EFFECT OF BIOLOGICAL SOIL AND WATER CONSERVATION ON DEGRADED SOIL AND FARMERS' PERCEPTION ON LAND MANAGEMENT PRACTICES. A CASE OF LEMO WOREDA, SOUTHERN ETHIOPIA

M.Sc. THESIS

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M.Sc. THESIS

Submitted to the School of Graduate Studies, Jimma University, College of Agriculture and Veterinary Medicine Department of Natural Resource Management in Partial Fulfillment of the Requirements for the Degree of Master of Science (M.Sc.) in Integrated Watershed Management

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APPROVAL SHEET

SCHOOL OF GRADUATE STUDIES

As thesis research advisors, we hereby certify that we have read and evaluated this thesis entitled "Effect of Biological Soil and Water Conservation on Degraded Soil and Farmers′ Perception on Land Management Practices. A case of Lemo Woreda, Southern Ethiopia" is prepared under our guidance by Tamrat Sinore Dalkaso. We recommend that it be submitted as fulfilling the thesis requirements.

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As member of the Board of Examiners of the M.Sc. Thesis Open Defense Examination, we certify that we have read, evaluated the thesis prepared by Tamrat Sinore and examined the candidate. We recommended that the Thesis be accepted as fulfilling the thesis requirement for the Degree of Master of Science in **Integrated Watershed Management.**

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DEDICATION

To my father Sinore Dalkaso and mother Abebech Abose for their all-rounded and unconditional support in my life.

STATEMENT OF AUTHOR

First, I declare that this thesis is my own work and that all sources of materials used for thesis have been duly acknowledged. This thesis has been submitted in partial fulfillment of the requirements for M.Sc. degree at Jimma University, College of Agriculture and Veterinary Medicine and is deposited at the University library to be made available to users under rules of the library. I solemnly declare that this thesis is not submitted to any other institution anywhere for the award of any academic degree, diploma, or certificate.

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BIOGRAPHICAL SKETCH

The Author, Tamrat Sinore, was born on 9th of May 1989 in Soro Woreda of Hadiya Zone, Southern Ethiopia. He attained his junior elementary school at Gimbichu Junior and Secondary School (1996 to 2003), and his secondary school at Gimbichu comprehensive secondary school from 2004 to 2007. He then joined Hawassa University Wondo Genet College of Forestry and Natural Resource in 2007/2008 and awarded B.Sc. in Natural Resource Management in 2010/11. After graduation, he was employed in Bureau of Agriculture and Rural Development as a Soil and Water Conservation Expert in Gombora Woreda of Hadiya Zone until he joined the School of Graduate Studies at Jimma University, College of Agriculture and Veterinary Medicine in September 2014 to pursue his M.Sc. degree in Natural Resource Management specialization in Integrated Watershed Management.

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LIST OF ACRONYMS

AAS	Atomic Absorption Spectrophotometer
ANOVA	Analysis of Variance
B.D	Bulk Density
CEC	Cation Exchange Capacity
CSA	Central Statistics Agency
DA	Development Agent
DM	Dry Matter
EfD	Environment for Development
EIAR	Ethiopian Institute of Agricultural Research
FAO	Food and Agricultural Organization
FGD	Focus Group Discussion
ICCD	International Committee on Science and Technology Desertification
JUCAVM	Jimma University College of Agriculture and Veterinary Medicine
LWARDO	Lemo Woreda Agricultural and Rural Development Office
m a.s.l	Meter Above Sea Level
MERET	Managing Environmental Resource Enable to Transformation
MoA	Ministry of Agriculture
NGO	Non-Governmental Organization
SAS	Statistical Analysis System
SNNPR	Southern Nations Nationalities and Peoples Regional State
SPSS	Statistical Package for Social Science.
SWC	Soil and Water Conservation
TLU	Tropical Livestock Unit
WFP	World Food Program
WOCAT	World Overview of Conservation Approaches and Technologies

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ABSTRACT

Land degradation in the forms of soil erosion is one of the major ecological and agricultural challenges in Ethiopia. To overcome this challenge various SWC practices (physical, biological and integration of both) are undertaken in different parts of the country, including Hadiya Zone. However, the effects of SWC practices particularly sesbania (S.sesbania) and elephant grass (P.purpureum) on soil properties are not well understood in Hadiya Zone Lemo Woreda. Therefore, this study was to assess the effects of sesbania and elephant grass on selected soil physicochemical properties, and farmers' perception on the uses of these practices. To achieve the objectives; soil samples (0-30 cm) were randomly collected from both lands treated with sesbania and elephant grass with four replications. Similarly, samples were collected from the adjacent degraded grazing land as control. The collected samples were analyzed for soil particle size distribution (texture), moisture content, bulk density, pH, EC, CEC, OC, TN, Av.P and exchangeable bases (K^+, Na^+, Ca^{2+}, Mg^{2+}) following soil laboratory standards. Whereas, information on farmers′ perception on sesbania and elephant grass use for SWC was assessed through structured questioner survey, FGD and Key informant. Cochran's, 1977 formula was used to determine household sample sizes. Accordingly, 117households were selected for this study. Significant difference of the selected soil physico-chemical properties between the land treated by sesbania, elephant grass and degraded grazing were analyzed using LSD test whereas, farmers' perception on the uses of sesbania and elephant grass for SWC was assessed by chi-square test. In addition logistic regression model used to assess farmers' perception determinants on soil conservation practices. The ANOVA result revealed that the adjacent degraded grazing land had significant ($p<0.05$) difference in clay%, silt%, SMC%, BD(g/cm^3),pH, EC(dS/m), Av.P(ppm), CEC (meq/100g) and Exchangeable bases(K^+, Na^+, Ca^{2+}, Mg^{2+}) compared to sesbania and elephant grass treated land. However, there was no significant difference on the sesbania and elephant grasses. In addition to this, there was highly significant ($p<0.05$) difference in OC% and TN% among sesbania, elephant grasses and adjacent grazing land. The highest OC% and TN% were observed under sesbania. Whereas, sand% had non-significant ($p>0.5$) difference among sesbania, elephant and degraded grazing land. Socioeconomic survey result showed that 82.9% of the respondents perceived sesbania and elephant grass has effects on soil physicochemical properties while 17.1% did not understood effects of the practices on the soil. From the total respondents (82.9%) perceived that these biological conservation improved soil physicochemical properties, the contribution of degraded land managed by sesbania and elephant grass were 52.1% and 30.8% of the respondents respectively. Regarding the socioeconomic uses of sesbania and elephant grass, 99.1% of the respondents perceived the sesbania and elephant grass has socioeconomic benefits. Age, education level and access to SWC extension services were significantly ($P\leq 0.1$) affects the farmers′ perception on sesbania and elephant grasses practices in the study area. The community gets benefit from these plants maybe resulted for local community to develop a positive attitude towards sesbania and elephant grass. Generally, sesbania and elephant grass has a great contribution on soil physicochemical properties improvement in the study area. Therefore, expanding sesbania and elephant grasses in to other degraded watersheds is better option for soil physicochemical property improvement with considering farmers perception.

***Keywords**: Soil Erosion, Biological SWC, Sesbania, Elephant Grass and Farmers Perception*

1. INTRODUCTION

Land degradation is a severe problem across sub-Saharan Africa, and Ethiopia is among the most affected country (Abiy, 2008; Holden *et al*., 2005). In Africa alone, it is estimated that 5 to 6 million hectares of productive land affected by water erosion each year (Stocking and Niamh, 2000). According to Mulugeta and Karl (2010), water erosion is the most threatening land degradation processes in the world and accounts for 56% of the total degraded land surface of the world. Land degradation is in the form of soil erosion and declining fertility is a serious challenge to agricultural productivity and economic growth in Ethiopia (Mulugeta, 2004). The productive land in Ethiopia in general and Southern (SNNPR) in particular has been seriously threatened by land degradation, which menacing both the economic and survival of the people (Genene and Abiy, 2014). Girma (2001) reported that due to high population pressure, continuous and steep slope cultivation, low vegetation cover, deforestation and inadequate soil conservation practices, about 1.5 billion metric tons of topsoil lost from Ethiopian highlands. Pender *et al*., (2001) reported that in Ethiopian high lands soil erosion has contributed to low agricultural productivity, food insecurity, extreme poverty and hunger, as evidenced by recurrent problems of famine and incomes.

Soil erosion is a major part of land degradation that affects the physical and chemical properties of soils and resulting in on-site nutrient loss and off-site sedimentation of water resources in Ethiopia (Hurni, 1993). Some of the farming practices within the highlands also encourage soil erosion. Rapid land use change due to intensive agricultural practices in the Ethiopian highlands results in increasing rates of soil erosion (Haregeweyn *et al.,* 2005; Tsegaye *et al.,* 2012). This has resulted in Agricultural yield reduction, fertility reduction and food insecurity in Ethiopia in general and particularly in the study area.

To combat land degradation at national level, environmental conservation and land rehabilitation efforts are started in 1970s, with particular focus on the fast deteriorating highland areas of Ethiopia (Abinet, 2011). The intention of the interventions is to reduce soil erosion, restore soil fertility, rehabilitate degraded lands, improve microclimate, improve agricultural production and productivity and restore environmental condition (Bewket 2007; Mekuria *et al*., 2007). According to Ayalneh (2004) the issue of resource (soil, water and forest) conservation has been given due attention by the Ethiopian government, its development partners and NGOs. In this regard, the practice of soil and water conservation measures are promising practice in different parts of Ethiopia namely in Tigray (Mitiku and Kindeya, 2001), Wello and Shewa (Tefera, 2001). The major promising physical soil and water conservation measures include construction of bunds, *fanya juu*, check dams, micro-basins and hillside terraces and as well as biological measures include exclosures of degraded land from human and animal interferences, planting of tree seedlings on farmlands, afforestation, and tree plantations around the homesteads and tree plantation in exclosures as enrichment to the natural regeneration (Mekuria *et al.*, 2011). Soil and water conservation interventions are focused on both physical and biological measures (Tamene *et al*., 2006; Babulo *et al*., 2009). Also Habtamu (2006) reported that physical soil and water conservation measures are *fanya juu*, soil bunds, check dams, graded bunds, waterways, and cutoff drains were common practices in Hadiya zone.

Biological soil and water conservation practices such as vegetative barriers, agronomic, alley cropping, grass strip establishment (like elephant grasses, desho grasses and vetiver grasses) in degraded land or in farm land, utilization of farmyard and green manures, and agro-forestry (like Sesbania) measures have been practiced in different parts of Ethiopia (MoA, 2005). For instance, Abay (2011) reported in Gununo area in the Southern Ethiopia the physical soil and water conservation (soil bund, *fanya juu*, cutoff drain,) measures were integrated with biological soil and water conservation measures (Sesbania, Elephant grass, and Banana) improve soil productivity this leads to heal the environment. A study conducted in the Borodo Watershed in the central highlands of Ethiopia by Zenebe *et al*., (2013) shown that soil bunds with sesbania and elephants grass improves soil fertility status in croplands. Increasing soil cover using biological conservation like sesbania and elephants grass and better soil management increases the amount of water that enters the soil and decreases the moisture loss through runoff and evaporation thereby improving soil quality of a given area (Brooks *et al*., 1997). Biological soil and water conservation practices are quick, cheap and lenient method for the rehabilitation of degraded lands (Abinet, 2011). It is believed that the soil resources will be protected from further degradation. In addition, biological SWC practices are important to stabilize the structural practices for long period and cost effective compared with physical soil and water conservation structures (Terefe, 2011).

Throughout history, efforts to combat soil degradation in Ethiopia are focused on physical soil and water conservation structures (Woldeamlak, 2003). Similarly, Temesgen *et al*., (2014a) reported that farmers in Dera Woreda, Ethiopia heavily depend on physical soil and water conservation structures, which have less contribution for the addition of nutrients removed and to control soil erosion as compared to vegetation measures. Temesgen *et al*., (2014b) also reported that practicing of vegetative measures is very much limited. In addition to this, there are limited studies dealing how the biological conservation measures restore degraded lands (Emiru, 2002; Mastewal *et al.*, 2006) and increasing a biomass accumulation (Ermias *et al.*, 2006).

Plantations of sesbania and elephant grasses are also one of the soil and water conservation mechanisms in the degraded land of Lemo Woreda, particularly in *Lisena Sena* kebele. However, the contribution of these selected plant species on the selected soil physicochemical properties by considering farmers′ perception have not been studied in the Lemo Woreda. Therefore, to fill this knowledge gap, the research was conducted on the effect of sesbania and elephant grass on soil fertility status and farmers′ awareness towards these practices. In Ethiopia, where sustainable land management is a priority for the overall development, availability of relevant land management information at all levels is very crucial (Million, 2001). Hence, the findings of this study would be a good reference for Lemo Woreda agricultural officials and other researchers, development agents and stakeholders to design strategies, investment programs and projects that might help farmers in SWC measures and create awareness of better strategies on land management technologies that may help in improving soil fertility status.

1.1. Objectives of the Study

The overall objective of the study was to better understand the influences of sesbania *(Sesbania sesban)* and elephant grass *(Pennisetum purpureum)* on selected degraded soil properties and farmers′ perception on these practices in the study area.

The specific objectives include;

- ✓ To assess the effects of sesbania *(Sesbania sesban)* and elephant grass *(Pennisetum purpureum)* on degraded soil physico-chemical properties in the study area.

- ✓ To assess farmers′ perception on sesbania *(Sesbania sesban)* and elephant grasses *(Pennisetum purpureum)* as soil and water conservation alternatives in the study area.

1.2 Research questions

The following research questions were raised to achieve the designed objectives;

- ✓ Did sesbania and elephant grasses improve soil physicochemical properties in the study area?

- ✓ How did farmers perceive sesbania and elephant grass as a biological SWC measures in the study area?

- ✓ What are the determinant factors for farmer's perception of sesbania and elephant grass as a biological SWC measures in the study area?

2. LITERATURE REVIEW

2.1 Soil erosion and its conservation in Ethiopia

The existence of soil erosion has been identified as one of the core resource depleting issue across the globe especially on the hillsides (World Bank, 2006). Densely populated and hilly countries in the Rift Valley area like Ethiopia has the most negative values because of a high ratio of cultivated land to total arable land, relatively high crop yields, and soil erosion (Biruk,2012). This calls for intervening the problem of soil erosion and the consequences of soil erosion by proper soil and water management systems. From this perspective, various on-farm SWC measure in the farmlands and hillside enclosures are considered effective in rehabilitating degraded hillside. Accordingly the Ethiopian government implemented them from the mid-1970s in different parts of the country (Betru *et al.*, 2005; Eleni, 2008).

Overgrazing destroys the most palatable and useful species in the plant mixture and reduces the density of the plant cover, thereby increasing the erosion hazard and reducing the nutritive value and the carrying capacity of the land (FAO, 2005). As overstocking decreases vegetation cover and leading to wind and water erosion, reduced soil depth, soil organic matter and soil fertility that hurt the land's future productivity. The consequences of overgrazing have been land degradation (soil compaction, broken soil crust and erosion) as well as reduced species diversity and density of vegetations (Chamshama and Nduwayezu, 2002).

Degradation of arable lands became the major constraint of production in East African highlands, due to mainly nutrient loss resulting from soil erosion, lack of soil fertility restoring resources, and unbalanced nutrient mining (Amede *et al*., 2001). In Ethiopia an estimated 17% of the potential annul agricultural GDP of the country is lost because of physical and biological soil degradation (Tilahun *et al.,* 2007). Causes for land degradation are human population growth, poor soil management, deforestation, insecurity in land tenure, variation of climatic conditions, and intrinsic characteristics of fragile soils in diverse agro ecological zones (Bationo *et al*., 2006).

In Ethiopia, the impact of soil erosion was recognized after the 1973 since then; the Government of Ethiopia initiated a massive program of soil conservation and rehabilitation in the highly degraded areas, which involved the mobilization of over 30 million peasants' workdays per year (Hurni, 1986). SWC interventions in the highlands focused both on physical and biological measures (Tamene *et al*., 2006; Babulo *et al*., 2009). The biological measures comprise enclosure of degraded land from human and animal interference, agro-forestry tree, seedling planting on farmlands, afforestation, and tree planting at homesteads and in enclosures as tree enrichment (Nyssen *et al*., 2009; Mekuria *et al*., 2011). In consideration it is costly to conserve huge areas of land with soil and stone bunds and difficult to construct continuous bunds, alternatively grass strips, contour leveling, trees or hedgerows, waterways and others are also used (Kato *et al.,* 2009). Even enclosures are also encouraging strategy in rehabilitation of degraded areas as they are fast and cheap (Eleni, 2008; Ermias *et al*., 2006). Generally, Soil and water management system aimed in maintaining soil fertility by tackling the impact of erosion processes.

2.2 Biological soil and water conservation

Biological soil and water conservation measures are vegetative barriers, agronomic and soil fertility improvement practices such as; alley cropping, grass strip establishment (like elephant grasses, desho grasses, vetiver grasses) in farmlands or degraded land, farmyard and green manures, planting of tree seedlings and agro-forestry practices, which help in controlling surface runoff, reduce soil losses and improve productivity (WOCAT, 2007). Agronomic measures are practiced as the second line of defense in erosion control exercise while physical measures are primary control measure and are often considered as reinforcement measures (MoA, 2005).

Biological SWC measures are the combination of the appropriate land use and management practices that promote the productivity and sustainable use of lands by minimize soil erosion and other forms of land degradation (Anne, 2009). They are fundamentally a matter of determining a correct form of land use and management. It can enhance the productivity of crops grown on the bare lands left between the grass strips. The grasses, which harvested from the strip can also serve as a mulch cover to protect the land left between the strips from erosion and helps to enhance the fertility status of the soil (ICCD, 1999).

According to EfD (2009) compared to other interventions elephant grasses can be established in farmlands and easily crossed by oxen and ploughs which rehabilitate the degraded land. It can also filter soil sediment, safely drains excess runoff and can withstand flooding. They may ultimately form into bench terraces, which helps to store soil moisture by increasing infiltration and prevent erosion by reducing soil loss, slowing the power of runoff water and regulates ecosystem services (Lenneke *et al.,* 2011). Eyasu (2002) argued that soil conservation measures in Ethiopia emphasis should be shifted from the construction of bunds alone to the use of vegetative and agronomic measures that are most effective in erosion control. Indeed, land degradation can be mitigated by various combinations of structural and vegetative measures chosen according to the site conditions.

2.2.1 Elephant grasses (*Pennisetum Purpureum)*

Elephant grass (*Pennisetum purpureum*) is a type of grass that is used as a cover crop and an amplifier terrace in soil and water conservation methods, as well as effective in reducing erosion, runoff, and improving soil physical properties. This plant is native to Africa, then spread almost in the tropics around the world with rainfall greater than 1000 mm, tolerant of wet areas, acidic, sandy soils with low fertility rates, and grow at pH 4.5 – 5.5 and widely used as a forage crop in Indonesia because of high production (fresh grass can reach 184 t/ha/year). According to Subagyono *et al*., (2003), it is perennial can grow as high as 1.8 to 4.5 meters, if allowed to grow freely can be as high as 7 m. The roots can reach 4.5 m and rhizome can grow up to 1 m, Stems covered with a leaf shield rather jointed, long grass leaf ranged between 16-90cm with a width of 8-35 mm.

Elephant grass can protect the soil surface from direct blows rainwater, so it does not spoil the soil aggregates. Effect of vegetation on run-off and erosion is mainly determined by its ability to cover the soil surface (Sinukaban, 1989). Mechanism in reducing the rate and amount of surface flow is as follows: raindrop collision inhibited / reduced, delay the onset of surface flow and delay the onset of water loss, restraining instantly scours run-off, thereby reducing run off, and inhibits the soil compaction. According to Haridjaja (1990) elephant grass greatly determines the infiltration capacity of soil. The crop canopy closure system protects the soil surface from raindrop punches, thereby reducing soil compaction. It also planted as hedgerows for erosion protection and forage production in the alley cropping system of agro forestry (Magcale-Macandog *et al.,* 1998) and it used as a wind break in horticultural crops and to mark boundaries between plots and properties (FAO, 2013; Tropical, 2013). In Africa, it is planted on riverbanks to prevent erosion, the thick culms are made into fences, screens, and reinforcement for mud huts (Francis, 1992).

2.2.2 Sesbania *(Sesbania sesban)*

Perennial sesbania species are used in a variety of agro forestry systems all over the world for fodder production, soil fertility improvement, firewood/wood products and human food. Although sesbania species are indigenous to Uganda, they have received little research attention in terms of their usefulness in Ugandan farming systems (Orwa *et al.,* 2009). The perennial species of sesbania establish easily, grow in difficult sites and do not require complex management to maintain productivity. They have many attributes that make them attractive as multipurpose plants and potentially useful species for agricultural production systems (Evans and Rotar, 1987). Gillett (1963) suggested that the chief economic value of the sesbania is likely to be as a green manure and livestock forage as nearly all of the species are palatable to stock. Sivaraman (1951) reported that a 20-40% increase in rice yields with the use of sesbania leaf as a green manure in southern India.

2.3 Effect of SWC measures on soil properties

There are different kinds of SWC measures like improved fallows, contour hedgerows, vegetative practices, soil bunds, *fanya juu*, check dams and others involving permanent cover play an important role in arresting and reversing land degradation via their ability to improve chemical as well as physical properties of the soil (Udawatta *et al.*, 2002), for instance, two and three year sesbania based crop production have proved highly effective in soil fertility restoration in Zambia (Chinangwa, 2006). Leguminous trees based agricultural systems has potential to reduce soil erosion (Tessema, 1988). Lal (1997) reported that the cover measure involving the use of vegetation for soil protection, maintains the hydrological balance in which the surface run-off component in the hydrological cycle would be minimized. In the same way, Juo and Thurow (1998) reported that from their findings the vegetative barriers are generally used in combination with physical land treatments such as micro catchments and trees/shrubs improve the physical properties of soils for instance, soil aggregation is higher in fields where trees are being grown which enhances water infiltration and water holding capacity of soils (Ajayi *et al.*, 2008).

Vegetative barriers enriches the soil fertility by providing organic matters which helps water to infiltrate, increasing soil fauna and flora, lower bulk density when compared to the bare soil (Fikadu, 2006; Acharya and Kafle, 2009) and improves the chemical properties of the soil such as organic matter which has long been recognized to improve soil fertility that is why it plays a pivotal role on essential soil functioning (Maritus *et al*., 2001; Brady and Weil, 2002). According to Masebo *et al*., (2014) to minimize the problems of soil erosion, several approaches such as rehabilitation of degraded lands, reforestation, and integrated physical and biological SWC practices were introduced to high lands of Ethiopia by governmental and nongovernmental organizations of which MERET project (WFP) is one. Integrated SWC activity was one of the dominant components of the project: an approach that uses Agroforestry multipurpose trees and shrubs (banana, *Gravelly robusta*, *Cajanus cajan*, *Sesbania sesban*, *Cordia africana*, in combination with grasses (elephant and desho grass which are the native grass of Ethiopia) were planted with integration of physical structures (soil bund, *Fanaya juu*, trench) to form developed terraces.

Herweg and Ludi (1999) reported that in the Anjeni area of Ethiopia, graded soil bund reduced soil loss by 40% and whereas graded *fanya juu* reduced soil loss by 50 percent, as compared with untreated plots. Gruhn *et al*., (2000) reported that SWC practices that add organic matter reduce erosion, improve infiltration; will generally improve soil physical and chemical properties. Therefore, management of soil physical and chemical property is important in alleviating land degradation and improving crop performance.

2.3.1 Effect of biological SWC on soil properties

According to Kebede, (2014) the fundamental roles of SWC measures are significantly reduced soil loss and its consequences. For instance, the loss that can be reduced by the structures is not only soil particles but also essential plant nutrients and applied fertilizers. The SWC measures are identified as the first line of defense that mostly acts as barrier due to the creation of obstacles against surface runoff. The major barriers are a channel and embankment of structures and the reduction of slope length between structures also reduce the volume of runoff and thereby reduce soil loss. Most structures gradually develop to bench and decrease the slope gradient and velocity of runoff. Owing to these characteristics of the structures, Tenge *et al.,* (2005) reported that grass strips, bench terraces and fanya juu reduced soil loss by 40, 76 and 88%, respectively, compared to the land without those structures.

Biological soil and water conservation measures require low labor, more effective when we compared with structural measures and provide multipurpose, and among them, elephant grass and sesbania were planted on the soil as a stabilizer that reduced soil losses, improved the availability of organic inputs for soil improvement, and offered animal feed and consequent increase in cash income (Tilahun, 2003). According to Abay (2011) sesban, legume plant species, besides being used as bund stabilizers and feed, it was chopped and incorporated in to the soil for improvement of soil fertility.

2.3.1.1 Effect of sesbania *(S.sesban)* on soil properties.

Within the Southern Africa Miombo ecozone, *S. sesban* has been used to enhance soil fertility in improved fallows, and alley cropping at Chipata and Chalimbana in Zambia. Initial results from these experiments are presented in the 1989 progress reports for Chipata and Chalimbana (Kwesiga and Kamara, 1989). In general, the prospect of developing viable technologies for improving soil conditions using these benefits will depend on existing land use constraints and the biology of the trees. Research conducted in Andit tid and Gununo showed that increasing the vegetation cover of the soil could decreases soil loss and runoff significantly (SCRP, 1996).

Since planting of trees to improve soil fertility was unknown in Zambia, the challenge was to identify a tree that was well adapted to increase soil fertility during the fallow period. Such a tree must grow fast and be out of reach of free-ranging livestock by the first dry season, be resistant to annual fires, and be tolerant of periodic droughts (Evans and Rotar, 1987). The selected tree must grow and survive under nitrogen limiting conditions prevalent in most small-scale farms; sesbania was identified as a potential species because of its wide distribution in Zambia (Kwesiga, 1990). Fast growth, ease of propagation and removal, and because its nodulates easily fixes N, and produces high biomass (Evans and Rotar, 1987).

A significant decrease in bulk density with an associated increase in total porosity of soil under sesbania is probably related to greater amount of organic matter deposition and loosening of soil by root action (Haynes, 2000; Lampurlanes and Cantero Martinez, 2003). Bulk density is inversely related to total porosity, which provides a measure of the porous space left in the soil for air and water movement (Min *et al.,* 2003). Lower bulk density implies greater pore space and improved aeration, developing a suitable environment for biological activity (Min, *et al.*, 2003).

Green manuring crops, like sesbania specifically influence soil structural properties by enmeshing soil primary particles and micro aggregates into macro aggregation through direct physical action of roots, and production of cementing agents from enhanced microbial activities. This implies that sesbania plant species has high contribution for soil improvement and used for forage, live fence, fuel wood and shade purpose. Sultani *et al,* (2007) reported that soil with sesbania as green manure had maximum plant available water that was 23% than the control. Sesbania was more effective in producing greater number of macropores and larger mesopores (15-1.5 μm) in the surface soil by about 47% increase over control, whereas positive influence of cluster bean and rice bean was 35% and 21%, respectively. Sesbania has deeper root system which helps produce greater number of macropores.

2.3.1.2 Effect of elephant grasses (*Pennisetum purpureum)* on soil property

According to Owino and Gretzmacher (2002), the elephant and Vetiver grasses as barriers against soil loss on a clay loam soil at Egerton University in Kenya, revealed that elephant and Vetiver grasses strip plots reduces soil loss by 92 and 48% respectively. This implies, there is high contribution on soil quality improvements. According to Amede *et al.,* (2001) elephant grass was the most successful biological stabilizer of the bund and became attractive for its side benefits like planted on the soil bunds so well and managed to get an additional income.

2.4 Farmers′ perception on soil and water conservation

Perception is process by which individuals interpret and organize sensation to produce a meaningful experience of the alternative chosen (Adesina and Baidu-Forson, 1995).Understanding farmers′ perception of soil erosion and its impact is important in promoting soil and water conservation technologies (Chizana *et al*., 2006). Soil erosion is a menacing and slow process therefore farmers need to perceive its severity and the associated yield loss before they can consider implementing soil and water conservation practices.

Soil conservation in Ethiopia has a long tradition in Sub-Saharan Africa, indigenous techniques, such as ridging, mulching, constructing soil bunds and terraces, multiple cropping, fallowing and the planting of trees, were performed starting from long decades and combined erosion control with water conservation (Fitsum *et al*., 2002). However, their effectiveness has been constrained by various means. For example, Azene (1997) stated that lack of farmers′ involvement in the planning and implementation of the programs, soil conservation measures were poorly executed and maintained. Different farmers may have different attitudes towards soil conservation. Sometimes, farmers who have good attitudes also may not practice soil conservation due to the socio economic failures (Bandara and Thiruchelvam, 2008). Perceiving the soil erosion problem and positive effect of soil conservation measures also provides stimulus to and shapes opinions about to adopt conservation practices that stop the problem (Habtamu, 2006).

Sidibe (2005) reported that, in Burkina Faso, education level and area of cultivation had a positive role for the practicing of SWC. In the west Usambara highlands of Tanzania, farmers responded that involvement in off-farm activities, insecure land tenure, location of fields and a lack of short-term benefits negatively influenced practicing of SWC measures (i.e., vegetative strips, bench terraces, *fanya juu*), whereas memberships in farmer groups, level of education and contacts with extension agents positively influenced the perception of those measures (Tenge *et al*., 2004).

Bewket (2007) reported that, soil conservation has been carried out with limited success, due to less-willingness of farmers to accept and maintain the extensively introduced practices of soil and water conservation. Anley *et al.*, (2007) in Dedo reported that household age and distance to plot from home has a negative influence, but formal education, frequency of extension agent visit and area of cultivated land has a positive influence on soil bunds, cut-off drains and *fanya juu*. In the Baressa watershed, age, perception of profitability, farm size and steep slopes positively influenced practices and livestock number and high fertility negatively influenced practices (Amsalu and De Graaff, 2006).

2.4.1 Farmers′ perception on biological soil and water conservation

Kebede (2014) reported, in principle and practice, the biological measures are the cheapest, most easily adoptable and effective measures, but little attention was given. In cultivable land, the compatibility of species with intended annual crops to be grown in inter-structure, poor survival of some species is an issue as the land is subjected for open grazing during off-seasons, lack of seed or seedling supply, lack of clear research outcomes to select species may contribute to challenges on scaling up biological measures on such land use.

Even though those quantified effects and the role of SWC on runoff and flood regulation/control have been recognized, adoption of the structures is still low (Admassu *et al.*, 2012). Tesfaye (2003) pointed out that our understanding of farmers' knowledge and their perception of factors that influence their land management practice is paramount importance for promoting sustainable land management. It is also interesting to know if and when farmers practice what they know and perceive.

Kebede (2014) reported that the current SWC measures based watershed management activities which are carried out by various approaches including massive public campaign, NGOs, safety nets, should intensively work on awareness of the land users so that rate of perception can be improved. Technical support and monitoring should be strengthened to select the appropriate structures, design and specification. Wherever possible, biological measures such as enclosures, tree and shrub planting and management, Agroforestry, strengthening the structures with grass or shrub, should be given priority due to their multiple and sustaining roles. Many case studies indicated that biological measures and soil fertility management could improve effectiveness of the structure and soil fertility (Zougmore *et al*., 2004; Admassu *et al*., 2012). The technical approach should also give due attention for livestock management which significantly creates conditions for soil erosion and damage of the built structures. As anticipated, farmers' perception of soil erosion problem affects the adoption of soil conservation measures positively and significantly (Kassie *et al*., 2008). The implication is that farmers who feel that their farmlands are prone to soil erosion are more likely to adopt soil conservation measures than those who do not perceive the problem of soil erosion.

2.4.1.1 Farmers′ perception on elephant grass and sesbania plant

Soil and water conservation technologies have not been widely adopted by smallholder farmers in Ethiopia or any other countries (Kassie *et al*., 2008). The southern region is not an exceptional that smallholder farmers living in different agro-ecology of the region have not yet adopt the soil and water conservation techniques permanently. Findings of Shiferaw and Holden (1998), Tadesse, and Belay (2004) showed that the rate of perceiving SWC technologies is low reported the same empirical evidence. Tadesse and Belay (2004) further pointed out, farm size, institutional patterns and technology specific traits are important factors to be considered in designing and implementing soil and water conservation measures.

According to EIAR (2012) elephant grass (*Pennisetum purpureum*), Rhodes grass (*Chloris gayana)*, bana grass (*Pennisetum glaucum*) and phalaris (*Phalaris aquatica*) has been on hedge fence, soil and water conservation as well as gully treatments globally. Ruth (2010) reported as the proportionate importance of Napier grass (elephant grass) either in feeding livestock for milk production which is represented by 96.4%, soil conservation (72.9%), stem borer control through Push-pull technology (51.4%), or selling for money which was represented by 27.9% of the interviewed farmers. This result implies that more interviewed respondents were used elephant grasses as soil and water conservation measures in Kenya, which means the more farmers, have positive attitudes towards these multipurpose grasses.

3. MATERIALS AND METHODS

3.1 Study area description

Location and Land Use

The study was conducted in *Lisena Sena* Kebele, Lemo Woreda which is located around the capital of Hadiya zone, Hosanna town, 232 km away from South of Addis Ababa (Figure 1). Geographically, Lemo Woreda is positioned between 7°22'00''- 7^{o}45'00"N latitude and 37°40'00"- 38°00'E longitude. The total area coverage of Woreda is 38,140 hectare, of which 91% covers *Woina-dega* and 9% *Dega* areas. Lemo Woreda is bordered by Silte Zone in the North, Kembata Tembaro zone in the South, Gombora Woreda of Hadiya Zone in the North West, Ana Lemo Woreda of Hadiya Zone in the North East and Shashogo Woreda of Hadiya Zone in the East. *Lisena Sena* kebele is located about 12 km North West of Hosanna town (LWARDO, 2009). The major land use types of the study area are annual and perennial cropland (85.96%), grazing land (4.24%), forest (natural and plantation) which covers (6.2%) and unproductive land, which covers 3.6%.

Rehabilitated land is found around 12km far from Hossana town to northwestern direction in *Lisena Sena* kebele. It is a communal degraded land before it has got the chance of rehabilitation, which covers 20 hectares. As the elder farmers around there stated that before seven years ago, the land was used for grazing of livestock. To reverse this environmental problem there were intervention of MERET project in 2002 with the objective of degraded land rehabilitation and ensuring local community food security problems in the study area. Since 2002, the total area of the land managed by the project for continuous three years, after three years whole responsibilities have been laid on the hands of local community. Before the management of the land, the project was discussed with the Woreda Administration and Agricultural Development office. After making consensus with all stakeholders and line departments they were started the management of the land. Next to closing biological land management practices such as planting of elephant grass and sesbania tree species were carried out. Due to this, land is rehabilitated and improved soil fertility status in the study area. It used as a source of grass for their cattle with cut and carrying system in drought season when forage is not available for the cattle and generates income for community.

Similarly, adjacent degraded grazing land is found in the Lemo Woreda, *Lisena Sena* Kebele. The total area of the communal degraded grazing land is 8 hectare and still now the community used for grazing of their livestock. This situation was also exposed the land for overgrazing by stocking cattle beyond its carrying capacity. This part of the study area has not got the chance of rehabilitation as that of the adjacent rehabilitated land by sesbania and elephant grass.

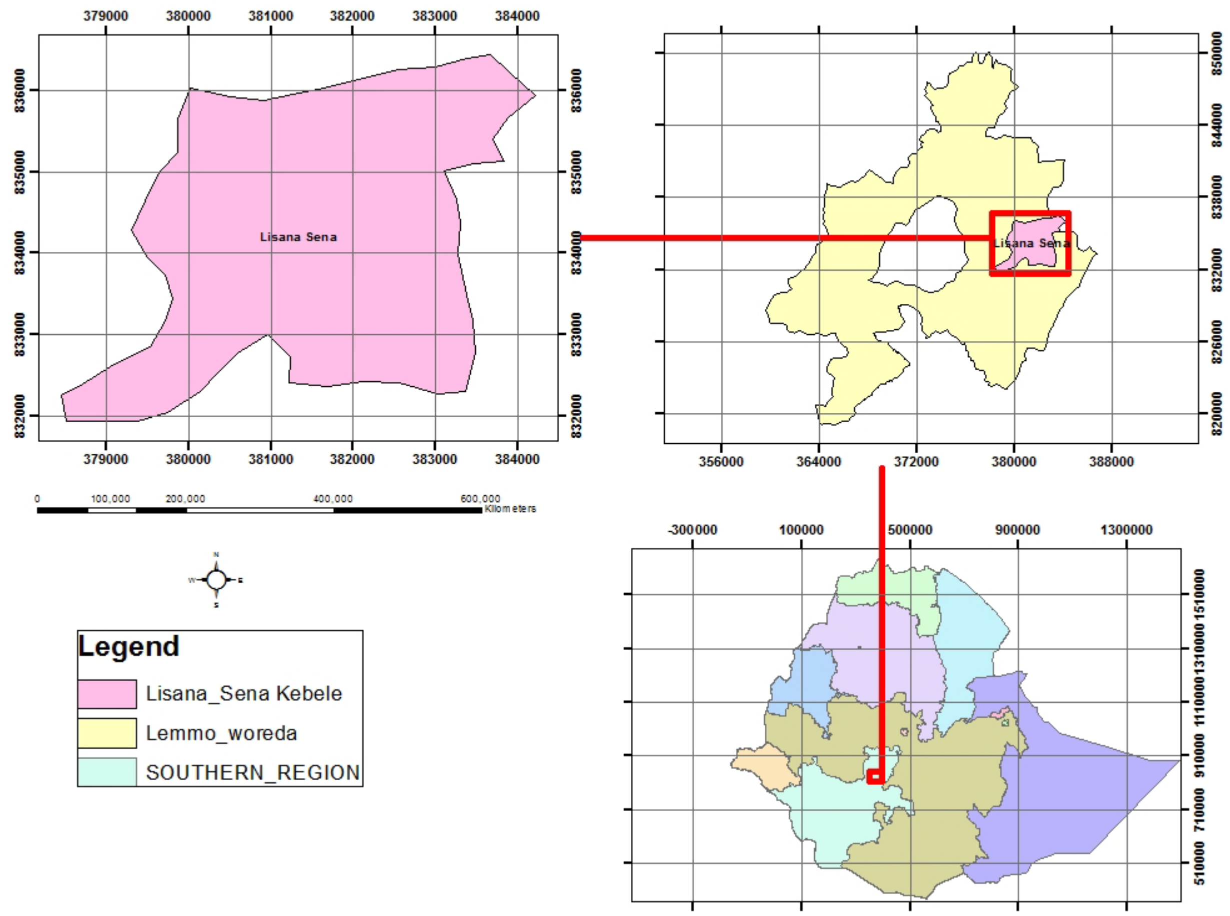

Figure 1: Map of the study area.

Climate and Vegetation

The Lemo Woreda has a bimodal rainfall distribution where the major annual rain fall season occurs in Maher (May to end of September) and short rainy season occur in Belg (beginning January to April). The mean annual precipitation varies between 900 - 1400mm and a mean annual temperature ranges from 13 $^{0}{}_{C}$ to 23^{0}C. The common vegetation in the area include, *Croton macrstachys, Ficus sur, Cordia africana, Hagenia abyssinica, Podocarpus falcatus, Milletia ferruginea, Schfflera abyssinica, Prunus africana, Juniperus procera* and *Erythrina abyssinica*, which are found as scattered in most farm lands. While *Eucalyptus* species and *Gravillia robusta* are grown as boundaries, live fences and woodlots (LWARDO, 2009).

Topography and Soil

According to LWARDO (2009), the topography of the study area was flat (54.3%), hilly (5.4%) and undulating (40%) and the altitude ranges between 1900 to 2700 m.a.s.l. Anne *et al (*2014) reported that farmers in Lemo Woreda characterized soils on their farm land locally called "*Kashar bucha"*, which referred to as red soil in color, clay loam in texture, and is mainly left behind following continuous surface runoff. This is found on the upper part of the fields where the gradient is sloped and less fertile which requires additional fertilizer.

The second soil type is locally called *"Hemach bucha"* which is darkish brown soil, most fertile, found at the bottom of the fields on the sloped areas as a result of deposition from upper areas due to surface runoff. It is easily erodible soil. The third soil type is locally "*Marare bucha"* **(**Vertisols) refers to clay soil, very fine particles and sticky. It is mainly found along swampy/ river banks. It is more fertile than "*Kashar bucha*"but less fertile than "*Hemach bucha"*.

Population and farming system

According to CSA (2007) census, the total population of Lemo Woreda is 118,594, of which 58,666 male and 59,928 female. Regarding settlement, 1.73% of the population is urban and the rest are rural.

Mixed agriculture (crop and livestock production) is the main livelihood bases of rural peoples. It is characterized by subsistence-level mixed farming and rain-fed. The main annual crops grown in the area includes wheat, teff, sweet potatoes, barley, maize, faba beans, pea, cabbage, carrots, and onions. The perennial crops grown in the district are enset, coffee, chat, sugarcane, avocadoes, mangoes and timber trees**.** Enset is the main perennial crop in Lemo Woreda, a source of food all year round (LWARDO, 2009).

3.2 Method of data collection

In this research both primary and secondary source of data were collected and used. The primary data were obtained from soil analysis, field observation, focus group discussion (FGD), Key informant and household interviews. The secondary information was obtained from published journals, reports, official records and project reports.

3.2.1 Study site selection

Two stages purposively sampling were used for this study. The first stage was selection of Lemo Woreda from 10 districts in Hadiya zone while the later stage was the purposively selected for soil sampling of *Lisena Sena* Kebele among 33 kebeles found in Lemo Woreda. This area was selected due to sesbania and elephant grass based soil and water conservation is practiced. In this Kebele biological soil and water conservation practices (such as elephant grass, sesbania, and pigeon pea) are carried out by Managing Environmental Resources to Enable Transitions (MERET) project for the last five years (since 2010) to improve soil productivity. According to department head of natural resource management in Lemo Woreda Agricultural office, among the biological soil and water conservation practices implemented by the project, elephant grass and sesbania were effectively survived while pigeon pea was failed in the study site. Hence, the lands treated with sesbania and elephant grass, and adjacent degraded grazing land as a control were considered for this study

3.2.2 Sampling procedure

To assess the effect of sesbania and elephant grass on selected physico-chemical properties of soil, composite soil samples were randomly collected using auger from 0 – 30cm. To make a composite 5 auger points were collected from sesbania, elephant grass and degraded grazing land separately with amount of 0.5kg and with four replication. In total 12 composite soil samples were collected using simple random sampling via auger (Margesin and Schinner, 2005) and handled in plastic bags to determine soil texture, pH, electric conductivity (EC), organic carbon (OC), total nitrogen (TN), available phosphorus (Av.P), exchangeable cations (K^{+}, Ca^{2+}, Mg^{2+} and Na^{+}) and Cation exchange capacity (CEC).Whereas, undisturbed soil sample was collected using core-sampling method (FAO, 2007) to determine soil bulk density. Four core samples were brought to laboratory from each land management sample site.

To assess farmers′ perception on sesbania and elephant grass as a SWC practices in the study area structured questionnaires were used. Socioeconomic, institutional and biophysical factors related to perception of sesbania and elephant grass as a biological soil and water conservation practices were collected from Focus group discussion, key informant (DAs, Woreda experts, and kebele heads) interview, field observation, and selected household interview. At the end of household interview, a Focus Group Discussion was carried out with nine members that comprise of *Kebele* leaders, religious leaders, elders, and targeted farmers with indigenous knowledge of SWC (Figure 2).

Among 809 of the total households of the study area, 117 respondents were selected through simple random sampling. The total sample size for household interview determined using probability proportional to sample size-sampling technique (Cochran, 1977).

$$no = \frac{Z^{2} * (P)(q)}{d^{2}} \rightarrow n_1 = \frac{no}{(1 + no/N)}$$

Where;

$n_{o=}$ desired sample size Cochran’s (1977) when population greater than 10,000

n_1 = finite population correction factors (Cochran’s formula, 1977) less than10, 000

Z = standard normal deviation (1.96 for 95% confidence level)

P = 0.1 (proportion of population to be included in sample i.e. 10%)

q =is 1-P i.e. (0.9)

N= is total number of population

d= degree of accuracy description (0.05).

Based on Cochran′s techniques, households randomly selected for the interview using an error margin of 5%, and the probability of the sample size has confidence interval of 95 %.

A Focus group discussion was carried out in study site to cross check the obtained primary information on sesbania and elephant grass as biological SWC from household heads.

Figure 2: Focus group discussion on the rehabilitated land with the *S.sesbania* and *P. purpureum.*

3.2.3 Soil Laboratory Analysis

The collected soil samples were transported to Soil Laboratory of Jimma University College of Agriculture and Veterinary Medicine and Hawassa University Wondo Genet College of Forestry and Natural Resource. The transported soil samples were air-dried, ground, mixed well and passed through a 2 mm sieve for selected soil physical and chemical properties analysis.

Soil physical properties such as texture, bulk density and moisture content were analyzed following standard procedure provided by (Sahlemedin and Taye, 2000). The particle size distribution was determined by the hydrometer method (Houba *et al.,* 1989). Hydrogen peroxide (H_2O_2) used to destroy the soil organic matter and sodium hexametaphosphate $(NaPO_3)_6$ as well as sodium carbonate (Na_2CO_3) were used as soil dispersing agent and also one drops of amyl alcohol was used for foam reduction. Bulk density of undisturbed soil sample was determined by core method (FAO, 2007) using core sampler and determining the mass of solids and the water content of the core, by weighing the wet core, drying it to constant weight in an oven at 105°C for 24 hours and calculated as:

$$BD = \frac{\text{Mcs} - \text{Mc}}{\text{Vc}}$$

Whereas,

BD = Bulk density in gcm^{-3}

Mcs = the mass of each core with its dry soil in g

Mc = the mass of each empty core in g and

Vc = Volume of core in cm^3

Soil moisture content was determined by gravimetric method. The collected core samples were arrived to JUCAVM soil laboratory 10 hrs after collection.

$$\textit{Percent of moisture} \text{ (weight in \%)} \quad = \frac{A-B}{B-C} x100$$

Whereas;

A=weight of wet soil in gram + tin weight,

B=weight of oven dry soil in gram + tin weight and

C=weight of the empty tin

In addition to physical properties, soil chemical properties like pH, EC (electrical conductivity), OC (Organic Carbon), Av.P (available phosphorous), TN (total nitrogen), CEC (Cation exchangeable capacity) and exchangeable bases were measured. Soil pH was measured using the glass electrode method with in a supernatant suspension of a 1:2.5 soil: water on a mass to volume basis. The pH meter was calibrated with buffer solutions of pH 4 and 7. After 30 minute of stirring, the pH was measured in the suspension by using standard pH meter. The electrical conductivity (EC) of soils was measured from a soil water ratio of 1:2.5 socked for one hour by electrical conductivity method as described by (Sahlemdhin and Taye, 2000).

Soil organic carbon was determined by using Walkley and Black wet digestion method. One gram of soil was reacted with a mixture of 10mL of 1N $K_2Cr_2O_7$ solution and 20mL of 98 % H_2SO_4. The excess dichromate solution was titrated against 1M ferrous sulphate

after addition of 200mL distilled water, 10mL of 85 % phosphoric acid and 1mL of indicator solution (0.16 % barium diphenylamine sulphate) and finally, multiply values of soil organic carbon by a factor of 1.724 to obtain soil organic matter, following the standard practice that organic matter is composed of 58% carbon (Nelson and Sommers, 1996). SOM = OC*1.724.
Where; SOM= Soil organic carbon and OC=Organic carbon.

Available phosphorus content of soil was analyzed using ammonium fluoride (NH_4F) extraction solution of Bray II method (Van Reeuwisk, 1992). Total nitrogen was analyzed by using Kjeldahl digestion procedure (Bremmer, 1996). Cation exchange capacity (CEC) and exchangeable bases (Ca^{2+}, Mg^{2+}, K^{+}, and Na^{+}) were determined after extracting the soil samples by ammonium acetate method (1N NH_4OAc) at pH 7.0 (Houba, *et al.*, 1989). The exchangeable Ca^{2+} and Mg^{2+} in the ammonium acetate leachate were measured by atomic absorption spectrophotometer (AAS) (Van Reeuwijk, 1992). The 1ml original ammonium acetate leachate was dropped into test tube and adds 9ml of 0.55% $LaCl_3$ solution and homogenizes it. Finally, exchangeable Calcium and Magnesium were measured in the sample solution by AAS at wavelength of 422.7nm and 285.2nm respectively, while exchangeable Potassium and exchangeable Sodium were determined by using flame photometer method with a wavelength of 768 and 598nm respectively (Houba, *et al.*, 1989; Morgan, 1941).

3.3 Data Analysis

The Analysis of Variance (ANOVA) was performed to test the differences in the soil properties due to different land management practices. The difference was determined following the General Linear Model (GLM) procedure at $P\leq0.05$ level using SAS 9.2. Mean separation was done using least significant difference (LSD) at $P\leq0.05$.In addition, correlation analysis was used to determine the relationship between the selected soil properties among land management practices. To understand how much the soil properties have changed due to sesbania and elephant grass when compared with degraded grazing land, the relative change was calculated using the following formula:

$$\text{Relative Change} = \frac{(Ps - Pg)}{Pg} X\, 100$$

Where P_s is the soil property measured on the sesbania or elephant grass site and P_g is the soil property measured on the adjacent degraded grazing site.

The household survey data analysis was carried out with Statistical Package for Social Science (SPSS) version 20 software. Descriptive statistics (such as mean, Standard deviation, percentage, minimum and maximum) was used to describe the analyzed data whereas, Chi-square test used to check significance difference between respondents perception (user and non-user group) in terms of practicing SWC. Logistic regression model was used to analyze determinants of farmers′ perception on the uses of biological soil conservation practices.

3.3.1 Empirical Model and Identification of Variables

Logistic regression is a widely applied statistical tool to study farmers′ perception on conservation technologies (Shiferaw and Holden, 1998; Neupane *et al.*, 2002). It allows predicting a discrete out come from a set of variables that may be continuous, discrete, and dichotomous or a combination of them. The dependent variable, (i.e., perception of soil and water conservation practices) is dichotomous discrete variable that is generated from the questionnaire survey as a binary response, and the independent variables are a mixture of discrete and continuous. Following the methods of used by Abera (2003) and Mekuria (2005), the logistic regression model characterizing perception of the sample households is specified as:

$$Pi \quad = F(\alpha + \beta Xi) = \frac{1}{1 + e^{-(\alpha + \beta Xi)}}$$

Where *i* denotes the *i*th observation in the sample; Pi is the probability that an individual will make a certain choice given Xi; e is the base of natural logarithms and approximately equal to 2.718; Xi is a vector of exogenous; variables α and β are parameters of the model, β1, β2……, βk are the coefficients associated with each explanatory variables X1, X2, …, Xn.

The above function can be rewritten as: $ln\ [P/(1-P)] = \beta 0 + \beta 1\ X1 + \beta 2\ X2 + ... + \beta k\ Xk$ Where the quantity *P/ (1-P)* is the odds (likelihoods); *β0* is the intercept; *β1, β2 …* and *βk* are coefficients of the associated independent variables of *X1, X2…*and *Xk.* It should be noted that the estimated coefficients reflect the effect of individual explanatory variables on its log of odds {ln[P/(1- P)]}.

The independent variables of the study are those, which are expected to have association with farmers′ perception of soil erosion and conservation practices. More precisely, the findings of past studies on the farmers′ perception, the existing theoretical explanations, and the researcher's knowledge of the farming systems of the study area were used to select explanatory variables. The definition and units of measurement of the dependent and explanatory variables used in the logistic regression model is presented in Table 1.

Table 1: Definitions and units of measurement of variables included in the model *(*n=117*)*

Variables	Variable code	Variable type	Unit of measurement
Dependent			
Perception of SWC	PRSWC	Dummy	1 if perceives erosion can be controlled; 0 otherwise
Explanatory			
Age of household head	Age	Dummy	1 if productive, 0 otherwise in year
Gender of respondents	Gender	Dummy	1 if male, 0 if female
Education level of respondents	EDUC	Dummy	1 if literate; 0 otherwise
Family size of respondents	FMSZ	Continuous	Measured in number
Land size of respondents	LNDSZ	Continuous	Measured in hectare
Livestock size of respondents	LVSK	Continuous	Measured in TLU
Access to extension service of respondents	ACCESS	Dummy	1 if the farmer get extension service; 0 otherwise
Distance of farm land from their residence	DISTNCE	Dummy	1 if far; 0 otherwise

4. RESULT AND DISCUSSION

4.1 Effect of sesbania and elephant grass on soil physico-chemical properties

In the study area, sesbania and elephant grass were planted on different plots of land by Managing Environmental Resources to Enable Transitions (MERET) project as soil and water conservation measures. The effects of these two land management practices (sesbania and elephant grass) on selected soil physical properties such as soil texture, bulk density and moisture content and chemical properties like soil reaction, EC, OC, TN, Av.P, CEC, and exchangeable cations (Ca^{2+}, Mg^{2+}, K^{+} and Na^{+}) are presented in the following sub-topics.

4.1.1 Soil physical properties

4.1.1.1 Texture

Based on USDA soil textural triangle (Rowell, 1994), the soils textural classes of studied land treated with sesbania, elephant grass and degraded grazing land were clay, clay and clay loam respectively (Table 2). Mean values of the soil texture: sand, silt and clay under land treated with sesbania, elephant grass and degraded grazing land were 22.5, 23.5 and 27.5, 28.5, 29.5 and 41, 49, 47 and 31.5% respectively (Table 2).

The clay and silt fraction of the soils were significantly *($P<0.05$*) affected by land management practices (Table 2). While there was no significant (*$P>0.05$*) difference in sand content among land management practices (Table 2). Besides, the clay and slit fractions under sesbania plant cover was not significantly *($P<0.05$*) varied from the land managed by elephant grass. As compared with degraded gazing land, sand content was reduced at land treated with sesbania by 22.2%, but the clay fraction was increased by 35.7% at the land treated with sesbania (Appendix 3). Similar trends were observed for these soil textures measured under elephant grass. The reason might be the higher sand and lower clay content on heavily grazed areas is probably caused by increasing run off and soil erosion due to the trampling effect of livestock and absence of vegetation cover lead soil erosion which selectively removes clay particle, whereas relatively higher clay and lower sand content under sesbania and elephant grass might be less erosion due to these plant species provides good land cover and binding soil. Similarly, Gachene and

Kimaru (2003) reported that clay particles are lighter than sand particles, and once detached by erosion they are easily transported. Moreover, Abinet,(2011) reported that the higher clay content in the vegetation means that there is relatively low soil erosion in the site, while the lower clay in the free grazing land means there is relatively higher soil erosion (particularly sheet erosion) at the degraded grazing land, which may reflect the differences in their vegetation cover.

Table 2**:** Mean (±SEM) effect of land management practices on soil particle sizes, bulk density and moisture content

Mgt practices	Sand (%	Silt (%)	Clay (%)	BD (g/cm^3)	SMC (%)	textural class
Sesbania	22.5 ±3.0^a	28.5±5.26^b	49.0±3.46^a	1.08±0.12^b	32.13±3.01^a	Clay
Elephant grass	23.5±5.26^a	29.5±7.72^b	47.0±11.8^a	1.12±0.02^b	31.09±2.11^a	Clay
Degraded grazing	27.5±1.91^a	41.0±1.15^a	31.5±1.9^b	1.26±0.04^a	22.22±5.18^b	clay loam
P-Value	0.180	0.017	0.014	0.024	0.007	
LSD (0.05)	5.865	8.696	11.522	0.1266	4.187	
CV	14.96	16.47	16.95	6.84	12.89	

Means within column followed by the same letter are not significantly different at $P \le 0.05$ according to Fisher's LSD (least significance difference)) CV= Coefficient of variance, BD = bulk density, and SMC = Soil moisture content.

4.1.1.2 Soil Bulk density and Moisture content

Mean values of the soil bulk density under land treated with sesbania, elephant grass and adjacent degraded grazing land were 1.08, 1.12 and 1.26g/cm^3 respectively (Table 2). Statistical analysis revealed that soil bulk density was significantly ($P \le 0.05$) affected with land management practices where, the highest value (1.26 g/ cm^3) was observed in degraded grazing land and lowest value (1.08 g/cm^3) in sesbania treated land (Table 2). While non- significant ($P>0.05$) difference was between lands treated with sesbania and elephant grass. Livestock trampling on the degraded grazing land could be the main reason for the observed relatively high bulk density in degraded grazing land. Livestock grazing compacts soil particularly under high grazing intensity (Abinet, 2011; Fatunbi and Dube, 2008). Whereas, the exclusion of livestock grazing and human interference, and organic matter addition from sesbania could be the cause for low soil bulk density in lands treated with sesbania. Likewise Chikowo *et al.* (2004) reported that incorporation of woody legumes into the soil reduces bulk density and increases soil granulation and porosity.

Furthermore, lower bulk density in the sesbania based natural forest, implies greater pore space and improved aeration, creating a choice environment for biological activity (Werner, 1997).

As compared to adjacent degraded grazing land, soil bulk density at land treated with Sesbania was reduced by 16.6% and elephant grass was reduced by 12.5 % (Appendix 3). This result agrees with earlier findings of Descheemaeker *et al*., (2005) who reported that vegetation cover prevented physical soil loss. The organic matter added due to management degraded land of the study site with biological conservation measures such as sesbania and elephant grass could be one of the reasons for lower bulk density of the site conserved by these plants. The correlation matrix (Table 4) also showed a negative and significant relationship between soil bulk density and soil organic carbon ($r= -0.544^{*}$).
Mean values of the soil moisture content for lands treated with sesbania, elephant grass and grazing were 32.13, 31.09 and 22.22% respectively (Table 2). The moisture content of both lands treated by sesbania and elephant grass was statistically significance ($P< 0.05$) different from the adjacent degraded grazing land (Table 2). However, non significant ($P>0.05$) difference was observed between land with sesbania and elephant grass in soil moisture content. As compared with degraded grazing land, soil moisture content of Sesbania increased by 30.84% (Appendix 3). Higher moisture percentage in land with Sesbania probably be attributed to the relatively higher organic matter accumulation or may be reduced the evaporation chance to occur by increasing surface cover with vegetation.

Besides, the higher clay percentage (Table 2) of the soil in the land treated with sesbania might have contributed to the higher moisture retention. The moisture content (Table 4) also showed that a positive and significant correlation with clay content ($r=0.548^{*)}$ and organic carbon content ($r=0.660^{**).}$ The presence of plant conservation for the different purpose may affect soil physical properties such as soil water retention and aggregate stability, leading to enhanced crop water availability (Brady and Weil, 2002). Masebo *et al*., (2014) reported that addition of organic matter through the litter fall from tree and shrubs had improved the soil physical conditions which in turn had increased the water holding capacity and thus the soil moisture content.

4.1.2 Soil chemical properties

4.1.2.1 Soil pH and Electrical conductivity

Mean values of soil pH of study area ranges between 5.5 and 6.1 (Table 3). The lowest soil pH was measured under degraded grazing land whereas the highest pH was estimated from the land treated with sesbania. Based on the classification by Pandey *et al*., (2000) soil pH in three land management practices were ranges of moderately to slightly acidic. Statistically, soil pH of the adjacent degraded grazing land was significantly ($P<0.05$) different compared with sesbania and elephant grass. This is probably due to the presence of relatively higher organic matter in lands treated with sesbania and elephant grasses than the adjacent degraded grazing land. The presence of higher pH in vegetation cover might be attributed to the ameliorating effect of the high content of OM that form Al and Fe-OM complexes and release of hydroxyl ions as well as deposition of basic cations (Habtamu *et al.*, 2014). However, non-significant ($P>0.05$) difference in soil pH was observed between land treated with sesbania and elephant grass.

Mean values of the electrical conductivity (EC) under land with sesbania, elephant grass and degraded grazing land were 0.24, 0.23 and 0.18dS/m respectively (Table 3).There was no significant ($P>0.05$) difference in EC between land treated with sesbania and elephant grass (Table 3).The highest (0.24 dS/m) and the lowest (0.18 dS/m) EC of the soils were obtained under the land treated with sesbania and the degraded grazing land respectively (Table 3). The highest EC value under the sesbania treated land might be due to high base forming cations (Ca^{2+}, $Mg^{2+,}$ $_{and}$ K^{+}) content and low EC value under degraded grazing land can be associated with the loss of base forming cations (Ca^{2+}, $Mg^{2+}$$_{and}$ K^{+}) due to overgrazing and leaching, which reduce soil pH and also less soil conductivity.The correlation matrix (Table 4) also showed positive and highly significant relationship between pH and EC ($r=0.835^{**}$).

Table 3: Mean (±SEM) effect of land management practices on selected soil chemical properties

Soil parameters	LS	LE	GL	CV	LSD (5%)	P value
pH H_2O	6.1±0.22[a]	6 ±0.29[ab]	5.5±0.35[b]	5.05	0.47	0.043
EC(dS/m)	0.24±0.0[a]	0.23±0.01[a]	0.18±0.0[b]	4.64	0.015	0.000
OM (%)	4.09±0.19[a]	3.73±0.05[b]	3.40±0.26[c]	5.14	0.30	0.002
OC (%)	2.37±0.11[a]	2.17±0.03[b]	1.97±0.15[c]	5.19	0.18	0.002
TN (%)	0.21±0.01[a]	0.185±0.0[b]	0.165±0.0[c]	5.05	0.015	0.000
Av.P(ppm)	3.85±0.31[a]	3.52±0.46[ab]	2.86±0.47[b]	12.31	0.67	0.025
CEC(meq/100g)	32.68±1.7[a]	30.96±6.0[a]	22.55±1.07[b]	12.75	5.86	0.007
Ca^{2+}(meq/100g)	25.48±1.33[a]	24.14±4.6[a]	17.58±0.8[b]	12.74	4.56	0.007
Mg^{2+}(meq/100g)	3.39±0.17[a]	3.20±0.6[a]	2.33±0.11[b]	12.73	0.60	0.007
K^+(meq/100g)	1.57±0.10[a]	1.41±0.18[a]	1.15±0.18[b]	11.94	0.26	0.015
Na^+(meq/100g)	0.05±0.00[a]	0.042±0.00[a]	0.032±0.0[b]	14.9	0.01	0.010

Means within rows followed by the same letters are not significantly different at P<0.05, LSD=Least significance difference, CV=Coefficient of variance, GL=Degraded grazing land, LS=Land with sesbania, LE= Land with elephant grass.

4.1.2.2 Organic carbon, Total nitrogen and Available phosphorus

Mean values of soil organic carbon under land with sesbania, elephant grass and degraded grazing were 2.30, 2.0 and 1.20% respectively (Table 3). Statistically, significant ($P \leq 0.05$) difference was observed among the three land management practices (Table 3).The reason was due to high biomass return in case of sesbania treated land and is removal of a major part of above ground biomass by livestock in case of degraded grazing land. Due to soil management practices and whereby the highest (2.37%) was observed under land with sesbania and lowest (1.97%) was observed under degraded grazing land (Table 3). As compared to degraded grazing land, soil organic carbon was increased by 16.88% under sesbania treated land (Appendix 3). This implies, there is soil organic carbon improvement due to sesbania. The presence of good vegetation covers reduce erosion through various mechanisms such as addition of organic matter and surface litter, and thus improve soil coherence, soil anchoring through root system, and physical blockage, and thus reduction of kinetic energy of surface run off (Skarpe,1991).The greater organic carbon content of the soil under sesbania might be due to the added organic matter input to the soil through decaying of sesbania biomass, maintenance of the available organic matter and plant nutrients and by improving the physical structures of the soil by reducing run off. Similarly (Abiy, 2008) reported that less biomass return causes the reduction of SOM, TN and Av.P in degraded grazing land compared with vegetative covered site in which litter found on the soil surface consists of dead plant remains, which protect the soil surface from raindrop impact and surface runoff. FAO (1980) reported that the most significant chemical and physical changes in soil parameters as a result of vegetation occur at or near the surface and are related to the supply of organic matter from litter.

The result of this study showed that higher mean values of soil total nitrogen was measured under land treated with sesbania (0.210%) than land managed by elephant grass (0.185%) and degraded grazing land (0.165%) (Table 3). Statistically, significant ($P \leq 0.05$) difference was observed among the three land management practices affected by three land management types (Table 3). The highest (0.21%) was recorded on the land treated with sesbania and lowest (0.165%) was recorded on the degraded grazing land, might be due to nitrogen fixing of sesbania and high OM content in the study site. This result was in agreement with that of Abiy (2008) reported that the differences in SOM content causes the significant difference in total nitrogen between plantations and free grazing land due to intensities of soil erosion. Similarly, Degefu *et al.* (2011) reported nitrogen fixation level of 500 to 600 kg N/ha/year and is particularly promoted for soil fertility replenishment through ‘improved fallow’ Agro forestry practice.

The result presented in table 3 shows that the mean values of available phosphorus in the study area changed from 2.86 to 3.52ppm due to land management by sesbania. The available phosphorus was significantly ($P \leq 0.05$) affected by degraded grazing land and land treated with sesbania. However, there was no significance ($P>0.05$) difference between the land treated with elephant grass and the rest of two land management practices (Tables 3). Accordingly, the highest (3.85ppm) and the lowest (2.86ppm) available phosphorus contents were observed under the land with sesbania and the degraded grazing land respectively (Table 3).

As compared to degraded grazing land, soil available phosphorus was increased by 25.71% under sesbania treated land (Appendix 3). The concentration of relatively higher phosphorus under sesbania might be due to the presence of high organic matter accumulation under sesbania. Similarly, Tadesse *et al*., (2002) observed available soil phosphorus concentration in the surface soils that were significantly higher under the trees than the open fields.

The correlation matrix (Table 4) also showed that organic carbon was directly and significantly associated with total nitrogen ($r=0.883^{**}$) and positively associated with available phosphorus (r=0.443). Besides, there was a synergetic and non significant association was observed between total nitrogen and available phosphorus (r=0.487). This is in harmony with the findings of Bot and Bentites (2005) who reported land covered with vegetation increased the accumulation of soil organic matter, and the presence of this organic matter affected both the chemical and physical properties of the soil and overall health. Furthermore, the increase in vegetation cover could decrease sediment-associated nutrient losses by reducing the erosive impact of raindrops and soil erosion velocity (Mekuria *et al.,* 2009).

4.1.2.3 Cation Exchange Capacity and Exchangeable bases

This study revealed that mean values of the Cation Exchange Capacity (CEC) was significantly ($P<0.05$) affected by land treated with sesbania and elephant grass when compared with degraded grazing land, but no significance ($P>0.05$) difference between land treated with sesbania and elephant grass (Table 3). Accordingly, the highest (32.68 meq/100g) and the lowest (22.55 meq/100g) CEC contents were observed under the land with sesbania and the degraded grazing respectively (Table 3).The reason might be due to the fact that, soil under sesbania accumulated relatively high organic carbon, clay contents and, has greater capacity to hold cations there by resulted greater potential fertility in the soil. Therefore, soil CEC is expected to increase through improvement of the soil organic matter content. Besides, CEC of the soil was positively and significantly correlated with clay ($r=0.996^{**}$) and organic carbon ($r=0.710^{**}$) (Table 4). In line with this Wild (1993) and Max *et al.* (1996) cited in Kibret (2008) reported that soil CEC is associated with clay and organic matter colloid especially organic matter renders soils a better CEC. Thus, slight difference in CEC can make a big difference in soil organic matter as observed in this study. Similarly, Kibret (2008); Abiy (2008) also reported a higher mean value of CEC in vegetation planted site than in adjacent degraded land.

Mean values of the Exchangeable bases (Na^+,K^+,Ca^{+2} and Mg^{+2}) under the land with sesbania, elephant grass and degraded grazing land were 0.05, 0.04 and 0.03, 1.57,1.41 and 1.15, 25.48, 24.14 and 17.58, 3.39,3.20 and 2.33meq/100g respectively (Table 3). The exchangeable bases in degraded grazing land showed that significantly ($P<0.05$) lower than land under sesbania and elephant grass (Table 3).The high values of exchangeable bases at land with sesbania might be due to the accumulation of woody biomass or nutrient cycling role of increased biomass and reduction of soil erosion.

In line with Sachs (1999) reported that the two colloidal substances (clay and OM) are essentially the cations' warehouse or reservoir of the soil and are very important because they improve the nutrient and water holding capacity of the soil. Moreover, according to Havlin *et al.*, (2004), the accumulation of organic matter and nitrogen modifies soil properties, and is beneficial to clay formation. This author reported also both organic matter and clay can provide more CEC sites and result in accumulation of exchangeable base cations in surface soil.

Table 4:Pearson correlation of soil physico-chemical properties in each land use types

	pH	EC	MC	BD	OM	OC	TN	Av.P	Clay	Silt	Sand	CEC	Ca	K	Mg	Na
pH	1															
EC	.835**	1														
MC	.796**	.855**	1													
BD	-.595*	-.701**	-.428	1												
OM	.455	.781**	.661**	-.544*	1											
OC	.453	.779**	.660**	-.544*	1.000**	1										
TN	.628*	.833**	.792**	-.458	.884**	.883**	1									
Av.P	.474	.695**	.441	-.588*	.445	.443	.487	1								
Clay	.395	.613*	.548*	-.580*	.641*	.642*	.670**	.409	1							
Silt	-.391	-.603*	-.585*	.591*	-.587*	-.588*	-.606*	-.477	-.947**	1						
Sand	-.280	-.441	-.305	.378	-.543*	-.543*	-.582*	-.150	-.787**	.548*	1					
CEC	.417	.657*	.583*	-.598*	.709**	.710**	.722**	.429	.996**	-.940**	-.789**	1				
Ca	.418	.657*	.583*	-.599*	.709**	.710**	.722**	.429	.996**	-.941**	-.789**	1.000**	1			
K	.566*	.777**	.513*	-.651*	.547*	.545*	.605*	.892**	.375	-.460	-.093	.409	.410	1		
Mg	.417	.657*	.582*	-.598*	.711**	.711**	.722**	.429	.996**	-.940**	-.790**	1.000**	1.000**	.409	1	
Na	.619*	.770**	.754**	-.584*	.639*	.639*	.768**	.626*	.473	-.579*	-.121	.512*	.512*	.831**	.510*	1

**= Correlation is significant at the 0.01 level (1-tailed).

*=Correlation is significant at the 0.05 level (1-tailed).

4.2 Farmers′ perception on biological soil and water conservation

To assess the farmers′ perception on sesbania and elephant grass in the study area as a biological soil and water conservation the demographic and socioeconomic characteristics of respondents and severity of soil erosion were presented in the following sub-topics.

4.2.1 Demographic and socio-economic characteristics

The demographic characteristics of the sampled household heads indicated that about 82.1% were males and 17.9% were females. From sampled households, 85.5% of the respondents′ age was ranges between 18 to 64 years which are under category of productive age and the rest was unproductive. The family size of the sampled household ranges between 1 to4 was 12.8% and 70.9% ranging between 5 to 9 family sizes. And only 16.2% of respondents have a family of 10 and above. The mean family size of the sampled households was 6.7 persons per family (Table 6).

As far as the educational levels of the sampled household heads, about 32.5% of the sampled household heads were illiterate and 67.5% of the respondents were attended formal education. The maximum education level of the household head was the completion of grade 12, and the overall mean education level was grade 4 (Table 5).

Table 5: Demographic and socio-economic characteristic of the respondents (n=117).

Variables	Category	Respondents	Min	Max	Mean	S.dev
Age(year)	18-64*	100(85.5%)	22	70	39.6	10.6
	>65**	17(14.5%)				
Family size(number)	1-4	15(12.8%)	1.00	12.00	6.75	2.63
	5-9	83(70.9%)				
	≥10	19(16.2%)				
	Female	21(17.9)				
Gender	Male	96(82.1)				
	Illiterate	38(32.5%)	0	12	4	
Education (Grade)	Literate	79(67.5%)				
	< 1	61(52.13%)	0.125	3.25	0.62	0.438
Land size(ha)	1 to 2	32(27.35%)				
	2 to 3	21(17.94%)				
	>3	3(2.56%)				
	None	22(18.8%)	0	13.80	2.48	2.16
Livestock(TLU)	Above zero	95(81.2%)				

Productive age group and non-productive age group**, TLU conversion factor oxen and cows =1.00, bulls and heifer = 0.75, horse =1.10, donkey =0.70, sheep and goat =0.13, and poultry =0.013, TLU according to Storch et al. (1991) cited in Tesfaye Lemma (2003).*

Most of respondents (81.2%) have livestock which are an integral part of the farming system in study area (Table 5). The common livestock are cow, oxen, mule, donkey, sheep, goats and poultry which provide different good and services for households. Out of interviewed farmers, 81.2% reported that feed shortage is currently the biggest obstacle to keeping livestock. In the *kiremt* season, the livestock are dependent on heavily degraded (overgrazed) communal lands and on some crop residues collected in bega season. In the bega season, crop residues are the main feed.

The conducted survey result indicated that the private landholding of the majority (52.13%) of respondents′ have less than one hectare, 27.35% respondents′ have between 1 to 2 hectares, 17.94% interviewed respondents have between 2 to 3 hectares and for only few respondents (2.56%) have more than 3 hectare. The average land size of respondents in the study area is 0.62 hectare (Table 5). This implies land size of respondents in the study area was very small in size due to high population pressure whose need depend on it. Similarly, Shibru (2010) reported that out of 112 interviewed farmers, 84.6% of respondents answered that their present landholdings are too small compared to the land needs of the household and they are not in a position to inherit land to their children in Lemo Woreda.

4.2.2 Farmers' perception on uses of sesbania and elephant grasses for conservation

4.2.2.1 Farmers' perception on soil erosion

Understanding of the farmers about soil erosion of the study area is one of the most important conditions to assess farmers′ perception on soil and water conservation measures. As presented in Table 6, about 85.47% of the respondents were users of soil and water conservation measures on their private land to minimize risk of soil erosion whereas,14.53% of respondents were non-users of soil and water conservation on their own farm land. Among the soil and water conservation users 21.36%, 51.28%, 9.4% and 3.41% were presented the rates of soil erosion on their farm as sever, moderate, minor and none, respectively. Of the non-user groups,1.7%,4.27%, 5.12% and 3.41% were perceived soil erosion was sever, moderate, minor and none, respectively. Hence, most of respondents perceived soil erosion problem on their own farms. This shown that most of the respondents reported the rate of soil erosion on their farm was moderate due to practicing different soil and water conservation practices in the study area. This was agreed with the report of Kibemo (2011) in Soro Woreda, about 65.5% of respondents′ rate degree of soil erosion as a moderate on their farm land and 4.8 and 29.8% of respondents mentioned erosion on their farm is none and minor respectively.

As presented in Table 6, the chi-square test revealed that, farmers′ perception on the degree of soil erosion on their farm was significantly different (*P<0.05* d.f=3) between conservation practices users and non-user groups in terms of perceiving degree of soil erosion as a sever and moderate. The difference might be due to education level, the most of respondents who practices soil and water conservation measures in the study area were an educated farmers and the rest was an illiterate. Kibemo (2011) reported that the level of expression of soil erosion problem shows difference among the educated and uneducated farmers. This shows that illiterate farmers differ in perceiving soil erosion problem compared with educated farmers and with an increasing level of educational attainment of farmers, there is higher perception of soil erosion problem. For instance, almost all farmers who attained education perceived the existence of soil erosion well and practicing soil conservation measures on their land. Therefore, as result of their educational level, uneducated farmers are likely to differ in practicing soil conservation measures compared with educated farmers.

Table 6: Farmers′ perception on severity of soil erosion in the study area (n=117).

Degree of soil erosion	Soil and water conservation measures		X^2- test
	Users	Non- users	
Sever	21.36%	1.7%	0.029*
Moderate	51.28%	4.27%	0.012*
Minor	9.4%	5.12%	0.240ns
No risk	3.41%	3.41%	0.431ns
Total	85.47%	14.53%	

*- Significant at 5%, ns-non significant

Besides, focus group participants (FGD) and key informant were revealed that, the rate of soil erosion were moderate in the study area. In addition to this, they reported that the main causes of soil erosion in the study area were topographic nature of the farmland, lack of fallowing, vegetation removal, free grazing, runoff from upslope; inappropriate farming and the easily erodible nature of the soil are some of the problems. According to

Woldeamlak (2002), perceiving soil erosion as a hazard and understanding its causes and effects on crop yields is the first step for searching soil and water conservation measures.

4.2.3 Farmers perception on sesbania and elephant grass

As presented in Table 7, about 46.15% of the respondents were involved in physical soil and water conservation measures (such as soil bunds, *fanya juu* and micro-basins), 11.96% practiced biological measures such as sesbania and elephant grasses and 27.35% uses combination of biological and physical such as soil bund, *fanya juu* with sesbania and elephant grasses. Whereas, 14.5% respondents were non users of any of soil and water conservation practices in the study area. The reasons why farmers not use SWC was uncontrolled grazing; distance of farm land from their residence, limited contact with development agents, involving in off farm activates and having gentle slope of farm land. Farmers reported that from November to May, our croplands were free, due to this uncontrolled grazing by livestock and involving of respondents in off farm activity did not give time to contact with development agents to get skills and knowledge regarding to soil and water conservation practices in the study area.

Although considerable amount (39.31%) of the farmers use sesbania and elephant grasses as soil and water conservation, there are also prominent figures of the respondents not use as biological conservation. As stated by focus group participants (FGD) and key informants, the reason for farmers′ did not apply sesbania and elephant grasses as a biological soil and water conservation measures on their farm were education level, having small farm size, uncontrolled grazing by livestock, nature of landform, limited contact with development agents. The educated farmers were practicing sesbania and elephant grasses as SWC measures than uneducated farmers, also having small farm size limits farmers to implement this multipurpose plant species as a SWC, farmers with small farm size give emphasis on crop production rather than soil and water conservation measures. Similarly, Amsalu and Graaff (2007) found that farmers who have a larger farm are more likely to invest in soil conservation measures because they have the funds to do so while farmers who have a small land is needed for crop production. The chi-square results indicate that there was a significant(X^2=0.000 at $P<0.01$ d.f=2) difference between soil and water conservation users and non-users regarding to practicing these multipurpose SWC measures on their farmlands.

Table 7: Farmers preference on different SWC measures in the study area (n=117).

SWC structures	Users	Non-users	X^2_{-test}
Fanya juu, soil bund and cut of drain(Physical)	46.15%		
Sesbania, and elephant grasses(Biological)	11.96%		
Soil bund with elephant grass and with sesbania(Integration)	27.35%		
Total	85.5%	14.5%	0.000

As presented in Table 8, regarding the effectiveness levels of different soil and water conservation practices, about 15.38%, of the respondents were perceived physical alone was less effective. Whereas, 10.25% and 9.4% were perceived biological alone (sesbania and elephant grasses) and combined practices less effective, respectively. Furthermore, about 45.29%, of the respondents were perceived physical alone was more effective whereas 33.33% and 47.86% were perceived biological alone and combination of physical and biological measures were more effective interms of stabilizing a degraded environment, cheap interms of cost and requires less labor to implement on their own private land in the study area. While, about 4.29%, 8.54% and 3.43% of respondents were no any idea on effectiveness of physical, biological (sesbania and elephant grasses) and combination of physical and biological soil and water conservation interms of stabilization the soil and technical view, respectively.

Substantial number of respondents (47.86%) reported that the combination of physical and biological soil and water conservation measures were more effective in reducing soil erosion and stabilizing a soil. Eyasu (2002) argued that soil conservation measures in Ethiopia emphasis should be shifted from the construction of bunds alone to the use of vegetative and agronomic measures that are most effective in erosion control. Similarly, Megersa (2011) reported that combination of biological and physical land management practices are more effective in improving soil fertility and cropland productivity.

The chi-square test, showed significant($P<0.05$ d.f=3) difference among respondents with regard to effectiveness and more effectiveness of physical alone, biological alone and combination of physical and biological SWC practices. The difference was due to in educational level and less contact of respondents with development agents in the study area. Similarly, Wagayehu, (2003) reported that a household head that has greater contact with a development agent has more likely to use soil conservation technologies. There was no significant difference between respondents interms of less effective and did not know of soil and water conservation practices. This indicates a respondent has similar ideas interms of less effective and did not uderstand of soil and water conservation.

Table 8: Farmers′ perception on effectiveness of SWC interms of stability (n= 117).

Effectiveness of SWC	Physical alone*	Biological alone**	combination***	X^2- test
Less effective	15.38%	10.25%	9.4%	0.13ns
Effective	35.04%	47.86%	39.31%	0.04
More effective	45.29%	33.33%	47.86%	0.03
Didn't know	4.29%	8.54%	3.43%	0.120ns

*ns- non significance at 5%, otherwise significant *Fanya juu, soil bund and cutoff drain ** sesbania and elephant grasses *** combinations of soil bund, elephant grasses and sesbania.*

As presented in Table 9, about 49% of the respondents use sesbania and elephant grass for soil and water conservation purpose and the rest 51% did not uses the practices. Of the farmers uses sesbania and elephant grass for soil and water conservation, 24.78% used in homestead, 19.65% used in degraded land and 4.3% used in crop land. Regarding the effect of these plants on soil fertility, about 82.9% of the respondents perceived sesbania and elephant grass has effects on soil fertility while 17.1% did not understood effects of the practices on the soil. From the total respondents perceived the importance of these plants, 52.1% answered the sesbania plant improved soil fertility and 30.8% of respondents reported elephant grass improves the soil fertility in the study area. The reason why they prefer sesbania rather than elephant grass was the leaf of sesbania is easily decomposed and improves fertility of soil. This was in line with the soil laboratory analysis, which indicated almost all selected soil physicochemical properties were higher under sesbania treated land than elephant grasses treated and degraded grazing land.

The focus group discussion participants and key informants revealed, farmers′ in the study area were aware on the effect of sesbania and elephant grasses on soil fertility and technically easy and it required less labor to manage and stabilizes physical soil and water conservation measures in well manner. The chi-square test, showed significant (*P<0.05* d.f=1) difference between respondents with regarding to effect of sesbania and elephant grass on soil fertility. The difference on perception between respondents might be due to less access to extension services and their educational level difference.

As presented in Table 9, regarding the socioeconomic uses of sesbania and elephant grass, 99.1% of the respondents perceived the sesbania and elephant grass has socioeconomic (such as forage,livefence,fuelwood and income) benefits in the study area. This was in line with focus group participants and key informants who reported that sesbania and elephant grasses provide multiservice for community such as forage, green manure, mulching, fuel wood, generating income and improve soil organic matter.

Table 9: Farmers′ perception on sesbania and elephant grass uses in the study area.

Descriptions		Sesbania and elephant grass		X^2 -test
		Users	Non- users	
Sites were farmers plant sesbania and elephant grasses as SWC	Degraded land	19.65%		
	Crop land	4.3 %		
	Homestead	24.8%		
	Total	49%	51%	0.065ns
Farmers perception on contribution of sesbania and elephant grass on improving soil properties	Sesbania	52.1%		
	Elephant grass	30.8%		
	Total	82.9%	17.1%	0.020*
Socioeconomic uses of sesbania and elephant grass	Forage	40.2%		
	Live fence	19.7%		
	Fuel wood	21.4%		
	Income	17.9%		
	Total	99.1%	0.9%	0.320ns

*-Significant at 5% of level and ns-non significant

Focus group participants and key informants revealed, farmers in the study area have positive perception towards the existence of rehabilitated land or after rehabilitation of degraded communal land by sesbania and elephant grass in their locality is positive. This is due to the farmers of the study area getting benefit, especially fodder from the sesbania and elephant grass, changes were observed on soil fertility with sesbania and elephant grass rehabilitated land due to this plant species and restricting from human and animal entrance. This made respondents to have a positive perception on this plant species in the study area

4.2.4 Factors affecting Perception of Farmers

The overall prediction by the regression model indicate dependent (such as perception sesbania and elephant grass use as SWC) variable and explanatory (such as age, gender, educational level, family size, land size, livestock size and access to extension service) variables sufficiently explained the perception of farmers on biological soil and water conservation practices. The analysis revealed, there was a strong association between farmers perception and the group of the explanatory variables (R^2= 0.8371) (Table 10).The predicted positive coefficient in logistic regression model for age, education level, family size, land holding size, and accesses to extension service of household imply an increase in these explanatory variables (age, education level, family size, land holding size, and accesses to extension service) improves farmers' perception of soil and water conservation practices. Whereas, the negative estimates of the coefficient by the model implies farmers' perception decreases with increase in those the explanatory variable (such as age, education level, family size, land holding size, and accesses to extension service). Accordingly, among an explanatory variables household head age, educational level and access to soil and water conservation extension services were significantly ($P \leq 0.1$) affects the sesbania and elephant grass use as conservation practices in the study area (Table 10).

As presented in Table 10, age of respondents were positively related with the probability of participating in SWC practices ($P \leq 0.1$) level of significance. As age increases by one unit, the probability of participation in this biological SWC practices increases by 14.46% while keeping other variables constant. This is due to the fact that majority of sample households in the study area were in productive (20-64 years) age category. This result is in line with Fikru (2009) most of the household heads in the age from 20-64 years group are assumed to have a good understanding of problems of soil erosion due to access to information, and as a result, usually more interested in soil and water conservation practices.

Table 10: Logistic regression result for perception of sesbania and elephant grass as SWC

Dependent variable: PRSWC	Coefficient	Marginal effects	Std. Error	Z	P>|z|
Explanatory variables:					
Age	5.607085	0.1446	2.894097	1.94	0.053*
Gender	-3.681264	-0.0025	4.649243	-0.79	0.428
EDUC	7.438811	0.01045	2.686694	2.77	0.006***
FMSZ	0.524725	0.00073	.6523725	0.80	0.421
LNDSZ	1.507679	0.00211	2.346121	0.64	0.520
LVSK	-0.026954	-0.00004	0.5852861	-0.05	0.963
ACCESS	8.810951	0.27045	3.775164	2.33	0.020**
DISTNCE	-4.4896	-0.02158	3.235313	-1.39	0.165

Number of obser = 117
LR chi2 (8) = 86.89
Prob > chi2 = 0.0000
Pseudo R2 = 0.8371

***, ** and * are significant at 1%, 5% and 10%, respectively.

Educational level of the head of the household significantly (*P≤0.01)* and positively affects farmers′ perception on sesbania and elephant grass as soil and water conservation practices (Table 10). The possible explanation was that the educated farmers tend to have better understanding of soil erosion risks and hence tend to spend more resources (such as labor, time and money) on soil conservation practices. This is because literate farmers often serve as contact farmers for extension agents in disseminating information about agricultural technologies from government agencies (Tenge *et al.*, 2004). Educated farmers can understand, analyze, and interpret the advantages of soil and water conservation technologies easily than uneducated farmers. Similarly, Samgalawe (1998), Paulos (2002) and Yitayal (2004) found a positive relationship between education and the decision to use soil and water conservation measures. Therefore, farmers who are literate are expected to be more likely to use soil-conserving technologies.

Access to extension service positively related and significantly (*P≤0.05*) influenced the perception of farmers on sesbania and elephant grasses as a soil conservation practices (Table 10). The farmer who contact every day with the development agents increased the probability of using biological soil and water conservation technologies through getting necessary information. Studies conducted by Wagayehu (2003) also shown that the positive relationship between extension service and use of improved soil conservation technologies Therefore, it is expected that a household head that has greater contact with a development agent has more likely to use soil conservation technologies.

5. CONCLUSION AND RECOMMENDATION

In the study area, sesbania and elephant grasses were contributing for the improvement of soil physico-chemical properties as compared with the adjacent degraded grazing land. The majority of soil physicochemical properties such as clay, soil moisture content, soil pH, EC, OM, OC, TN, Av.P, CEC and exchangeable bases(Na^{+},K^{+},Ca^{+2} and Mg^{+2}) were higher in sesbania and elephant grasses treated land as compared with adjacent degraded grazing land. The reason might be due to high biomass return for soil improvements. Whereas, Soil bulk density, silt and sand contents were higher in adjacent degraded grazing land compared with sesbania and elephant grasses treated land. This might be due to the less biomass return to the adjacent degraded grazing land because the major part of above ground biomass was removed by livestock grazing which in turn negatively affect the soil physicochemical properties. Besides, the trampling and compaction effect on the soil due to free livestock grazing, soil erosion problem has a role to play in physicochemical soil degradation of the adjacent degraded grazing land.

Regarding farmerś perception, the result of this study indicated that 82.9% of the respondents perceived sesbania and elephant grass has effects on soil physicochemical properties, while 17.1% did not understood effects of the practices on the soil. The reasons why they prefer sesbania rather than elephant grass was the leaf of sesbania is easily decomposed and improve soil properties. This made respondents to have positive understanding on sesbania and elephant grass as a biological SWC. Among an explanatory variables, household head age, education level and access to soil and water conservation extension services were significantly ($P \leq 0.1$) affects the farmers′ perception on sesbania and elephant grasses practices as SWC. Hence, we conclude that on top of the result of selected soil fertility indicated measured, according to the perception of the farmers, sesbania and elephant grasses based SWC were contributed to the improvement of soil physicochemical properties.

Therefore, expanding sesbania and elephant grasses in to other degraded watersheds is better option for soil physicochemical property improvement by considering farmeŕs perception. Besides, further research is needed on amount of sediments trapped by sesbania and elephant grass, micronutrient improvement, and soil health improvements in order to more understand effects of the practices on soil environment.

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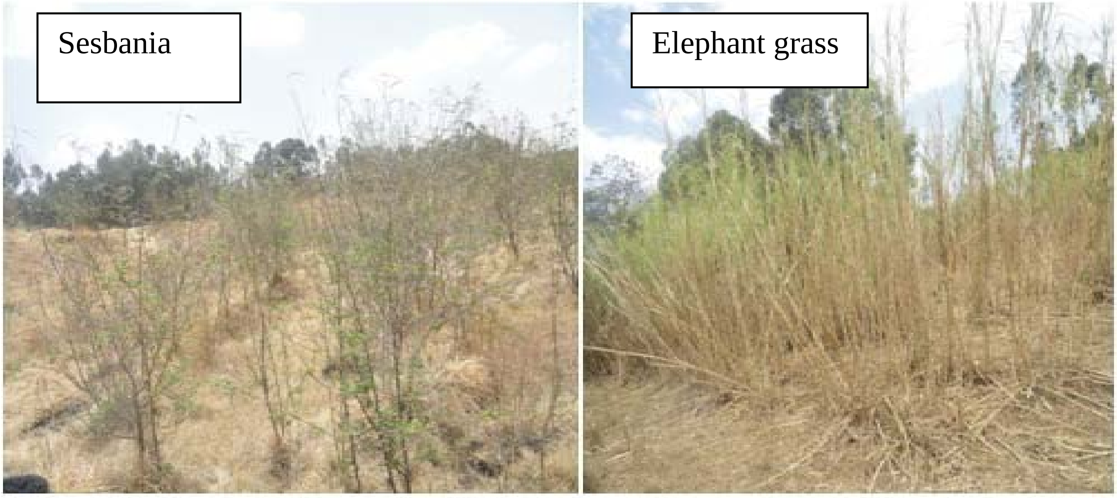
APPENDICES

Appendix 1: Land rehabilitated with sesbania and elephant grasses in Lemo Woreda, Hadiya Zone.



Appendix 2: Focus Group Discussion with selected households and Key informant interview

Appendix 3: Relative change of land management practices compared with control

Soil properties	Land mgt practices			Relative change of sesbania and elephant grass as compared with control	
	LS	LE	GL	∆LS	∆LE
Clay	49	47	31.5	35.71	32.98
Sand	22.5	23.5	27.5	-22.22	-17.02
Silt	28.5	29.5	41	-43.86	-38.98
BD	1.08	1.12	1.26	-16.67	-12.50
SMC	32.13	31.09	22.22	30.84	28.53
pH	6.1	6	5.5	9.84	8.33
EC	0.24	0.23	0.18	25.00	21.74
OC	2.37	2.17	1.97	16.88	9.22
TN	0.21	0.18	0.165	21.43	8.33
Av.P	3.85	3.52	2.86	25.71	18.75
CEC	32.68	30.96	22.55	31.00	27.16
Mg	3.39	3.20	2.33	31.27	27.19
Ca	25.48	24.14	17.58	31.00	27.17
K	1.57	1.41	1.15	26.75	18.44
Na	0.05	0.042	0.032	36.00	23.81

LS=land with sesbania, LE=land with elephant grasses, ∆LS=relative change of sesbania and ∆LE=relative change of elephant grasses as compared with control. Here degraded grazing land used as a reference point, this implies sand, silt and bulk density decreasing at sesbania and elephant grass site.

Appendix 4: Questioner for socioeconomic data collection

This questionnaire is designed to gather information for a study on **Effect of Biological Soil and Water Conservation on Degraded Soil and Farmers' Perception on Land Management Practices**. **A case of Lemo Woreda, Southern Ethiopia.**

Kebele: ________________question no__________ Date of interview________________

Part-I: Households' Characteristics

1.1. Age of household: ________sex______ education status________family size_____

1.1.1 What is the composition of the household by age and sex group?

Age group	Male	Female	Total
<18			
18-64			
>65			

1.2. How many hectares of land do you have? ______________

Do you think that your landholding is sufficient to support the household (food production, transferring to adult boys)? ______________________________________

1.2.1. How do you get the land you have currently? a) Renting b) share cropping c) inherited from parents d) if any other specifies ___________________

1.2.2 How do you think about the productivity (input/output) of your land? a) Increasing b) Decreasing c) Constant

1.2.2.1 If it is increasing or decreasing, how? ________________________________

1.2.2.2 What are the indicators (based on the answer he/she should give indicator for increasing, decreasing, constant)

1.2.3 Do you think that your soil is fertile? Yes/no?

If yes, how do you keep the fertility of your soil? _________________________________

If no, do you have planned to work on restoration of your soil's fertility by applying a) fertilizer? b) Compost c) manure, ____________________________________

1.2.3.1 If the fertility of your land is declining what is the indicator? __________________

1.2.3.2 How many home animals (in number and in kind) do you have and for what purpose do you use the manure generated from them?

Part-II: Soil Erosion

2. Causes and consequences of soil erosion

2.1. What are the indicators of soil erosion in your land? ____________________________

2.2. What condition brings soil erosion? (Put in order from most to least important)

Causes of Soil Erosion	Rank (1, 2…)
Land forms:(cultivation of slope-gradient, length and shape)	
frequent tillage and lack of fallowing	
Absence of soil conservation practices	
Inappropriate farming	
heavy rainfall	
Vegetation (any green plants) removal	
Over grazing by cattle. If any other……………	

2.3. What is the effect of soil erosion on your land?

Effects of Soil Erosion	Rank (1, 2…)
Top fertile soil loss	
Growth of crop and yield reduction over time	
Soil color change over time	

Gully formation	
Siltation in ditches, streams , reservoirs	
Pollution of water bodies	

2.4. How do you describe the degree of soil erosion in your farmland? a) Severe b) Moderate c) Minor d) No erosion risk

Part-III: Soil Conservation

3. Awareness and practicing of soil conservation technologies

3.1. Do you perceive that the land productivity increasing with soil conservation practices?
a) Yes b) Never c) Do not know

3.2. If your answer is ‘Yes’, have you been practicing soil conservation?
a) Yes b) No c) Do not know

3.3. If say ‘Yes’, what kinds of soil conservation practices do you apply?

3.4. If your answer is ‘No’, what is the reason behind? ____________________________

3.5. If you do not practice biological SWC in your land, what is the reason? _______

3.6. How do you think biological soil and water conservation in terms of cost? a) Very cheap and easy b) cheap c). Expensive d) Expensive and labor intensive e) do not know

3.7. How do you perceive the effectiveness of biological methods to reduce soil erosion?
a) Less effective b) Effective c) More effective) do not know

3.8. Where/on which plot do you practice specific type of biological soil conservation?
a) Cultivation field b) Grazing field c) degraded land d) Other

3.9. Do you get training on soil and water conservation technologies? a) Always b) Sometimes c) Never d) Do not know

3.10. Where did you get information on soil and water conservation practices?
a) Traditionally b) from neighbors c) From DAs and experts d) from other non-governmental organizations e) Other sources specify__________

3.11. Do you have contact with DAs? a) Yes b) No c) Do not know

3.12. How do you describe the contact with DAs? a) None b) Limited c) good d) Very good

3.13. What factor do you think affect practice of biological soil conservation practice?

3.14. Do you like trying new technologies whenever they are introduced to the area?
a) Yes b) No c) Do not know

4. Which grass and tree species do you use for rehabilitating degraded land? ________

4.1 What is your awareness towards elephant grass and sesbania on rehabilitating degraded land? ____

4.2 Why do you prefer them than other species? ________________________________

4.3 Where do you plant sesbania and elephants grass? a) On degraded land b) on cropland

c) around homestead d) as a boundary or live fence

4.4 Which one is more effective in rehabilitating degraded land? _____________________

4.5 Do you think any other use of elephant and sesbania rather than rehabilitation of degraded land?

4.6 What are socioeconomic factors, which influence biological SWC (E&S) practices in your Kebele) List and describe influence these practices? ___________________________

4.7 What are institutional factors, which influence biological SWC practices?

a) List and describe how they influence these practices? _________________________

4.8. What are biophysical factors, which influence biological SWC practices (E&S)?

a) List and discuss how they influence these practices? ___________________________

4.9 Why did you rehabilitate degraded land? ___________________________________

4.10. Do you practice biological SWC measures as like to physical measures?

If say No, why? _______________________________________

4.11. If yes, what type of biological SWC practices? a) Crop rotation b) Agroforestry c) elephants grass d) sesbania e) desho grass f) vetiver g) Green manure h). If any other____

4.12. Is this rehabilitated land communal or individual? And who is responsible?

4.13. What are the reasons for the failure of different SWC practices?

4.14. Who is your source of information (rank them in order) regarding conservation strategies of land management? a) Neighboring farmer b) NGOs c) Extension services (DAs) d) Field days & training's

4.15. Who initiated the rehabilitation of degraded land and why it needed?

4.17. What was your feeling during land rehabilitation? a) Positive b) negative c) Neither

4.18. How is the rehabilitated land managed? a) Committee b) PA administrators c) Community d) Idir e) other

4.19. Does the entire community member participate in the management of the rehabilitated land? a) Yes b) No