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Full Length Research Paper

Assessment of farmers' practices on soil erosion control and soil fertility improvement in rift valley areas of east Shoa and west Arsi zones of Oromia, Ethiopia

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Farmers' perception and indigenous knowledge to conserve natural resources in general and soil and water conservation in particular have received little emphasis in Ethiopia. This study aimed to understand farmers' perception on prevalence of soil erosion and their indigenous mechanism in soil erosion control and soil fertility management. The study was conducted in March, 2011 in purposively selected districts of East Showa Zone (Adama and Lume districts) and West Arsi zones (Shashemene and Kofele) of Oromia, Ethiopia. Data was collected using household interviews where a total of 160 farmers were randomly selected and interviewed. It was identified that the land allocated for the agricultural land and forest land showed an increasing trends since five years back in all study districts while the land allocated for grazing was decreasing. This was due to conversion of grazing land and other marginal lands into cropland to satisfy an increased food demand. Water and wind erosions are the two major types of soil erosion identified in this particular study. Heavy and erratic rain fall, topography and deforestation are the major causes of soil erosion in all study area. To tackle the soil erosion problem, farmers are using different physical structures such as soil bund, cutoff drains and micro basins. In addition, crop rotation, compost, animal manure and intercropping are also the major biological soil and water conservation activities practiced by the farmers. In their decisions for fertilization or production farmers use yield response, soil color, vegetation cover, soil type and topography as soil fertility indicators. Chemical fertilizers, though perceived expensive, are still the dominant strategy used by farmers to increase production. In addition, farmers' perception and training on use of other alternative organic fertilizer is very low in all study areas.

Keywords: Farmers' practice, soil erosion, soil and water conservation.

BACKGROUND AND JUSTIFICATION

Ethiopia experiences extreme rural poverty and some of the worst land degradation in the world (1900 million tons of soil lost per year). The main development effort to reduce soil erosion implemented since the mid 1970s is based on food for work at a huge per hectare cost. Symptoms of erosion have been tackled by physical engineering, the construction of terraces and bunds, the plugging of gullies and the planting of woodlands. Every year over 30 million farmers' working days are mobilized for soil and water conservation activities. Engineered conservation provides a measure of land protection, but a terrace brings no reward to the farmer if he cannot plough it.

Sustaining soil fertility has become a major issue for agricultural research and Development in Sub Saharan Africa (Smaling 1998 cited from Marc et al. 2000). In the

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past, most research consisted of trials to determine the appropriate amount and type of fertilizers needed to obtain the best yields for particular soil types and specific agro-ecological locations. This approach emphasized the use of external inputs and expensive technologies, and often disregarded farmers' knowledge and the resources at their disposal. Since then, research has gradually shifted towards an approach based on Integrated Soil Fertility Management which combines various existing soil fertility management techniques. This approach is based on a thorough scientific understanding of the underlying biological processes of Integrated Soil Fertility Management and aims to promote options that make the best use of locally available inputs, and that are tailored to suit local agro-ecological conditions, and farmers' resources and interests (Marc, et al. 2000).

Besides, many of the projects sponsored both by the government and the WFP were also criticized for putting emphasis only on mechanical conservation measures, most of which were alien to the farmers. The farmers were virtually considered ignorant of soil and water conservation practices and were excluded from the planning, commenting on and implementation of these conservation measures (Amsalu, 2007). Decisions on which types of conservation measures to use and where to place them were not made by the farmers concerned (top down approach), and only rare attempts were made to include indigenous experience and knowledge. Although the achievements were remarkable in quantitative terms, the impacts of these efforts were far below the expectations and land degradation continued to be a serious problem (Admassie, 2000).

Farmers' decisions to conserve natural resources in general, and soil and water in particular are largely determined by their knowledge of the problems and perceived benefits of conservation (Amsalu and Graff, 2007)**.** In Ethiopia, however, farmer perceptions of soil erosion and soil fertility management problems and farmers conservation practices have received little emphasis either in status analysis or use in conservation planning**.** This study will help to understand perceptions of farmers and prevalence of soil erosion, identifying the dominant soil erosion types and farmers' soil erosion control mechanisms, identifying soil fertility management practices in the area, and problems and opportunities of both erosion and fertility management of soils to device future research directions for the benefits of farmers.

Objectives of the study

To identify farmers' soil erosion control mechanisms in central rift valley areas,

To identify the dominant soil erosion types in central rift valley areas, and

To know farmers' perceptions on identification and classification of soil erosion types and ways of erosion control mechanisms

To assess soil fertility management practices in the central rift valley areas

Rationale of the study

Erosion removes top-soils, reduces levels of soil organic matter, and leads to breakdown of soil structure. In soils having restrictions to root growth, erosion decreases rooting depth, which in turn decreases amount of water, air, and nutrients available to plants. Erosion removes surface soil, which often has the highest biological activity and greatest amount of soil organic matter, and causes loss in nutrients. It often creates less favorable environment for plant growth. Nutrients removed by erosion are no longer available to support plant growth onsite, but can be accumulated in water where such problems as algal blooms and Lake Eutrophication may occur. Deposition of eroded materials can obstruct roadways and fill drainage channels. Sediments can damage fish habitat and degrade water quality in streams, rivers, and lakes. Blowing dust can affect human health and create public safety hazards (USDA 1999). Rift Valley of Oromia is home for human-being, many different birds, fish and other living things. The ecology includes different lakes, national parks, towns, conventional and irrigation farm lands, grazing land, settlement area, flower industry, escarpments following the valley, etc. Beyond these factors, the soils of the area are made from volcanic, Andosols. These soils are more susceptible to erosion than any other type of soils in the region. Hence, assessing the severity level of erosion in the study area is very crucial to address priority areas and future research plan.

MATERIALS AND METHOD

Descriptions of the Study area

The study was conducted in purposively selected districts of East Showa (Adama and Lume districts) and West Arsi zones (Shashemene and Kofole districts) of the central rift valley of Oromia, Ethiopia. Adama and Lume districts are found in lowland areas of similar agro climate that are characterized by agropastoral farming system. On the other hand, Shashemene and kofole represent the highland and mid altitude agro climate that are also characterized by mixed or agro pastoral farming system.

Methods of data collection

Field research on the assessment of soil erosion problem, farmer's response against soil erosion problem and soil fertility management strategy was carried out using both informal and formal survey methods. All the necessary data required for the study were gathered through a farm household survey. At the beginning stage of the survey, PRA was undertaken with a representative sample of farmers in order to know the general agricultural, social and economic situation of the population of the study area. Also informal meetings with key informants (farmers, experts and development agents) were held to get in-depth knowledge about the area and to pretest the questionnaire. In addition to the informal meeting, transect walks across the village were conducted in order to obtain all the necessary physical information and determine the questions that need to be included in the survey. Generally Four(4)PAs were selected from each district depending on severity of soil erosion problem of in the area. For the detailed personal interviews, a random sampling technique was used to select 10 farmers from each PA. Therefore, 40 farmers were interviewed in each district making it a total of 160 respondents in all districts.

Data Analysis

Finally the data acquired were analyzed using descriptive statistics techniques and cross tabulation with the Statistical Package for Social Sciences (SPSS)-V20 software. In addition, MS-Excel was used to generate graphs

RESULT AND DISCUSSIONS

Trends of land owned by farmers in the selected districts

The change in the land allocated for arable or crop land, grazing land and forest was assessed through the individual interviews of each selected household. The aim is to see the relationship between the change in land size and farmers perception in soil and water conservation activities. This is also important to judge the effect of current raise in population size on land use change that consequently resulted in land degradations.

The land allocated for the agricultural land (crop land)since five years back showed an increasing trend in all study districts. The average land allocated for crop production was increased from 1.32ha to 2.10ha in Adama, from 0.90ha to 1.39 in Kofele, from 1.56 to 2.6ha in Lume and from 1.08ha to 1.26ha in Shashemene districts (see figure).This is may be due to an increased the population growth that forces the farmers to add more agricultural land to maximize the food demand. On the contrary, the change in the land allocated for grazing showed a decreasing trend since five years back in all selected districts. The average land allocated for grazing was decreased from 0.5ha to 0.13ha in Adama, from 0.25ha to 0.12ha in Kofele, from 0.5ha to 0.15ha in Lume and from 0.25ha to 0.13ha in Shashemene districts (see figure 1). This is mainly due to the conversion of previous grazing land to agricultural land to satisfy the food demands of the current increased population size.

On the other hand, the change in the land allocated for forest or plantation showed an increasing trend in all selected districts since five years back. The average land allocated for plantation or forest was increased from 0.0625ha to 0.0681ha in Adama, from 0.15ha to 0.17ha in Kofele, from 0.022ha to 0.10ha in Lume and from 0.0078ha to 0.0141ha in Shashemene districts (see figure 2).

This is mainly due to the current government agenda that encouraged farmers in afforestation and reforestation of degraded land especially since Ethiopian millennium (2000 E.C), farmer's awareness on environmental protection through a forestation of marginal land was increasing.

It was identified that in Ethiopia in general and in Oromia region in particular, where the study conducted, human population showed an increasing trend since 2007. According to the report by the Ethiopian statistical agency’s population census conducted in 2007, human population is increasing with the rate of 2.9% annually in all study districts (see table 1)

The increased in population size is believed to be the main driver for the change in the size of land use and land use types. This also strongly agreed and justified by the previous studies done by Dubale, 2004. According to this study, population size is strongly positively correlated with the land size. In this case, increased in population size in rural areas increase the food demand that become threat to sustainable land management. In order to meet the current increased food demand, farmers are forced to cultivate soils that were previously under grazing and forest cover causing deforestation and consequently environmental degradations. The study added, at present there is more cultivated land in different parts of the country in comparison to the amount cultivated 10 years ago.

Types of soil erosion

Water and wind erosions are the two major types of soil erosion identified in this particular study. This study showed that water erosion is the major problem at all study areas. It is more sever in highland districts of kofele and shashemene where 90% and 77.5% of the farmers respectively are affected by the water erosion problem (table2). The water erosion problem is relatively higher in these districts mainly due to their higher annual rain fall followed by steep topography of the districts as compared with the lowland districts (Lume and Adama). Wind erosion is another source of erosion problem identified in this study though the problem is relatively lower as compared with water erosion.

It was identified that wind erosion is common problem for the districts in the low land areas like in Adama and Lume where it accounts 2.5 % for both. Estimates indicate that 25% of the highland is highly affected by soil erosion due to water where average annual soil loss is 42t/ha/yr (Hurni, 1990).

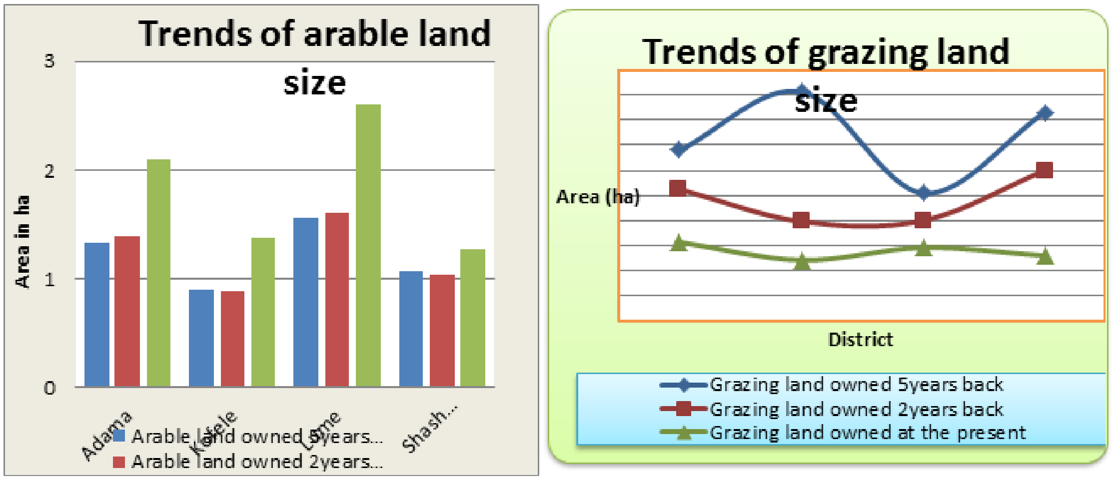

Figure 1. Trends of land allocated for arable and grazing from left to right respectively since 2007.

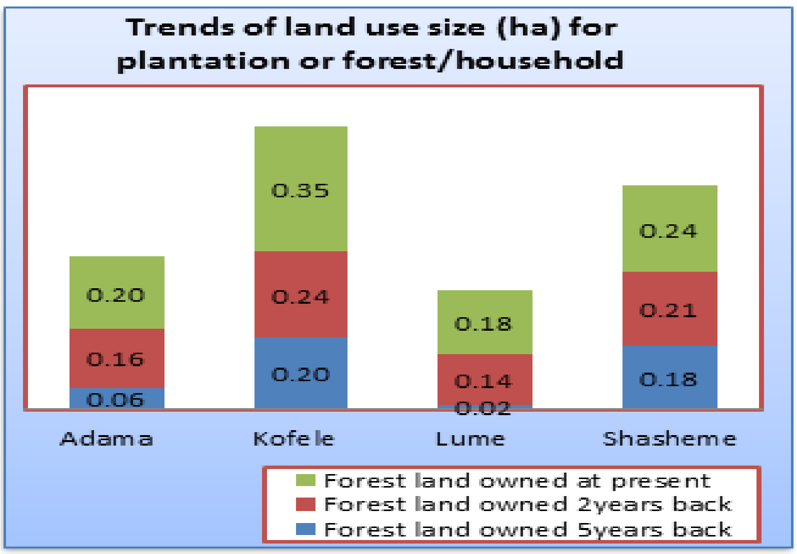

Figure 2. Trend of land allocated for plantation/ha/household since 2007.

Table 1. Trends of human population size since 2007.

Districts	Human Population size		
	2007	2010	2012
Adama	155000	168879.85	178816.9
Kofole	179508	195582.47	207090.74
Lume	116501	126933.36	134402.25
Shashemene	102062	111201.39	117744.59

The study by Tadesse and Belay, 2004 also indicated that, though land provides a means of livelihoods for the majority of the population in Ethiopia, land resources are facing increasing degradation mainly due to water erosion in the form of sheet and rill erosion that has made it difficult to attain food self sufficiency at a national level.

The "Global Assessment of Human induced Soil Degradation" (GLASOD) under the United Nations Environment Program (UNEP and Oldeman, L.R. 1999) states that about one-sixth of the earth's terrestrial surface, including one-third of its agricultural land, is already affected by human-induced soil degradation such

Table 2. Major source of soil erosion in the study area (Number of respondents (N) =40 for each district).

Type of soil erosion	Frequency	Districts			
		Adama	Kofele	Lume	Shashemene
Water erosion	Count (%)	28 (70)	38 (95)	30 (75)	32(80)
Wind erosion	Count (%)	5 (12.5%)	0.0	4 (10.0%)	0.0
Both	Count (%)	3 (7.5%)	0.0	3 (7.5%)	0.0
No erosion	Count (%)	4 (10%)	2 (5%)	3 (7.5%)	8 (20%)

Table 3. Soil degradation processes contributing to continental and global land degradation (%).

	World	Europe	N & C America	South America	Austral-asia	Asia	Africa
Processes							
Erosion by water	55.6	52.3	67.0	50.6	81.0	58.0	46.0
Erosion by wind	27.9	19.3	25.0	17.2	16.0	30.0	38.0
Chemical deterioration	12.2	11.8	4.0	28.8	1.0	10.0	12.0
Physical deterioration	4.2	16.6	4.0	3.4	2.0	2.0	4.0

Source: GLASOD by UNEP, 1999.

Table 4. Major Causes of soil erosion identified in all study area.

Major causes of soil erosion	Frequency	Districts			
		Adama	Kofele	Lume	Shashemene
Deforestation	Count (%)	14 (35%)	5 (12.5%)	15 (37.5%)	10 (25.0%)
Steep slope	Count (%)	4 (10%)	20 (45%)	5 (12.5%)	7 (17.5%)
Heavy rainfall	Count (%)	8 (20%)	10 (30%)	10 (25.0%)	15 (37.5%)
Diversion	Count (%)	6 (15%)	2 (5%)	5 (12.5%)	5 (12.5%)
Soil characteristics	Count (%)	8 (20%)	3 (7.5%)	5 (12.5%)	3 (7.5%)

as water erosion, wind erosion, chemical and physical degradation. According to Oldeman et al. 1999), in Africa 46% of all human-induced soil degradation resulted due to soil erosion by water, and 28% from wind erosion (table 3).

Major Causes of Soil Erosion

Soil degradation is one of the major environmental problems in Ethiopia, which manifests itself mainly in the form of land on which the soil layer has been eroded away and nutrients have been continuously extracted with little or no any replenishment. Major causes of soil erosion in this particular study area were identified. Accordingly, deforestation or land degradation, heavy rainfall, steep slopes, diversion from the upper catchment and soil characteristics are some of the causes for the soil erosion problem. The magnitude of the causes varies between the districts (See table 4).Deforestation and heavy rainfall are the two major causes of soil erosion in Adama, Lume and shashemene districts. Topography or steep slope and heavy rainfall are the other major causes of soil erosion in Kofole district. Previous study by Hurni, 1988, 1989 suggested that, soil erosion is not a new phenomenon in Ethiopia rather it is a process as old as the history of agriculture in the country. This process has been accelerated by population growth that has brought with it more deforestation. With the increase of population pressure, development of agricultural production involves an increased risk of land degradation through deforestation and expansion to new marginal lands that are often fragile and susceptible to erosion. The process of erosion is further aggravated by the intensity of the rainfall and topography where 70% of the highlands having slopes in excess of 30% that favor severe soil erosion once the vegetation is reduced (Gronvall, 1995).

Severity of erosion

For these specific study the degree of erosion according to farmers perceptions were grouped as high, medium,

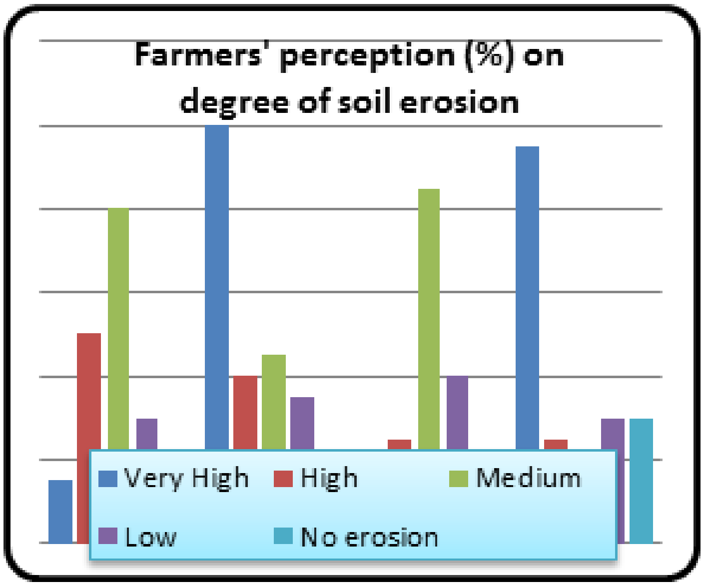

Fig 3. Farmers Perception on degree of erosion on their arable land.

low and no erosion. Figure 3 shows that high number of respondents on all districts responded as the degree of erosion on their arable lands as medium. Very high erosion is reported at Kofele which can be associated with high steep slope and high rainfall of the area. High Erosion is reported mainly in both Adama and kofele. At Adama these high erosion is associated with high slope. A small portion of respondents responded as they don't have erosion problems on their arable land

Soil and Water Conservation Activities

Despite the severity of soil erosion problem however, it is only recently that soil and water conservation has received political attention in Ethiopia. Since the 1960s, various conservation strategies have been introduced to enhance agricultural development and rural livelihoods (Kelly and Scoones, 2000). Recognizing land degradation as a major environmental and socio-economic problem, the government of Ethiopia has made several interventions. As a result, large areas have been covered with terraces, soil bunds, area closures and millions of trees have been planted especially since the Ethiopian millennium (2007).

Physical soil and water conservation measures

Moisture conservation is the primary purpose of SWC practices in arid and semi-arid areas. In contrast to sub-humid areas, the most important aspect in drier areas is water retention and water storage on cropland. Furthermore, the same technologies help to reduce soil erosion in highland areas where there is heavy rain fall. On sloping high lands, graded contour bunds or terraces reduce runoff velocity and extend the time span for water to infiltrate into the soil system. In addition, it also provides safe drainage during extreme storms. On flat slopes, level bunds and smaller micro basins are important to increase water infiltration especially in water stressed areas. The study by Bekele W and Drake L, 2003 also indicated that, rain water harvesting on farm lands through construction of variety of physical structures can raise the level of moisture in the soil ensuring better crop growth and crop production.

The assessments showed that, Even though the government intension is high, farmers' use of different physical soil and water conservation structures to tackle the soil erosion problems on their land holdings is limited. It was identified that soil bund, cutoff drain and micro basins are the physical soil and water conservation measures used by the farmers. From the total number of respondents on average 23% of the respondents practice cutoff drains followed by Soil bund which is 20% and Micro basin is only practiced by 2.03% of respondents. Micro basin is the least practiced conservation measures (table 5). Only 3% and 5% of the respondents in Adama and Lume districts respectively have experienced using the micro basin as soil and water conservation measures. Development agents and others, including NGO's and neighboring farmers are the source of information about the use of these physical soil and water conservation measures.

Biological soil and water conservation measures

Organic fertilizers such as animal manures, green manure, and compost are likely to not only provide plant nutrients but also increase soil organic matter and reduce

Table 5. Major physical soil and water conservation activities practiced by farmer Number of respondents (N) =40 for each district.

Type of physical SWC	Source of information about SWC in all the districts (%)			Frequency of farmers practicing the physical SWC (Count (%))			
	DA	NGO and others	No info	**Adama**	**Kofele**	**Lume**	**Shashemene**
Soil bund	41	20.5	37.5	25 (62.5)	27 (67.5)	24 (70)	20 (55)
Micro basin	2.5	3.4	93.1	3 (7.5)	2(5)	5 (12.5)	0(0)
Cutoff drains	20	31.9	48.1	21 (52.5)	25 (62.5)	31 (77.5)	25 (62.5)

Table 6. Major biological soil and water conservation activities practiced by farmers.

Districts*	Frequency	Biological Soil fertility management strategies						
		Using compost	**Using animal manure**	**Crop rotation**	**Crop residue**	**Inter cropping**	**Fallowing**	**Live fencing**
Adama	Count (%)	16(40)	31 (77.5)	5 (12.5)	35(87.5)	8 (20)	0(0)	14 (35)
Kofele	Count (%)	12 (30)	37 (92.5)	40 (100)	23 (57.5)	3 (7.5)	23 (57.5)	28 (70)
Lume	Count (%)	24 (60)	35 (87.5)	36 (90)	11 (27.5)	10 (25)	2 (5)	24 (60)
Shashemene	Count (%)	19(47.5)	36 (90)	40 (100)	12 (30)	11 (27.5)	5 (12.5)	21 (52.5)
Total from all the districts*	Count (%)	71(44.4)	139(86.9)	151(94.4)	51(31.9)	32 (20)	30(18.8)	87(54.4)

*Total number of respondent (N) = 40 for each district.

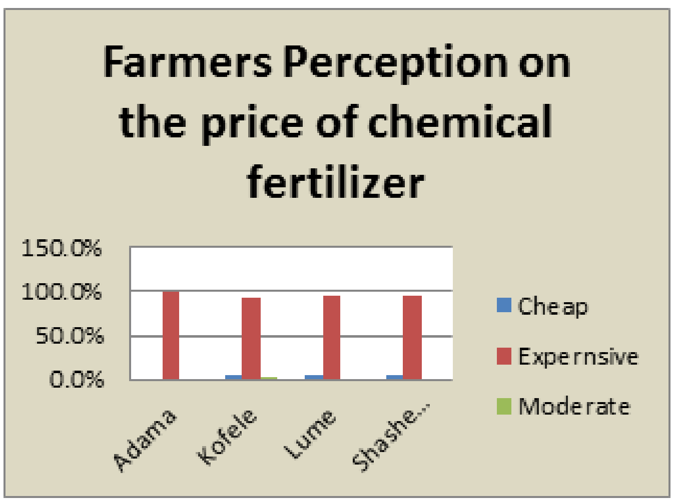

Fig 4. Farmers Perception on the price of chemical fertilizers.

erosion (Stombaugh and Shearer, 2000). The study by Nyakataw et al. (2000) also found that applications of animal manure promoted good emergence, vigorous growth, and high yields of cotton and helped control erosion in Alabama. The return of plant residues serves a similar purpose and may be especially important in developing countries where little fertilizer is used. Kayuki and Wortmann (2001) suggest that plants from hedgerows and other areas can provide green manure for Ugandan soils and others that contain little organic matter. In the study about seven different biological soil and water conservation measures that farmers are using are identified. These include; using of compost, animal manure, crop rotation, crop residues, inter cropping, fallowing and live fencing. The biological conservation measures generally aimed to improve soil fertility that consequently helps to reduce soil erosion. About 87% of the respondents depend on animal manure, 94.4% on crop rotation and 54.4 % on life fencing as the major strategy to improve soil fertility in all districts (table 6). On

Table 7. Farmers soil fertility indicators (Total number of respondents (N) = 40 for each district).

Districts*	Frequency	Farmers soil fertility status indicators				
		color	Soil type	Yield response	Vegetation cover	topography
Adama	Count (%)	11(27.5)	3 (7.5)	39 (97.5)	6(15)	15(37.5)
Kofele	Count (%)	26 (65)	8 (20)	39 (97.5)	20 (50)	15 (37.5)
Lume	Count (%)	15 (37.5)	10 (25)	39 (97.5)	12 (30)	18 (45)
Shashemene	Count (%)	27(67.5)	18 (45)	39 (97.5)	10 (50)	19 (47.5)
Total	Count (%)	79(49.4)	39(24.4)	156(97.5)	58(36.3)	67 (41.9)

the other hand, compost (44.4%), intercropping (20%) and fallowing (18.8%) are the least soil fertility management strategies practiced by farmers.

Farmers' use of chemical fertilizer

The study shows that chemical fertilizer is perceived to be expensive for more than 92% of the respondents or farmers (figure 4). However, all the farmers in all study area depend on chemical fertilizers, both UREA and DAP. This is mainly due to lack of any other alternatives that replace the chemical fertilizers. On the other hand, farmers' perception on the importance of compost to increase yield is very low in all districts. Only 22.5%, 12.5%, 12.5 and 15% of the farmers in Adama, Kofole, Lume and Shashemene respectively responded as compost can increase yield (table 6).

Indicators of soil fertility status

Farmers through their lifelong experiences have their own indicators for classifying the fertility status of soil on their land holdings. These indicators help farmers in their choices for soil fertility improvement techniques, productions and soil and water conservation (Ingrid, 2000). In the study area the major indicators identified are yield response, color, soil type, vegetation cover and topography (Table7). Accordingly, yield response 97.5% was found as the main indicator followed by soil color 49.4%, topography 41.9%, vegetation cover 36.3 and finally soil type 24.4% respectively. The study across districts also shows yield response as main indicator in all district and as the use of these indicators is relatively low at Adama and high at shashemenne.

CONCLUSIONS

Increased in population size in all study districts is the main driver for the increased agricultural land through conversion of grazing land and other marginal land that consequently accelerated human induced soil erosion. Deforestations (as a result of population pressure) followed by Erratic heavy rain fall and steep landscape are the major causes of soil erosion problems in all study areas. Soil bunding, cutoff drains and micro basins are the physical soil and water conservation measures used by the farmers. However, the number of farmers practicing physical SWC measures is very low in relative to soil erosion problems in the study areas. This is mainly due to lack of information or training on SWC practices for the farmers. It was identifies that farmers use different indicators to identify the fertility status of their land holdings which are yield response, color, soil type, vegetation cover and topography. The biological SWC measures aimed to improve soil fertility that consequently helps to reduce soil erosion. It was identified that biological SWC measures are the most commonly used by farmers to improve soil fertility. About 93.8% of the respondents used crop rotation, 85% animal manure, and 54.4 % used life fencing as the major strategy to improve soil fertility in all districts.
Even though the price of chemical fertilizer is perceived to be expensive, more than 90% of the respondents depend on it to increase production. This is because farmers' perception on use, importance of Organic fertilizer is very low in all study districts.

Recommendations

Based on the findings of the study the following recommendations are given since one of the biggest problem of farmers related with soil and water conservation is knowledge gap, regularly training and demonstrating different SWC and soil fertility improvement activities to the farmers are the core issues to be considered for sustainable NRM
Afforestation programs should be implemented in all the districts to reduce erosions resulted from deforestation in the upper catchments participatory soil and water conservation mechanisms involving farmers should be implemented taking into consideration farmers' decision on type of conservation and site selections to decide where to implement the conservation activity is important to make the SWC activities more fruitful and sustainable
There should be strong linkage between research and other organizations (Government & NGOs) to transfer better experiences and technologies in SWC
This result may vary with time and place. Therefore, this activity should be repeated at least every five years to evaluate and monitor the dynamics or trends of change in land use type, land use size and SWC activities

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