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Soil degradation extent and dynamics of soil fertility improvement technologies In Majete Watershed, North Ethiopia

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Soil degradation is among the serious environmental hazards of this generation. It is threatening agricultural production and leads to food insecurity. The objective of this study is to assess current soil degradation status and soil fertility enhancement technologies practiced by the land owners. Data were obtained through questionnaires administered to 156 respondents selected randomly from all watershed classification schemes (upstream, mid-land, and downstream). Field observations, interviews and discussions with village elders, farmers groups, and village scholars were conducted using a check list of topics focusing on soil degradation, and attempts were made to combat the problem. The result revealed that 70% of farmers experienced soil degradation on their farm land and also crop productivity decreased from time to time. Productivity cannot be boosted without intensive fertilizer application. Most farmers (>64%) mentioned steep slope, high rainfall, deforestation and poor soil cover as the major causes to soil degradation. Soil fertility amelioration measures like application of compost, construction of terraces, farmyard manure, fallowing, the protection of regenerating natural vegetation, and tree planting were practiced but adoption level of technologies from farmer to farmer is entirely dependent on their awareness level. Simple soil conservation technologies which are easily adopted by farmers should be available. Above all, education infrastructure focusing on soil conservation should be available for land owners.

Key words: Soil degradation, soil fertility, soil fertility amelioration.

INTRODUCTION

Soil degradation is one of the most severe global environmental problems of this generation (Adugna et al., 2015; Antonio, 2016; Meseret, 2016). Even though degradation status is different from place to place, it is touching every corner of the world (Ouyang et al., 2018; Pimentel and Burgess, 2013; Raiesi, 2017; Vanwalleghem et al., 2017). This worldwide depletion of soil resources continues to be a serious hazard, particularly, in the least developing countries, where agriculture is the main pillar of their economy (Ayalew, 2011; Kassa et al., 2013; Pimentel and Burgess, 2013; Vlek and Denich, 2012; Zhu, 2014). It is threatening their

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survival on this planet as well as national prosperity.

Soil degradation in the Eastern African highlands is manifested mainly in the form of soil erosion, gully formation, soil fertility loss, with a consequence of reductions in crop yield (Gashaw et al., 2014; Meseret, 2016). Even though Ethiopia (largest country in east Africa) is endowed with an enormous land resource potential, agricultural production is held back by land degradation (Adugna et al., 2015; Beyene, 2011; Esser and Haile, 2002; Zegeye, 2009). As it is indicated in many research works, land degradation in Ethiopia has started with the history of the country's agriculture (Adugna et al., 2015; Beyene, 2011; Kassa et al., 2013). It is highly affecting the livelihood of the rural people as well as the economy of the nation.

Ethiopians have a long history of efforts to combat soil degradation and associated land degradation problem. Governments and development agencies have invested substantial resources in promoting soil conservation practices as part of their efforts to improve environmental conditions and ensure sustainable agricultural production (Antonio, 2016; Ayalew, 2011; Birhanu and Meseret, 2013; Esser and Haile, 2002; Kassa et al., 2013). Even if various soil and water conservation interventions have been introduced, land degradation in the form of soil erosion and soil fertility loss has continued to be a serious problem in Ethiopia (Pimentel and Burgess, 2013), and with continued population growth, it is more likely to be even more severe in the future. Since the country's development is totally dependent on its land resources, the loss of productivity due to degradation has serious implication on social and economic development endeavors (Ayalew, 2011; Birhanu and Meseret, 2013; Kassa et al., 2013; Teklewold and Köhlin, 2010). As a result of this extensive land degradation, which in turn is caused by various intermingled factors, soil productivity has been negatively affected and agricultural production has not been able to meet the basic food requirements of the growing population (Kassa et al., 2013; Pimentel and Burgess, 2013). This has significantly contributed to the hunger faced by some five to seven million people in the country, thereby requiring external assistance every year for their survival and more than 45% of the total population to fall below the absolute poverty line (Kassa et al., 2013).

In the study area (North Ethiopia), despite many externally introduced soil fertility technologies, crop production is getting low and livelihoods of local communities are under risk (Adimassu et al., 2013; Meseret and Amsalu, 2017; Thiemann et al., 2005). Several reasons contribute to the inefficiency of soil conservation effects. Most of the time, the extension approach is top to down and command type. Such command and control type of policies that have not been linked to the indigenous land conservation knowledge of the farmers as well as their local institutions made the people to have limited sense of responsibility over the assets created. In addition, inefficiency of early introduced soil conservation and fertility maintenance technologies is observed here and there. The objective of this study is to assess current soil degradation status, soil conservation and fertility enhancement technologies practiced by the land owners.

RESEARCH METHODS

Description of the study area

The study area is located in the North part of Ethiopia. This mountainous area is one of the most severely eroded parts of the Ethiopian highland. The common land use types of the watershed are mainly agricultural (crop) land, forest land and grazing land. The study watershed detailed characteristics are shown in Table 1.

Agriculture in the area is characterized by small-scale subsistence mixed farming-system, with livestock production as an integral part. Crop production is mainly rain-feed. Almost all of the cropland is planted to annual food crops, including cereals (maize, sorghum, barley, wheat, teff), pulses (beans, soybeans), and root crop (potatoes). The absence of irrigation infrastructure makes vegetable production nil.

Land and soil degradation, reoccurring drought, small farm plots, high population density and agricultural input shortage including improved animal and seed variety are the major agricultural problems of the study area. These agricultural production problems are aggravated with poor delivery of research technology and extension support. Cash income for household financial requirements is mainly generated from sales of livestock and crop products. Households face seasonal food shortage and seek food aid from government and good will organizations.

Sampling and data collection

Watershed classification scheme (upstream, mid land and downstream) was used as units for sampling. Representative samples were selected proportionally from each category with the help of district agricultural officers who have extensive experience and knowledge of the area. Sample size varied from among three sampling place based on their population. Data were obtained through structured questionnaires administered to 156 respondents selected randomly from all watershed classes. The questionnaire was prepared, tested, and amended to fulfill the objectives of the present study. It was intended to gather information about the extent of soil degradation, type of soil conservation and fertility maintenance. Data were also generated by interviewing local agricultural technology extension officers. In addition, field observations and a number of discussions with village elders, farmers groups, and village scholars were conducted using a check list of topics to guide the sessions. Data collected during observation and group discussions were used to crosscheck and verify data acquired via questioners and interview. All quantitative data were grouped, organized and analyzed using excel software.

RESULTS AND DISCUSSION

Landowners' outlook regarding soil degradation, its cause and consequence

Whenever we strive to combat environmental degradation, it is quite important to understand local

Table 1. Major bio-physical and socio-economic characteristic of study watershed.

Characteristics	Study watershed
Area (ha)	10, 500
Topography	Steep to very steep
Mean elevation (m)	2112
Annual rainfall (mm)	1923
Temperature (°C)	Max. 32°C, Min. 21°C
Agricultural Land (%)	65
Area under soil erosion by water (%)	70
Major soil erosion process	Rill, gullies
Farming system	Mixed farming
Major crops' grown	Barley, pea and wheat
Fertility status	Very low
Food Security condition	Insecure
Average land size per households (ha)	0.25
Total number of farmers	34, 000
Dominant tree species	Several native species

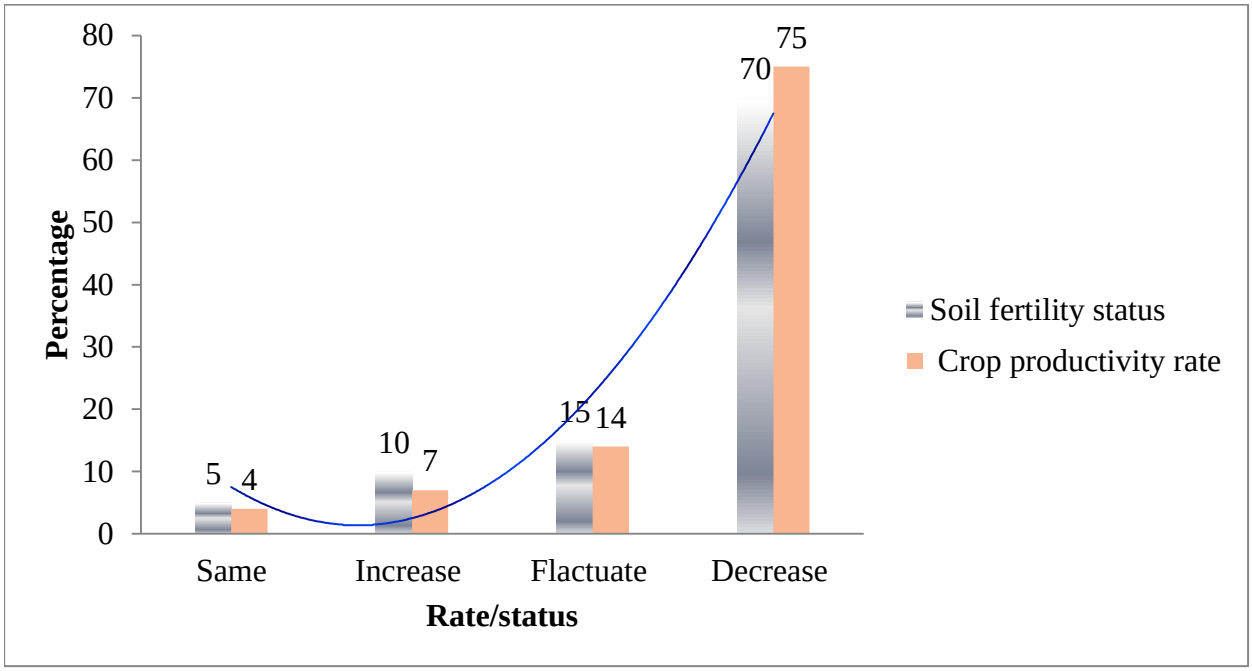

Figure 1. Land owners' view regarding soil fertility and crop productivity.

communities' awareness of the problem. It is easy to mobilize awareness societies to eliminate common problems. In the same fashion, soil fertility maintenance is not just the responsibility of a certain individual rather it needs collective effort of all awareness communities. This research revealed that 70% of farmers experienced soil degradation on their farm land (Figure 1). Though farmers are unable to understand chemical, physical and biological soil degradation separately, they can explain degradation as inability of land to give high crop yield. Farmers were more aware of physical soil degradation forms like gullies, rills and land slide. More than 75% of the farmers reported that decline of crop productivity is a result of soil fertility reduction. Very small portion of the society believes that their farm land soil fertility is same from time to time, but that might happen for farmers using fertilizer every year. Another small portion of the society reported fluctuation of soil fertility and crop productivity

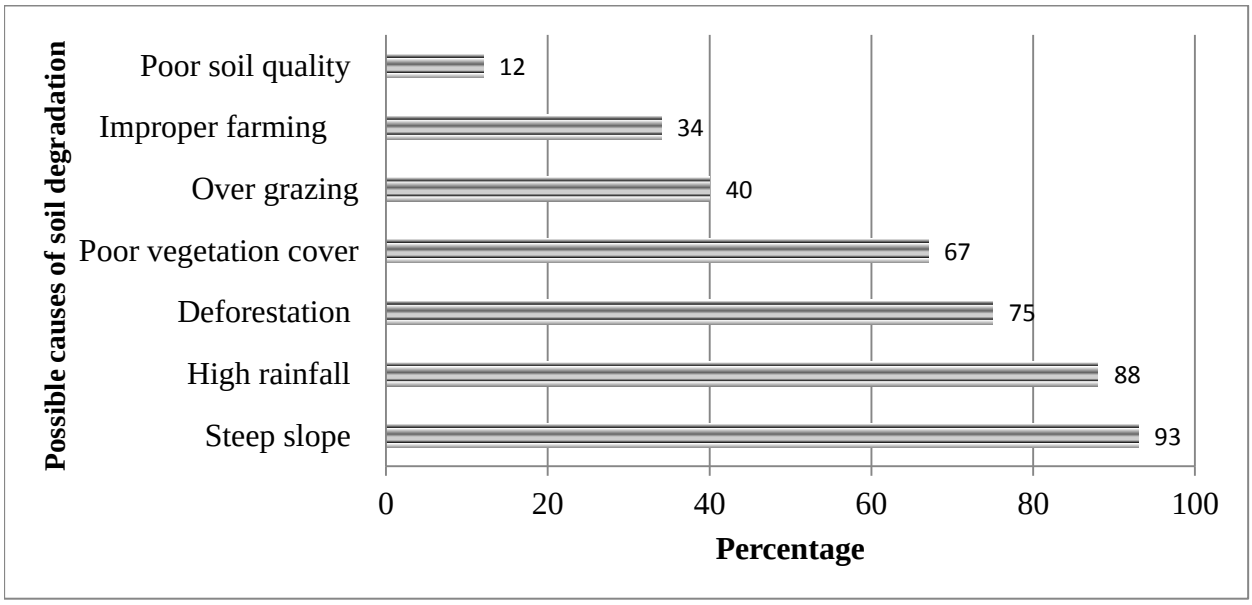

Figure 2. Perceived causes of soil degradation.

which is entirely dependent on their fertilizer application trend. Their farm land soil fertility and crop productivity is getting high when they apply fertilizer and the reverse is happening during free sowing due to financial stress to afford fertilizer. In addition, another small portion of the society believed that the increment of soil fertility and crop productivity happens because of the increased use of fertilizer from time to time. In conclusion, soil fertility is a crucial factor for crop productivity (Figure 1). Soil fertility boosts crop and the productivity might increase.

The highest number of farmers reporting an awareness of soil degradation on their fields was in upstream land, followed by mid land. This is in line with what can be observed in the field. Several erosion features such as rills and gullies are easily observed and denser in upstream and mid land classes. These classes are mostly covered by mountains and receive erratic rain fall which are key contributors to severe degradation. Another vital explanation for the observed soil erosion in these ecologies could probably be due to intensive cultivation; as a result livelihood of people living in highland is hampered by soil degradation. Downstream area communities are slightly vulnerable to soil degradation like erosion but severely affected by flood and sedimentation emanating from high land and mid land. From this point, we can understand that soil degradation type and status are different across altitude. Different soil degradation measures are required for different agro ecologies.

Most farmers mentioned steep slope, high rainfall, deforestation and poor soil cover as the major causes of soil degradation (Figure 2). High land areas in Ethiopia are receiving high rainfall in short period of time and it is likely to be the major reason for soil degradation in the form of erosion. Other causes of soil degradation were overgrazing, improper farming and poor soil quality. Most farmers did not associate later causes with the on-going soil degradation. The result revealed that land owners do not know the role of poor geological material and soil quality for soil degradation.

Applied soil fertility maintenance measures

For centuries, communities have been carrying out soil fertility maintenance measures. Soil fertility amelioration measures that have been used to date include the application of compost, construction of terraces, farmyard manure, fallowing, the protection of regenerating natural vegetation, and tree planting (Figure 3). The biggest challenge is technology low adoption level of communities; some are eager to start and adopt certain soil fertility maintenance technology but others are stagnant to change.

The results indicate that only terrace was the most widely used measures to augment soil fertility. A significant proportion of farmers are none adopters of almost all soil fertility maintenance technologies. Soil fertility management practices like, compost, land resting and nitrogen fixing trees are not adopted by the society though they are vital technologies. Recently introduced soil fertility maintenance strategies like conservation farming and organic farming were given moderate attention by many farmers. In general, the adopters of all soil fertility management technologies are far behind non adopters but the reverse is the case. Despite the efforts

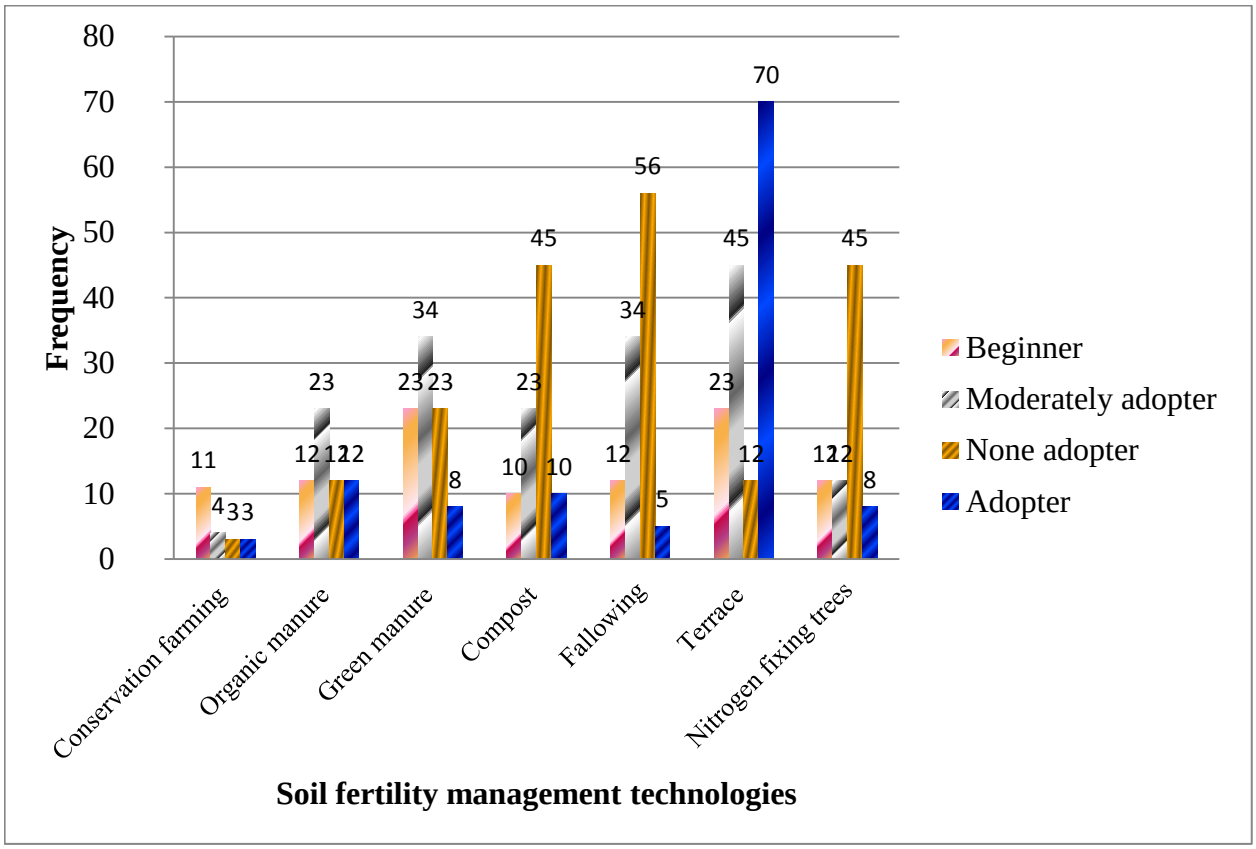

Figure 3. Soil fertility management technologies and adoption level.

that have been made to conserve as well as restore soil fertility of arable lands, soil degradation is proceeding so fast nowadays that it can constraint the hope of achieving sustainable agriculture in the foreseeable future.

Factors for deny soil fertility management technologies

Farmers listed several constraints encountered when starting to use soil fertility management technologies. The main constraints were illiteracy, lack of support from the government and technology attributes (Figure 4). In the study area, the soil fertility management technologies under implementation were physical structures (terrace), nitrogen fixing trees, compost, farm yard manure, conservation farming and organic manure. Of these, farmers were more willing to adopt terrace due to high awareness campaign by both government and development agencies regarding compacting soil erosion using terrace. Among the constraints explained by farmers, tenure security, lack of equipment and unavailability of nitrogen fixing trees seedling are moderate constraints of soil fertility management. Farmers give less attention to labor because of high unemployed youths in the district. In general, complexity of technology, illiteracy and inability of government to support farmers are primary constraints of soil fertility management technologies.

Conclusion

Worldwide depletion of soil resources continues to be a serious environmental hazard. It is threatening poor nation's survival on this planet through hampering their agriculture. This research revealed that almost all farmers experienced soil degradation on their farm land. Farmers were more aware of physical soil degradation forms like gullies, rills and land slide. More than 75% of farmers reported that decline of crop productivity is a result of soil fertility reduction. Most farmers mentioned steep slope, high rainfall, deforestation and poor soil cover as the major causes to soil degradation. High land areas are receiving high rainfall in short period of time and it is likely to be the major reason for soil degradation in the form of erosion. Soil fertility amelioration measures that have been used include the application of compost, construction of terraces, farmyard manure, fallowing, the protection of regenerating natural vegetation, and tree

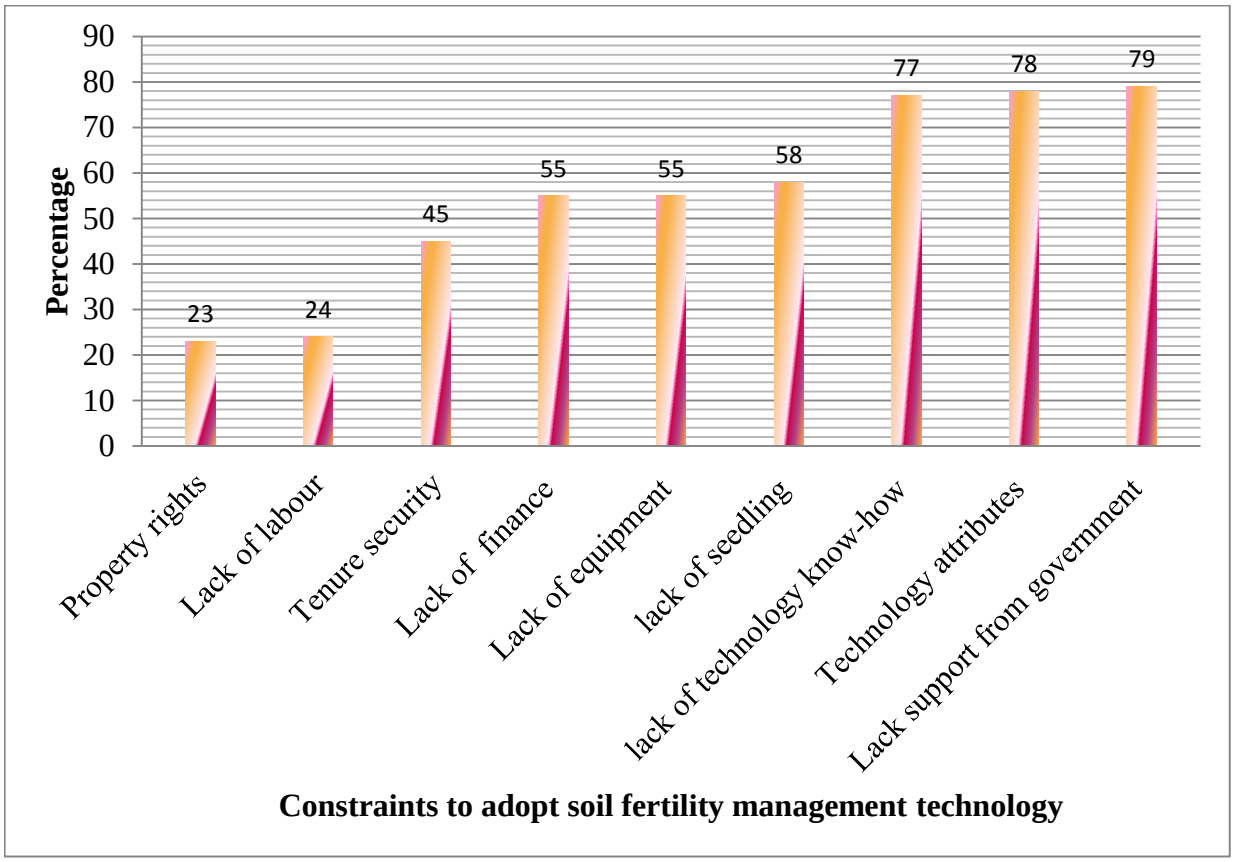

Figure 4. Constraints to adopt soil fertility management technologies.

planting. The biggest challenge in soil fertility management is low technology adoption capacity of some land owners. Awareness creation campaign and education should be available for land owners regarding soil conservation as well as natural resource conservation. Among opportunities available on hand to overcome awareness problem, non-governmental organizations experts can be used profitably as consultants to environment authorities and can also be used as teachers in public awareness programs for the community.

CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

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