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On Farm Participatory Evaluation of Integration of both Mechanical and Biological Soil and Water Conservation Practices in West Arsi and East Shoa Zone, Oromia, Ethiopia

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Abstract

Soil erosion is one of the major challenges of Ethiopia deteriorating the productivity of the land. Soil and water conservation (SWC) is the alternative to reverse the threat and protect the land. Over the last three decades, different soil and water conservation activities have been undertaken. However, soil erosion still persists and become major threats of Ethiopian farmers. Despite the massive mobilization of resources for SWC, only very few studies have been done to analyze the impacts of integrated soil and water conservation measures with respect to restoration of degraded agricultural lands. In addition, most plot-based studies are focused on assessing the severity of soil erosion in physical terms and lack information on the impact of SWC on soil fertility improvement and soil nutrient content dynamics. This study was conducted at purposively selected districts namely Adama and Shashemene in East Shoa and West Arsi Zones of Oromia regional state respectively. The study was aimed to evaluate the effect of integrated Soil and water conservation measures in restoring degraded agricultural land. Dasho grass (Pennisetum pedicellatum) and Elephant grasses (and Pennisetum purpureum) were planted on graded soil bund in both districts as an integration measures. It was identified that soil nutrient contents in terms of total nitrogen, available phosphorous, available potassium and soil organic carbon content showed an increasing trend since establishment (2013). On the other hand, this kind of soil and water conservation practices on agricultural land showed promising way of carbon sequestration as the climate change mitigation strategy. The findings recommended that use of integrated soil and water conservation measures as strategy of rehabilitating degraded agricultural land should be considered in implementing integrated water shed management. In conclusion, to reduce soil erosion sustainably, integrated soil and water conservation should be introduced considering agro ecology and climatic condition of the intervention area.

Keywords: *Soil and water conservation; Soil erosion; Soil nutrient*

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Introduction

Agriculture is the major source of livelihood in Ethiopia. However, land degradation in the form of soil erosion has hampered agricultural productivity and economic growth of the nation (Haileslassie., *et al*. 2005; Balana., *et al*. 2010). Land degradation, low agricultural productivity and poverty are critical and closely related problems in the Ethiopian highlands (Gebremedhin, 2007; Yitbarek., *et al*. 2012). Investments in soil and water conservation (SWC) practices enhance crop production, food security and household income (Adgo., *et al*. 2013). Recognizing these connections, the government of Ethiopia is promoting SWC technologies for improving agricultural productivity, household food security and rural livelihoods. Particularly, in the Ethiopian highlands, different SWC technologies have been promoted among farmers to control soil erosion problem. The traditional physical SWC measures, such as soil bund and terraces, have been practiced in a few areas for several hundred years (e.g., Konso area by Tadesse, 2010), for which awareness and experience have been confined in that particular area. The structures having certain technical designs and specifications have been introduced to many new areas, assuming that land users can adopt it sooner or later. Recently, pilot projects, campaign work, food for work programs (grain and edible oil support), etc. were initiated and are ongoing by both government and non-governmental organizations. However, most of these SWC technologies, especially construction of SWC practices on agricultural land, has got less acceptance (Tesfaye., *et al*. 2013; Teshome., *et al*. 2014), largely because investments by farmers in SWC are influenced by the ecological, economic and social impacts of the SWC technologies. The actual and long term financial profitability to farm households critically influences the process of accepting and replicating such structures (De Graaff., *et al*. 2008). Poverty and a long time span to get return from soil conservation activities reduced adoption of SWC technologies in East Shewa (Ethiopia) (Shiferaw and Holden, 2009). In the northwestern Ethiopian highlands, labour shortage, problems with fitness of the SWC technologies to the requirements of farmers and land tenure insecurity discouraged farmers from adopting SWC measures such as soil and stone bunds, fanya juu, etc. (Bewket, 2007).

Therefore, it is important to improve farmers' level of understanding on the effect of soil and water conservation technologies in controlling soil erosion and maintaining soil nutrient content on agricultural land. On the other hand, participatory evaluations of these technologies are also equally crucial to improve farmers' level of adoption of SWC technologies. Despite the massive mobilization of resources for SWC, only very few studies have been done to analyze the impacts of integrated soil and water conservation measures with respect to restoration of degraded agricultural lands. In addition, most plot-based studies are focused on assessing the severity of soil erosion in physical terms and lack information on the impact of SWC on soil fertility improvement and soil nutrient content dynamics. Consequently in this study we highlighted some important aspects of importance of SWC with following objectives;

1. To evaluate the impact of the integration of both physiscal and biological SWC on controlling soil erosion and improving soil fertility.
2. To improve farmers' practical level of awareness/understanding on SWC technologies.

Expected output

1. The impact of the integration of both physiscal and biological SWC on controlling soil erosion and improving soil fertility will be identified.
2. The contribution of the integrated SWC in storing SOC on agricultural land will be known.
3. Production and productivity of the land will be improved.

Materials and Methods

This conservation measure was established at six different Sites (three in Shashemene, three in Adama districts). Animal forages such as Elephant grass (*Pennisetum purpureum*), Dansho grass (*Pennisetum pedicellatum*) and Rhodes grass (*Chloris gayana*) were used as an integration measure with soil bund.

Farmers' field visit was done to improve farmers' level of understanding on SWC technologies. Composite Soil samples were collected from each site every year since establishment and analyzed to evaluate soil nutrient dynamics.

Result and Discussions

Change in total Nitrogen, available phosphorous, potassium and SOC from 2013-2016 were analyzed every year. Accordingly, Total N, available phosphorous, potassium and soil organic carbon showed an increasing trend at all sites since 2013 (Figure 1)

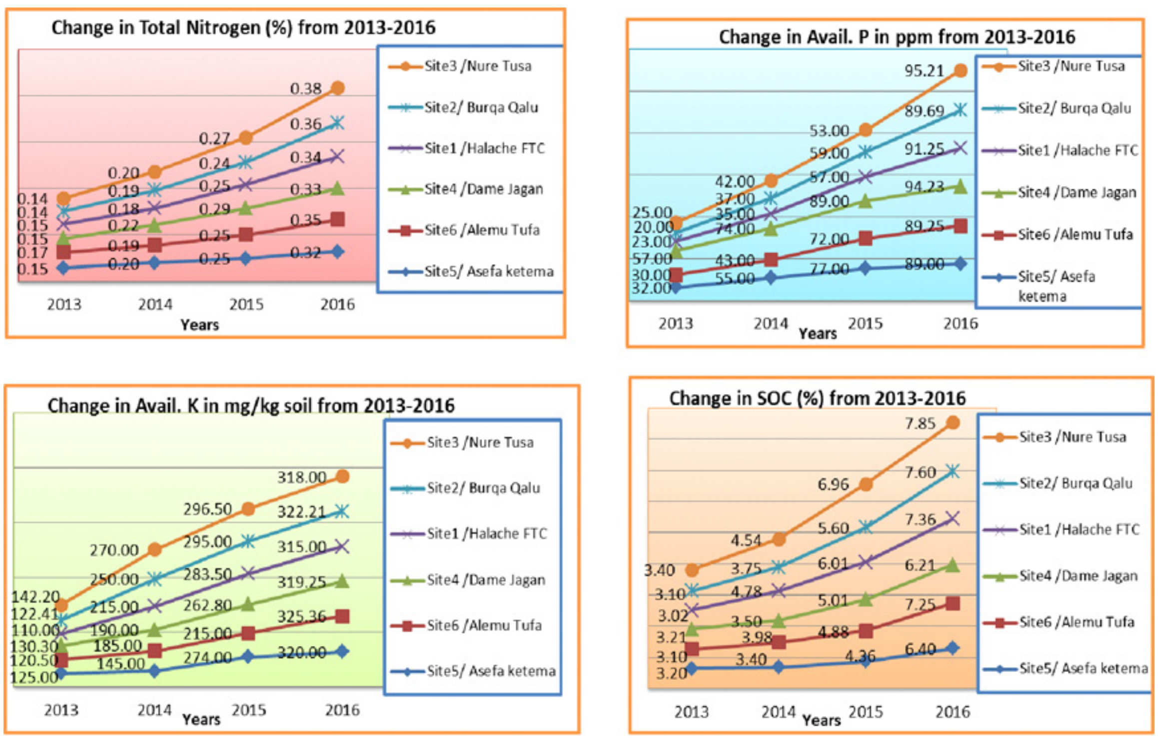

Figure 1: Change in total Nitrogen, available phosphorous, potassium and SOC from 2013-2016.

Soil nutrient content is highly significantly different at $p < 0.05$ between and within experimental sites across the years (Table 1). Major soil nutrient contents also showed an increasing trend since 2013 (baseline) indicating that integrated SWC measures interventions have appositive effect in improving soil nutrient content. On the other hand, SOC content of the soil showed an increasing trend since establishment of integrated SWC indicating that it is a promising way of carbon sequestration on agricultural land. Major soil nutrients such as Total N, available phosphorous, potassium and soil organic carbon are highly significantly different $p < 0.05$ across the year in both districts (Table 2). In addition, Soil nutrient status in 2013 (baseline) is also smaller and highly significantly different from the soil nutrient status after intervention. EC (electrical conductivity) and soil pH are not significantly different across the year with in the district but are significantly different $p < 0.05$ between the districts.

Similarly, Eshatu (2004) reported that SWC practices significantly increased organic carbon, total nitrogen and soil-organic matter in the soil. Other studies also indicated that there is a positive contribution of SWC measures to the reduction of soil erosion, conservation of soil moisture, and soil nutrient content (Asefa., *et al*. 2003; Vancampenhout., *et al*. 2006; Gebreegziabher., *et al*. 2009; Mekuria., *et al*. 2011). Many other cases studies also indicated that integration of biological with physical measures improved effectiveness of the structure and soil fertility Zougmore., *et al*. (2002) and Adimassu., *et al*. (2012).

District	Sites	Years	Total N (%)	Avail. P in ppm	Avail. K in mg/kg soil	EC in mmhos/cm	Soil pH	SOC (%)	C/N
Adama	Didibissa	2013	0.17^{fgh}	30.00^{hi}	120.40^{j}	0.22^{f}	6.23^{f}	3.53^{d}	21.01^{abcd}
	Didibissa	2014	0.19^{efg}	43.00^{e}	185.00^{g}	0.37^{b}	7.05^{d}	3.49^{d}	18.44^{bcd}
	Didibissa	2015	0.25^{bc}	77.33^{b}	274.00^{c}	0.36^{b}	6.63^{e}	5.74^{b}	22.66^{abc}
	Didibissa	2016	0.32^{a}	89.44^{d}	319.52^{e}	0.32^{abc}	7.51^{a}	7.05^{a}	21.82^{ab}
	Qobo	2013	0.15^{gh}	32.00^{gh}	125.00^{ij}	0.31^{c}	6.57^{e}	2.90^{def}	19.98^{abcd}
	Qobo	2014	0.20^{def}	55.00^{c}	145.00^{h}	0.32^{c}	7.55^{c}	4.66^{c}	23.81^{abc}
	Qobo	2015	0.25^{bc}	72.00^{b}	215.00^{f}	0.21^{f}	8.03^{b}	5.62^{b}	22.16^{abcd}
	Qobo	2016	0.33^{a}	85.44^{d}	322.52^{e}	0.32^{abc}	7.61^{a}	8.05^{a}	24.24^{ab}
	Futala	2013	0.15^{gh}	57.00^{cd}	130.10^{i}	0.37^{b}	6.10^{g}	2.65^{ef}	17.71^{cd}
	Futala	2014	0.22^{cde}	74.00^{b}	190.00^{g}	0.29^{cd}	8.00^{b}	4.22^{c}	19.20^{bcd}
	Futala	2015	0.30^{a}	89.00^{a}	262.27^{d}	0.36^{b}	8.17^{a}	5.90^{ab}	19.75^{abcd}
	Futala	2016	0.34^{a}	85.00^{d}	320.52^{e}	0.33^{abc}	7.61^{a}	8.05^{a}	24.14^{ab}
Shashem-ene	Ebicha	2013	0.14^{h}	20.00^{j}	122.41^{j}	0.27^{de}	5.62^{h}	2.54^{f}	18.38^{bcd}
	Ebicha	2014	0.19^{efg}	37.00^{fg}	250.00^{e}	0.46^{a}	5.55i	4.53^{c}	24.00^{ab}
	Ebicha	2015	0.24^{bcd}	59.00^{c}	295.00^{a}	0.26^{de}	5.56^{hi}	5.56^{b}	23.18^{abc}
	Ebicha	2016	0.32^{a}	91.50^{d}	315.42^{e}	0.31^{abc}	7.25^{a}	7.05^{a}	21.82^{ab}
	Halache	2013	0.15^{gh}	23.00^{j}	110.00^{k}	0.12^{h}	5.27^{k}	2.40^{f}	16.18^{d}
	Halache	2014	0.18^{efg}	35.00^{gh}	215.00^{f}	0.31^{c}	5.45^{j}	3.27^{de}	18.32^{bcd}
	Halache	2015	0.25^{bc}	57.00^{cd}	283.33^{b}	0.27^{de}	5.58^{hi}	6.19^{ab}	25.49^{a}
	Halache	2016	0.36^{a}	92.50^{d}	325.42^{e}	0.31^{abc}	7.25^{a}	7.05^{a}	21.12^{ab}
	Abaro	2013	0.14^{h}	25.00^{ij}	142.07^{h}	0.17^{g}	5.15^{l}	2.44^{f}	18.45^{bcd}
	Abaro	2014	0.20^{def}	42.00^{ef}	270.00^{c}	0.32^{c}	5.55^{i}	4.18^{c}	22.26^{abcd}
	Abaro	2015	0.27^{ab}	53.00^{d}	296.17^{a}	0.24^{ef}	5.59^{hi}	6.54^{a}	24.29^{ab}
	Abaro	2016	0.35^{a}	93.50^{d}	324.42^{e}	0.33^{abc}	7.05^{a}	7.25^{a}	20.72^{ab}
	CV (%)	12.68	7.2	1.79	6.7	0.57	9.15	17.99	
	LSD0.05	0.04	5.89	6.00	0.03	0.06	0.64	6.21	

Table 1: *Mean comparison of soil nutrient content at different site across the years (significant at p < 0.05).*

Districts	Years	Total N (%)	Avail. P in ppm	Avail. K in mg/kg soil	EC in mmhos/cm	Soil pH	SOC (%)	C/N
Adama	2013	0.16^{c}	39.67^{c}	125.17^{d}	0.30^{bc}	7.30^{a}	3.03^{c}	19.57^{bc}
	2014	0.20^{b}	57.33^{b}	173.33^{c}	0.33^{ab}	7.53^{a}	4.12^{b}	20.48^{bc}
	2015	0.27^{a}	79.44^{a}	250.42^{b}	0.31^{abc}	7.61^{a}	5.75^{a}	21.52^{ab}
	2016	0.32^{a}	89.44^{d}	312.52^{e}	0.32^{abc}	7.51^{a}	7.05^{a}	21.82^{ab}
Shashemene	2013	0.14^{c}	22.67^{d}	124.83^{d}	0.29^{bc}	5.35^{b}	2.46^{d}	17.67^{c}
	2014	0.19^{b}	38.00^{c}	245.00^{b}	0.34^{ab}	5.52^{b}	4.00^{b}	21.53^{ab}
	2015	0.25^{a}	56.33^{b}	291.50^{a}	0.29^{bc}	5.58^{b}	6.10^{a}	24.32^{a}
	2016	0.33^{a}	76.33^{a}	320.50^{e}	0.30^{bc}	5.50^{b}	6.21^{a}	24.52^{a}

CV (%)	12.86	18.44	9.23	21.26	5.82	12.24	17.75
LSD0.05	0.02	8.55	17.64	0.05	0.34	0.49	3.50
p-value	0.001	0.001	0.001	0.065	0.001	0.001	0.012

Table 2: *Mean comparison of major soil nutrient content across experimental period significant at $p < 0.05$.*

Conclusion and Recommendations

Major soil nutrients such as total nitrogen, phosphorous, potassium and SOC contents showed an increasing trend since establishments of integrated soil and water conservation measures at all sites. In addition to providing forage to the livestock and controlling soil erosion, integrated soil and water conservation can improve soil fertility and increase soil organic carbon pool. Based on this study, the following recommendations were given:

1. Integrated SWC activities should be scaled up particularly on agricultural land as means to control soil erosion problem, improving soil fertility and as a source of feed for livestock.
2. Integrated soil and water conservation is a promising way of carbon sequestration on agricultural land. Therefore, this should be considered in the implementation of climate smart agriculture as strategy to mitigate climate change.

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