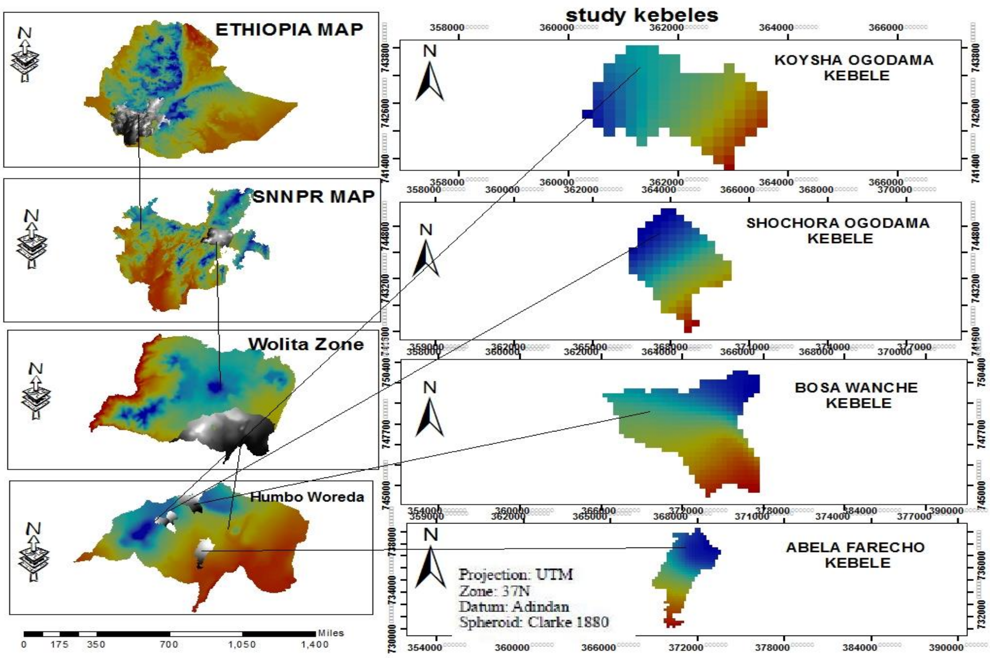

Figure 1: Map of the Study Area (source: DEM DATA)

2.2. Experimental Design and Layout

This particular study was conducted in Four Kebeles` in Hamusse and Hamassa 250-500 Sub-watersheds in Humbo Woreda two kebeles from each watershed respectively. The criteria was availability of different-aged, well maintained and established cropland soil bunds, Faynajuu and trench in low land and mid high land areas and with a view to accessibility of the site for frequent visits. The investigation was conducted at a compact unit of land consisting of four treatments viz. unprotected cropland (T1), soil bund (T2), Fayna Juu (T3), and Trench (T4). The experiment was replicated at lowland and mid-high land areas (or representative sites) in the Hamusse and Hamassa Sub-watershed. The field experiment was laid out in a completely randomized design (CRD) with one slope category (slope between two consecutive bunds), and one spacing category between bunds of the four treatments and each replicated four times where the locations served as block containing all treatments. The Experiment was a total of 16 (4 treatments) sampling units on which soil samples for studying soil texture, Bulk density, total porosity, soil pH, organic carbon, total nitrogen, available phosphorus, and exchangeable potassium and sodium was collected.

2.3. Soil Sampling and Analysis

For soil analysis, composite soil samples' representing the treatments was collected from each replication situated at soil deposition zone from 0-30 cm soil depth using simple random sampling technique. A reconnaissance survey was carried out to identify representative soil sampling plots. Sampling sites was selected both from the farm plots where different SWC structures were practiced and in plots with no SWC practice in the catchments of the study area. In the case of conserved farm plot, the sampling plots refer to the area between the two successive structures. In the case of the non-conserved plots, the sampling plots refer to the area under cultivation which is found adjacent to each structural type.

Composite auger hole samples was taken along the major slope to a depth of 30 cm (i.e. 0-30 cm). Accordingly, 16 composite soil samples, 12 from conserved plots and 4 from non-conserved (control) plots was collected from respective SWC measures. So as to determine soil texture, Bulk density, total porosity, soil pH, organic carbon, total nitrogen, available phosphorus, and exchangeable potassium and sodium was collected. 16 undisturbed core soil samples, which retain the original pore geometry, was collected (one sample from each experimental plot). Thus, a total of 16 soil samples were collected for soil physical and chemical analysis at Sodo Soil Laboratory Center. The undisturbed core soil samples and disturbed soil samples collected was bagged separately with appropriate labels and transported to the laboratories. In the laboratory all disturbed soil samples was air dried by separating in trays and placing them in an open air. The air dried soil samples were crushed to pass through a 2 mm sieve in preparation for laboratory analysis.

The composite soil samples were analyzed for different physical and chemical properties of the soil. A standard laboratory procedure was employed for the parameters required. In determining particle size, the density of soil-water suspension is measured with buoyance hydrometer that was calibrated to read the density of soil water suspension in grams per liter (gm/lit) and the procedure was followed as indicated by Sahelemedhin and Taye (2000). Bulk density was determined from the undisturbed soil samples collected by core samples from 60 cm depth of soil at 20 cm depth interval. This method involved sampling a soil core from a desired depth in the most natural condition and determining the mass of solids and the water content of the core, by weighing the wet core, drying it to a constant weight in an oven at 105℃ for 24 hours and reweighing after cooling (Sahelemedhin and Taye, 2000). $\rho b = Wd / Vt$ (4), Where, ρb is bulk density (gm/cm3), Wd is weight of dry soil (gm) and Vt is volume of the bulk soil (cm3. The pH of the soil was measured potentio-metrically using a digital pH meter in the supernatant suspension of 1:2.5 soils to water ratio. Organic carbon also determined by following the Walkley-Black wet digestion method as described by Bremner and Mulvaney (1982) and then the value was multiplied by 1.724 to get the organic matter content of the soil. The Kjeldahl procedure was followed for the determination of total nitrogen as described by Bremner and Mulvaney (1982). Available phosphorus was determined by the Olsen procedure. In the Olsen procedure, the soil samples was shake with 0.5M sodium bicarbonate at nearly constant pH of 8.5 in 1:20 of soil to solution ratio for half an hour and the extracts was obtained by filtering the suspension (Olsen *et al*., 1954). Exchangeable K+ and Na+ were extracted with 1M ammonium acetate at pH 7.0.

2.4. Data Analysis

Soil and water conservation measures and adjacent control farm plots and slope gradient was used as independent variables and the soil parameters as dependent variables. The significance difference of soil property due to SWC practice and slope gradient was tested using analysis of variance (ANOVA) following general Linear Model (GLM) procedure at $P \leq 0.05$ level of significance and interpreted.

3. RESULTS AND DISCUSSION

3.1. Effects of SWC Measures on Physio-chemical Prosperities of the Soil

3.1.1. Soil Texture and Bulk Density

Analysis of the soil texture showed no significant difference at ($p < 0.05$) with in the conserved and non-conserved treatments. This indicated that the soil texture is the inherent soil property and the position on the landscape (slope gradient). Similarly Ann *et al.* (2005) reported that the soil depths are the factors which cause the variation in soil texture than the soil conservation practices. Since soil weathering is a relatively slow process, texture remains fairly constant and is not altered by soil conservation practices. There were no textural class difference between the three types of SWC measures and non-conserved (Sandy Loam). This might be due to the fact that the high mean annual precipitation over the study area was selectively transported and leached fine soil fractions leaving behind the coarser fraction.

As indicated from the two catchments in Humbo Woreda, the highest mean bulk density (BD) was recorded in the Hamusse catchment koysha Ogodama kebele 1.28 g/cm³ and the least mean bulk density was Hamessa catchment Abella Farecho Kebele 0.75 g/cm³. This could be due to the presence of significantly higher OM resulted from conservation measures and decay of plant residues in mid-high land areas than lowland area. In line to this, similar result was reported by Gebreselassie et al. (2013. According to Landon (1984) classification, the soils with mean 1.53 g/cm3 bulk density ranges with soils showing root restriction which reduces the plants ability to exploit the plants environment.

Table 1: Interaction effect of SWC measures and location on organic carbon in Hamusse and Hamessa watershed in 2018

SWC	Location Sochora Ogodama	Koysha Ogodama	Bosa Wanche	Abela Farcho	Mean
Soil bund	1.81^b	1.86^b	0.75^c	1.90^b	1.58
Fanyajuu	1.67^b	2.06^b	1.70^b	1.79^b	1.81
Trench	1.92^b	0.79^c	1.81^b	2.98^a	1.88
Non-conservation	0.23^c	0.22^c	0.64^c	0.12^c	0.30
CV%	3.176				
LSD(0.05)	0.735				

3.1.2. Soil Organic Carbon and Total Nitrogen

The soil organic carbon showed a significant variation ($p < 0.05$) with respect to various SWC measures types and the un-conserved. The organic carbon content under the un-conserved land was significantly lower than the content in the selected physical SWC measures in soil bund, Fayna Juu and Trench (Table 2). Similarly, Million (2003) reported that soil organic carbon content in soils under the well conserved site were higher compared to the un-conserved sites of similar slopes and depths. Gebresilase *et al.* (2009) also reported that the non-conserved fields had significantly lower SOC as compared to the conserved fields. This might be because of the decomposition of different plant biomasses on the soil of conserved land.

The total nitrogen content of the soil also showed a significant variation ($p < 0.05$) with respect to various SWC measures. The overall mean total nitrogen content in soils under the un-conserved land was (0.06); which was significantly lower than the nitrogen content under the soil bund, Fayna Juu and Trench. Similarly Mulugeta and Karl

International Journal of Novel Research in Life Sciences
Vol. 6, Issue 1, pp: (54-61), Month: January - February 2019, Available at: www.noveltyjournals.com

(2010) also reported that the land treated with different soil conservation measures have high total nitrogen as compared to the un-conserved land. Gebresilasse *et al*. (2009) also found that the mean total N content of the terraced site were higher as compared to the average total N contents of the corresponding non-terraced sites. This might be because of the nitrogen fixing tree species planted in the conserved land such as (*Sasbania sesban and Acacia species*) had increased the total nitrogen content of the soil.

Table 2: Interaction effect of SWC measures and location on Total nitrogen (TN) in Hamusse and Hamessa watershed in 2018

SWC	Location				
	Sochora Ogodama	Koysha Ogodama	Bosa Wanche	Abela Farcho	Mean
Soil bund	0.19^{c}	0.17^{dc}	0.20^{bc}	0.18^{c}	0.19
Fanyajuu	0.16d^{c}	0.20^{bc}	0.15^{dc}	0.17^{dc}	0.17
Trench	0.26^{a}	0.12^{de}	0.19^{c}	0.25^{ba}	0.21
Non-conservation	0.05^{f}	0.06^{f}	0.07^{fe}	0.06^{f}	0.06
CV%	2.13				
LSD(0.05)	0.05				

3.1.3. Available phosphorus and Soil reaction

The relatively higher percentage of available phosphorous was also observed in the soil bund and Trench SWC measures. This indicates that there is high deficiency of available phosphorus in the study area. According to ATA (2014) critical level classification for available phosphorus there was very weak status of available phosphorus in all the landscape categories of the soil. Phosphorus is one the most important element in the soil nutrient required by plant. The presence of available content depends upon a number of factors such as climate, vegetation, soil texture, land use pattern, fertilizer practices, drainage, irrigation and moreover the availability of phosphorus in the soil is greatest in the pH range 6.0–6.5 (Prasad & Power, 1997).

As indicated from the finding, Hamessa catchment particularly Bosa Wanche kebele in Humbo was characterized by low available phosphorus and this could be due to the existence of acidic soil (mean pH with 5.5–6.0) throughout and the presence of low organic matter. This result was supported by Tisdale and Nelson (1975) who found available phosphorous decreased with higher acidic soil pH.

Table 3: Interaction effect of SWC measures and location on available phosphorus in Hamusse and Hamessa watershed in 2018

SWC	Location Sochora Ogodama	Koysha Ogodama	Bosa Wanche	Abela Farcho	Mean
Soil bund	24de	27^{dc}	7^{ghi}	47^{a}	26.25
Fanya juu	9^{ghi}	15^{gef}	3.6^{i}	14^{ghf}	10.40
Trench	5^{hi}	15^{gef}	5^{hi}	43^{ba}	17.00
Non-conservation	3^{i}	35^{bc}	3^{i}	23^{def}	16.00
CV%	9.02				
LSD(0.05)	3.116				

3.1.4. Exchangeable bases

All the treatments in the study area have shown non-significant difference among the mean values of exchangeable Ca++, K+, Mg++, Na+ and sum of exchangeable bases. The mean relative abundance of basic cations in the exchange complex for all the treatments categories in the study samples were in the order of Ca++ > Mg++ > Na+> K+. The results of this study was in agreement with Amare et al. (2016), who found a non-significant variation in exchangeable bases among different soil and water conservation measures. Similarly, the difference in the sum of exchangeable base (SEB) was not statistically significant at $P < 0.05$ among the mean of different landscape categories.

Table 4: Interaction effect of SWC measurement and location on (CEC) In Hamusse and Hamessa watershed in 2018

SWC	Location Sochora Ogodama	Koysha Ogodama	Bosa Wanche	Abela Farcho	Mean
Soil bund	20.0^{dc}	23.7^{c}	18.6^{e}	28.1^{a}	22.6
Fanya juu	24.3^{bc}	22.1^{dc}	26.4b^{a}	26.3b^{a}	25.18
Trench	23.3^{c}	22.0^{dc}	27.0^{a}	27.3^{a}	24.9
Non-conservation	23.3^{c}	28.2^{a}	11.3^{f}	28.8^{a}	22.9
CV%	6.5				
LSD (0.05)	2.593				

3.1.5. Soil PH

The variations for soil pH, which affects nutrient availability and toxicity, microbial activity and root growth (Brady,2002) both under conserved and non-conserved farm plots were generally small. No significant differences were detected between treatments. Similarly Alemayehu (2003) also found that stone bund had no significant effect on soil pH when compared to the control treatment (non- conserved plots), also reported pH values did not vary with position in the plots between consecutive stone terraces. According to (Olaitan, 1984), rating of surface soil pH (4.5 as very acidic, 5.0 as acidic, 5.5 as moderately acidic and 6.0 as slightly acidic) the pH value of both the conserved and the non-conserved farm plots in study area can be classified as moderately acidic. It may be attributed to the application of acid forming fertilizers, continuous intensive cultivation, intense erosion and leaching of basic nutrients like calcium, potassium and magnesium as excess rainfall passes through the soil. The other reason could be related to the parent material of the Trapp series that include rare rhyolites of the sampled soils (Fikre, 2010). As explained by (Olaitan, 1984), soils developed from acidic rocks (parent materials) such as granite and rhyolite contain an excess of quartz or silica and these, combined with various proportions of water, form acids such as silicic acid, and trisilicic acid. As a result, most soils in high rainfall area have the problem of nutrient availability for the production of agricultural crops such as potassium, calcium, and magnesium and phosphorous. This is one of the problems mentioned by many researchers (FAO, 1997) that make the tropical countries poor and unable to feed themselves in most cases in addition to other problems related to agricultural production and productivity.

Table 5: Interaction effect of SWC measures and location on soil reaction (PH) In Hamusse and Hamessa watershed in 2018

SWC	Location Sochora Ogodama	Koysha Ogodama	Bosa Wanche	Abela Farcho	Mean
Soil bund	6.1^{dc}	6.1^{dc}	5.6^{fe}	6.8^{a}	6.15
Fanyajuu	5.6^{dfe}	5.9^{dce}	5.0^{g}	6.3^{bc}	5.7
Trench	4.9^{g}	5.7^{de}	5.2^{gf}	6.1^{dc}	5.48
Non-conservation	5.8^{de}	6.8^{a}	5.3^{gf}	6.7^{ba}	6.15
CV%	4.64				
LSD(0.05)	0.455				

4. CONCLUSION

The use of SWC structure is promising in protecting the cultivated land from erosion and the associated nutrient depletion. With regard to analysis of soil characteristics in treated and untreated plots, SOC and total N were higher while BD was lower under the conserved farm. Generally, the soil physical and chemical properties were better in conserved farm plots than the non-conserved plots. As Laboratory result indicated soil bund almost equally improves soil physiochemical properties of both Hamessa and Hamusse catchments of the study area. Moreover, Trench is more efficient as per laboratory result in Hamusse (mid-high land area) catchments particularly in SOC, TN, CEC and AP. The difference in soil properties between the loss zone and accumulation zone within the conserved plot should also be evaluated further for complete understanding. However, it is possible to suggest better soil and water conservation measure based on farmer's perception and soil analysis studied for two catchments. Hence, among soil and water conservation measures soil bund was better soil organic matter content and recommended to the study area.

ACKNOWLEDGEMENTS

The authors thank the Humbo District Agricultural office for providing the budget for this research work and Wolaita Soddo University for providing research materials and necessary facilities.

REFERENCES

[1] Alemayehu Mulugeta. Characterization of Indigenous Stone bunding (Kab) and its effect on crop yield and soil productivity atMesobit-Gedba, North Showa Zone of Amhara Region. Thesis, Alemaya University. 2003.

[2] ATA(Agricultural Transformation Agency) (2014). Soil Fertility Status and Fertilizer Recommendation Atlas for Tigray Regional State, Ethiopia. Addis Abeba

[3] Brady, N. C., Weil, R. R., 2002. The nature and properties of soils. Prentice- Hall Inc., New Jersey, USA, 13th Ed. 2002; Pp.960.

[4] CSA (Central Statistics Authority). 2008. Agricultural sample survey 1999/2000. Report on area and production for major crops (private peasant holdings, main season). Statistical Bulletin Vlo.1. Addis Ababa, Ethiopia.

[5] FAO (1997). Report on the FA O/UNEP expert consultation on methodology for assessing soil degradation. Rome: FAO, 70 pp.

[6] Fikre G/silassie. A Multi Method Approach to Study Landslide Hazard. A case study in Ada Berga Woreda, Western ShowaZone, Oromiya Region, Ethiopia. MSc Thesis, Addis Ababa University, 2010.

[7] Landon, J.R. (Ed.) Tropical Soil Manual. A Handbook of Soil Survey and Agricultural Land Evaluation in the Tropical and Subtropical. Longman Broak. 447 p. 1991.

[8] Million, A. 2003. Characterization of indigenous stone bunding (Kab) and its effect on crop yield and soil productivity at Mesobit-Gedba, North showa zone of Amhara region, M.Sc. Thesis, Alemaya University, Alemaya, Ethiopia.

[9] Mitiku H., Herweg, K.andStillhardt, B. 2006. Sustainable Land Management Morgan, R.P.C., 2005, Soil Erosion and Conservation, Blackwell Publishing, 3rd ed., USA, p. 303

[10] Mulugeta D, Karl S (2010). Assessment of integrated soil and water conservation measures on key soil properties in south Gondar, northwestern Highlands of Ethiopia. J. Soil Sci. Environ. Manag. 1(7):164- 176.

[11] Omotayo, O.E. and Chukwuke K.S., 2009. Soil fertility restoration techniques I. Sub-Saharan Africa using organic resources. African Journal of Agricultural Research, 4(3): 144 – 150.

[12] Olaitan, S. O., Lombin, G., Onazi, O. C. 1984. Introduction to Tropical Soil Science. Macmillan Publishers: Hong Kong,.

[13] Omotayo, O.E. and Chukwuke K.S., 2009. Soil fertility restoration techniques I. Sub-Saharan Africa using organic resources. African Journal of Agricultural Research, 4(3): 144 – 150.

International Journal of Novel Research in Life Sciences
Vol. 6, Issue 1, pp: (54-61), Month: January - February 2019, Available at: www.noveltyjournals.com

[14] Safene Chuma, AbayAyalew, WagaMazengia and TilahunAmede. 2006. Integrating various biological measures of erosion control and soil fertility management: The case of Gununo, Ethiopia,

[15] Sahelemedhin, S. and Taye, B. 2000. Procedures for soil and plant analysis, Technical Paper No. 74, National Soil Research Center, Ethiopia Agricultural Research Organization, Addi Ababa, Ethiopia, p. 110

[16] Tisdale, S.L., Nelson, W.L., Beaton, J.D. and Havlin, J.L.(1995). Soil fertility and fertilizer, 5th Ed. Prentice-Hall of India, New Delhi. 684p.

[17] United States Agency for International Development (USAID), 2004. Ethiopia land policy and administration assessment, Final Report with Appendices, USAID Contract No. LAG-00-98-00031-00, Task Order No. 4, p. 110.