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Extent & Impact of Land Degradation and Rehabilitation Strategies: Ethiopian Highlands

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Abstract
Throughout the world today, depletion of natural resources is among the major problems facing human beings. Land degradation, especially in the highlands, has been identified as the most serious environmental problem in Ethiopia. The Hararghae highlands in Eastern Ethiopia, Tigrai, Wollo, and Semen Shoa highlands in the north and the Gamo-Gofa highlands and the Bilate River basin, which starts in eastern slopes of Gurage highlands and stretches through eastern Hadiya and Kembatta highlands are some of the seriously eroded/degraded land surfaces in Ethiopia. The dominant man induced causes of land degradation in Ethiopia are poor farming practices, population pressure, overgrazing, over cultivation, soil erosion, deforestation, salinity and alkalinity problems, and the use of livestock manure and crop residue for fuel as energy resource of the rural households. The recorded annual soil erosion (surface soil movement) in Ethiopia ranges from low of 16 tons/ha/yr to high of 300 tons/ha/yr depending mainly on the slope, land cover, and rainfall intensities. The total estimated annual soil loss (surface soil movement) from the cultivated, range and pasture lands (780,000 km^2) in Ethiopia is estimated to range from low of 1.3 to an average of 7.8 billion metric tons per year. Study put the degraded area on the highlands at 27 million ha of which, 14 million hectares is very seriously eroded with 2 million ha of this having reached a point of no return, and the soil depth is so reduced that the land is no longer able to support any vegetative cover. Land degradation costs/indicators are reduced yield, change in land-use, and change in crops, abandonment of fields, and altered livestock mixes and patterns of grazing, flooding, changes in stream flow, silting of rivers & dams, unreliability of irrigation water flow and decline in quality of drinking water and ground water, loss of environmental services, migration and associated loss of human capital and break up of communities, social costs of poverty, and reduced ability to invest in anti-degradation activities, loss of soil from farm plots and the loss of nutrients resulting in decreased productivity or the need for increased inputs to maintain productivity. Therefore, to minimize or avoid the current and potential undesirable consequences, proper attention must be given to the degraded areas in the country. Rehabilitation measures of degraded lands improve the overall ecological conditions of degraded areas so that they can provide better socio-economic benefits, Biodiversity and environmental services to the local communities.
Keywords: Land degradation, Rehabilitation strategies, Ethiopian highlands

Introduction

Environmental problems in the developing world are closely linked with the use of the environmental resources particularly land resources [61]. Land degradation is worldwide problem with its acuteness in developing countries. "The fight against drought, land degradation and desertification is now an international priority, and our Strategy is the battle plan, signaling an ambitious yet pragmatic new departure in the life of our Convention" [70] was the introductory speech by General secretary of the UNCCD on high level policy dialogue. Land degradation is one of the major socio-economic and environmental problems, affecting one billion people in 110 countries worldwide and is prevalent across about 40 percent of the earth's surface [72] and [23]. Land degradation may occur at any time in any geographical region of the planet. It is limited neither by space and time nor by particular natural circumstance. However, specific types of land degradation problems and the level of severity exhibit considerable differences across various parts of the world [74] and [76]. It is an increasing problem in many parts of the world. Success in fighting land degradation requires an improved understanding of its causes, impact, degree and relationship with climate, soil, water, land cover and socio-economic factors [46].

Natural resource degradation in general and land degradation in particular has a great effect on the economies of developing countries. It is one of the most critical environmental issues facing many countries today [11]. In Africa, it is estimated that about 320 million ha, or about one quarter of its dry lands, are affected by different types of soil erosion [4]. The economy of many developing countries, including Ethiopia, is heavily dependent on agriculture, and the livelihoods of the vast majority of their populations depend directly or indirectly on this sector. This dependence on agriculture increases the vulnerability of the economy of these countries to problems related to land degradation [76].

Land is being the critical agricultural resource and the basis for survival of most people in Ethiopia. The largest proportion of the employment for labour is contributed from the agriculture sector. In spite of this, land is seriously threatened by land degradation throughout the country, threatening both the economic and survival of the people. It is a severe problem that leads to low agricultural productivity, which aggravates food security problems [36] and one of the major environmental threats that have well been acknowledged as a serious

problem in Ethiopia. Land degradation in Ethiopia is a result of complex and interacting processes including adverse changes in soils, water, vegetation, biodiversity, and local climatic resources [58].

The Ethiopian highland studies revealed that the Ethiopian highlands, which cover 44% of the country's total land area are seriously threatened by soil and biological degradation. Land degradation, especially in the highlands, has been identified as the most serious environmental problem in Ethiopia [10]. Some 27 million ha representing approximately 50% of the highlands are already significantly degraded. Of this area 14 million ha are badly eroded and if the present trend of soil degradation continues, per capita income in the highlands will fall by 30% in 20 years' time. Around 54% of the remaining highlands are highly susceptible to erosion ([29]; [30]).

According to ([29]; [2]) the Hararghae highlands in Eastern Ethiopia, Tigrai, Wollo, and Semen Shoa highlands in the north and the Gamo-Gofa highlands and the Bilate River basin, which starts in eastern slopes of Gurage highlands and stretches through eastern Hadiya and Kembatta highlands are some of the seriously eroded/degraded land surfaces in Ethiopia. **As** in [3] in Ethiopia land degradation, declining agricultural productivity, and poverty are severe and interrelated problems that appear to feed off each other. In light of the increasing population and the low levels of urbanization, all projections indicate that land degradation in Ethiopia is bound to proceed at aggravated rates unless significant progress is made in conservation, rehabilitation, and restoration.

The general aim of this paper is to review the magnitude, extent, causes, consequences and potential impacts of land resource degradation and rehabilitation strategies in Ethiopian Highlands.

2. Results and Discussion

2.1 The Concept of Land and its Resource Deterioration

Land is internationally defined as "a delineable area of the earth's terrestrial surface, encompassing all attributes of the biosphere immediately above or below this surface, including those of the near surface climate, the soils and the terrain forms; the plant and animal population, the human settlement pattern and physical results of past and present human activity" [77]. It is the main resource on which our society depends for production of food, energy and other requirements [58].

Land degradation and soil degradation are often used interchangeably; however land degradation has a broader concept and refers to the degradation of soils, water, climate, and fauna and flora [6]. It refers to changes in the qualities of soil, water and other characteristics that reduce the ability of land to produce goods and services that are valued by humans [36]. The term land degradation refers "the aggregate reduction of the productive capacity of the land, including its major uses like rain fed, arable, irrigated range land, forest and its farming systems such as smallholder subsistence and its value as an economic resource" ([63]; [4]).

It is also broadly defined as any form of deterioration of the natural potential of land that affects ecosystem integrity either in terms of reducing its sustainable ecological productivity or in terms of its native biological richness and maintenance of resilience. It is a worldwide phenomenon substantially affecting productivity in over 80 countries on all continents [35]. It is in Africa a serious problem with a considerable impact on the economies of many countries in the continent. About 25 percent of the world's degraded land is located in Africa ([58]; [56]). Land degradation is a composite term; it has no single readily-identifiable feature, but instead describes how one or more of the land resources such as soil, water, vegetation, rocks, air, climate, relief has changed for the worse [63].

The cause of land degradation may be single or a complex mix of causes. Some are bio-geophysical; some socio-economic (human) activities, while some are institutional factors like inadequate land policy frameworks and it is quite possible that causes may be indirect, perhaps cumulative and difficult to identify [28]. Population pressure is given emphasis on the speech as the significant factor that is aggravating land degradation.

Ecological restoration is an intentional activity that initiates or accelerates the recovery and sustainability. Frequently the ecosystem that requires restoration has been degraded, damaged, transformed or destroyed as those direct or indirect human activities [7]. Rehabilitation is a broader term that refers to any attempt at repairing or restoring a damaged ecosystem, without necessarily attempting a complete restoration to any specific prior conditions or status. In essence both restoration and rehabilitation are similar, but unlike restoration, rehabilitation contains little or no implication of recreating the original ecosystem. The word 'rehabilitation' is used to indicate any act of improvement from a degraded state ([62]; [40]). Restoration is defined as the return of an ecosystem both the structure and the function to a close approximation of its condition prior to disturbance ([21] and [52]).

In Ethiopia, rehabilitation starts with area closure that involves the protection and resting of severely degraded land to regenerate its productive capacity [78]. Continuous deterioration of the natural resource base has become a serious threat to both ecosystem functions and economic production of Ethiopia. To combat these problems national level environmental conservation and rehabilitation efforts were started in the 1970s with particular focus on the forest deteriorating highland areas [13] and are focusing mainly on installing biophysical

measures or structures and pay less attention to the socio-economic and institutional side of the problem. This had led to poor performance of many of the environmental reclamation programmes in Ethiopia [5].

2.2 Land Degradation in Ethiopian Highlands

The highland areas in Ethiopia are defined and delineated to represent the land areas above 1500 m a.s.l. and the lowlands are defined as areas below 1500 m a.s.l. in altitude. More than 90% of Ethiopia's population live in the highlands including about 93% of the cultivated land, around 75% of the country's livestock and accounts for over 90% of the country's economic activity. Land degradation is seriously threatening the economic and social development of the country as a whole. Due to degradation, increasing number of Ethiopians have become vulnerable to the effects of drought. The severity of the devastating droughts and the resulting famines in 1972/73 and 1984/85 can be attributed to an accelerating process of degradation combined with widespread general poverty of the population [29].

2.2.1 Severity and Consequence of land degradation in the Country

There is no region of the globe where water erosion is not a threat to the long-term sustainability of mankind. Accelerated soil erosion is the one influenced by man through overgrazing, cultivation, road construction and monocultures on steep land without conservation measures (Alemayehu, 2009). According to [33] Ethiopia faces the most pressing and difficult problems in feeding its population. FAO described that between1996-98 more than 35 percent of the population of the country was undernourished and high-energy deficit. Land degradation due to soil erosion and nutrient depletion, cause a serious problem on the livelihood of the rural producers.

Ethiopia's fast-growing population is also significantly hurrying land degradation. The population has tripled in the last 50 years and has abused the land by deforestation for more cropland and grazing area and by overgrazing. Recurrent droughts have further aggravated the situation, leading to repeated cycles of famine in recent years. Efforts are being made to avert the degradation, but with very little progress [59].

Land degradation in the form of soil erosion and declining fertility in the country is serious challenge to agricultural productivity and economic growth [52]. Soil erosion by water is by far the greatest land degradation problem. Water erosion not only removes nutrients but also may reduce thickness and the volume of water storage and root expansion zone. Under extreme gully erosion, farm activities are extremely affected. The magnitude and rate of soil erosion continued to increase despite the considerable efforts made during the past three decades. The soil conservation research project estimated an average soil loss of the 42 t/ha/year on cultivated lands and in highly erodible and intensively cereal cultivated fields it ranges 300-400 t/ha/ year [1].

Table 3:Soil loss from three measure land use sytems [44]

Type of land use	Topographic features	Annual soil loss
Cultivated Land	Steep slope	>100t/ha
Grazing Land	Flat-undulating	<10t/ha
Forest Land	Undulating	10t/ha

Table 4: Comparison between predicted and observed (Ethiopia) [55]

Research Site	Slope Gradient [%]	Calculated Soil Loss (mean)	Measured Soil Loss (Mean)	Remark
Andit Tid	39		212t/ha	
	40	686t/ha		
Anjeni	12		213t/ha	
	10	20t/ha		
Maybar	16		22t/ha	
	16	24t/ha	-	

Table 5: soil loss under different crop variety [55]

Source of information	No of plots	Crop Type	Soil loss	Remark
SCRP 2000b, 41:	7	Wheat	185.1t/ha*a	
	12	Lentil	180t/ha*a	
	10	Barley	141.1t/ha*a	
SCRP 2000c 40:	4	Wheat	192.6t/ha*a	
	6	Teff	178.3t/ha*a	
	5	Barley	111.9t/ha*a	
	3	Horse Beans	115.5t/ha*a	

The implications of land degradation are extremely important, as the livelihoods of many Ethiopians are entwined with land resources. Degradation reduces the production potential of land, and thus makes it difficult to produce enough food to feed the growing population. It also increases farmers' vulnerability to food shortages

and becomes a threat to the mere survival of the people. The looming food insecurity in the country is mainly linked to the prevailing degradation problem [4]. Land degradation impacts were assessed in social and economic terms only for soil erosion. Four types of costs were specified such as lost cropland, lower crop yield, lost grazing land, and lower grass yield. These costs were compared to costs incurred in the absence of soil erosion [3]. Associated with the soil movement is the loss of organic matter, nitrogen, phosphorus, potassium and other essential plant nutrients [41].

2.2.2 The cost of land degradation in Ethiopia

Land degradation represents a loss of natural capital, the value to society of land, water, plant, and animal resources. Indicators are reduced yield, change in land-use, and change in crops, abandonment of fields, and altered livestock mixes and patterns of grazing [12]. The quality of environmental services indicated by such processes as changes in stream flow, silting of dams, unreliability of irrigation water flow and decline in quality of drinking water. These losses also result in costs related to changes in rural society due to processes such as migration and associated loss of human capital and break up of communities, social costs of poverty, and reduced ability to invest in anti-degradation activities. Most current evaluations of the costs of land degradation have focused on the loss of soil from farm plots and the loss of nutrients resulting in decreased productivity or the need for increased inputs to maintain productivity [4].

Table 4: Annual loss of OM, N and P associated with the loss of top soil under various land use systems [42].

			Nutrient documented range of annual loss, kg/ha					
		OM	15	50	100	200	500	1000
	Land area	N	5	10	15	30	50	65
Land use type	million ha	P	15	30	50	75	100	150
			Amount of nutrient loss, million kgs					
1. Cultivated land	18	OM	270	900	1800	3600	9000	18000
		N	90	1800	270	360	900	1170
		P	270	360	900	1350	1800	2700
2. Pasture & rangelands	60	OM	900	3000	6000	12000	30000	60000
		N	300	600	900	1800	3000	3900
		P	900	1800	3000	4500	6000	9000
Total	78	OM	1170	3900	7800	15600	39000	78000
		N	90	780	1170	2160	3900	5070
		P	1170	2160	3900	5850	7800	11700

Table 5: Annual soil movement (loss) documented in Ethiopia under various land use systems and topographic features [42].

Land use type	Land area million ha	Documented range of annual soil loss, ton/ha/year 16	50	100	200	300
		Annual soil movement, million tons				
1. Cultivated land	18	288	900	1800	3600	5400
2. Pasture & rangelands	60	960	3000	6000	12000	18000
Total	78	1248	3900	7800	15600	23400

Land degradation has direct and indirect costs.

Direct costs include:

- The costs of nutrients lost through topsoil erosion and the cost of replacing these nutrients.
- The production that is lost because of nutrient and soil losses.
- The costs of forest removal.
- The loss of livestock carrying capacity.
- The decline in cropped area.

Indirect costs mainly include:

- ✓ The loss of environmental services.
- ✓ The silting of rivers and dams.
- ✓ Increasing irregularity of streams and rivers.
- ✓ Reduced groundwater reserves.
- ✓ Flooding.
- ✓ Other costs, related to social and community losses from malnutrition, poverty and migration

A number of conceptual issues interrupted on estimates of the cost of land degradation, the most important of which are definitional guess. Such as differentiate between land degradation and soil degradation. These terms are often used interchangeably but are not necessarily synonymous. Land degradation is a broad, composite, and value-laden term that is complex to define but generally refers to the loss or decline of biological and/or economic production. [71] defines land degradation as a reduction of resource potential by one or a combination

of processes including water erosion, wind erosion, a long-term reduction in the amount or diversity of natural vegetation. Soil degradation is a narrower term and a component of land degradation. It refers to a process that lowers the soil's current and/or potential capacity to produce goods or services. Six specific processes are recognized as the main contributors to soil degradation are soil erosion, wind erosion, water logging, excess salts, chemical degradation, biological degradation, and physical degradation [19].

Most studies estimating the costs of land degradation restrict themselves to on-site impacts; the analysis of off-site effects, although frequently recommended, is rare. It is usually conducted only in qualitative terms because it is difficult to measure such impacts. The implication is that tendered values often underestimate actual costs [3].

[30] tried to assess the magnitude of the degradation problem in social and economic terms. Referring to the conclusion in 1981 of a USA National Soil Erosion/Soil Productivity Research Planning Committee that "erosion reduces productivity first and foremost through loss of plant-available soil water capacity", and the need to consider the relation between erosion induced yield reductions and remaining soil depth. It is difficulty of estimating these in the Ethiopian highlands. Because of slopes in much of the cropland in the Ethiopian highlands are much steeper.

Impact on Production and Environment Rehabilitation

As from [42]; the major impacts of land degradation on production and env't rehabilitation include:

- Soil loss caused by erosion reduces soil depth, consequently decreasing the amount of soil moisture and leading to the loss of plant nutrients. This contributes to the loss of grain production in the order of 80,000–180,000 tons per year ([57]; [29]). In addition, if the present soil erosion rates stay at their current levels, it is projected that land covered by soil less than 10 cm deep will increase from 20,000 km2 in 1985 to 100,000 km^2 by 2010, contributing to large losses to crop production potential.
- The estimated soil movement ranges from 1,248 to an average value of 7,800 million tons per year causes a loss of organic matter of the order of 1.17–7.8 million tons, nitrogen from 0.39 to 1.17 million tons and phosphorus 1.17–3.9 million tons per year. The yearly loss of nitrogen and phosphorus from 780,000 km2 of cultivated, pasture and rangelands in Ethiopia is estimated to be equivalent to 327–1064 million US dollars per year [42].
- The recurring droughts and low, erratic rainfall are responsible for the loss of thousands of human lives, millions of livestock and annual crop loss of up to 20% during severe drought years in-terms of grain produced (1,8 million tons per year).
- The present burning of animal dung and crop residues for fuel is estimated to represent a loss in crop production of 700,000 tons of grain [57].
- The estimated annual loss of forests of between 150,000 and 200,000 ha is equivalent to about 6% of the remaining natural high forest. At this rate the natural forests will be gone in 15–20 years [24].

Table 6: Soil erosion loss on 6 SCRP sites in various parts of Ethiopia [18]

Site	Soil loss (tons/ha/year)
South Wollo	36.5–53.8
Sidamo	41.2–49.5
Harar	25.5–27.8
North Showa	152.4–214.8
Gojam	40.2–199.2
Illubabur	18.0–135.3

2.3 Causes and Consequences of land degradation

2.3.1 Causes of land degradation

Land degradation is one of the major causes of low and in many places declining agricultural productivity and continuing food insecurity and rural poverty in Ethiopia. Part of the reason for lack of solution to the problem is the need for multiplex approaches; "one size fits all" approaches won't solve the problem in the heterogeneous environment of the Ethiopian highlands. Therefore, there is a need to identify what works where and provide farmers an array of potentially effective options, as well as addressing constraints that inhibit adoption of potentially effective measures through appropriate policies and investment programs**.** The causes of land degradation can be divided in to natural hazards, direct causes, and underlying causes. Natural hazards are the conditions of the physical environment, which leads to the existence of a higher degradation hazard. Land degradation is the result of complex interactions between physical, chemical, biological, socio-economical, and

political issue of local, national or global nature [31] and [65].

Causes of land degradation are not only biophysical, but also socioeconomic like land tenure, marketing, institutional support, income and human health; and political incentives, political stability. Land degradation damages soil structure and leads to the loss of soil nutrients through processes such as water or wind erosion; water logging and salinization; and soil compaction. The main causes of land degradation are inappropriate land use, mainly unsustainable agricultural practices, overgrazing, and deforestation [56].

According to [71], the effects of deforestation, forest degradation and forest fires represent a permanent loss of the potential capacity of forest resources to generate economic benefits. Deforestation is a major issue in Ethiopia, since it is one of the main causes of the prevailing land degradation and loss of biodiversity. Tree cutting is a common occurrence which has been taking place for centuries [56]. A long time back in history some parts of northern Ethiopia, which are today suffering from conditions caused by land degradation, were covered with forests. In present day Ethiopia, however, forests are being destroyed at an alarming rate and the area covered by forests at present is only less than 2.4 percent compared to the estimated 40 percent before one hundred years initial coverage [45].

2.3.1.1 Direct causes of land degradation

There is a general agreement on the direct causes of land degradation. These include production on steep slopes and fragile soils with inadequate investments in soil conservation or vegetative cover, erratic rainfall patterns, decline uses of fallow, limited recycle of dung and crop residues to the soil, limited application of external source of plant nutrients, deforestation and overgrazing. Many factors underlie these proximate or direct causes including population pressure, poverty, high costs of inputs and limited access to agricultural inputs and credit, low profitability of agricultural production and many conservation practices, high risks facing farmers, fragmented land holdings and insecure land tenure, short time horizons of farmers and farmers' lack of information about appropriate alternative technologies [4].

There are four major causes of land degradation such as deforestation, overgrazing, agricultural activities, and over exploitation. The well known proximate causes of land degradation include deforestation, overgrazing, limited soil and water conservation measures, limited application of nutrients/organic matter, burning of dung and crop residues and declining use of fallow [32] & [76].

Agricultural mismanagement of soil and water resources include non-adoption of soil and water conservation practices, improper crop rotation, use of marginal land, insufficient and/or excessive use of fertilizers, mismanagement of irrigation schemes and over pumping of ground water [33]. Lack of early awareness about soil erosion and soil fertility decline by farmers is another possible cause of land degradation [69]. These all are direct causes of land degradation primarily caused by human intervention exposing natural resources to depletion and loss. Human interventions expose the soil to erosion and induce depletion of natural capital asset of society [76].

3.3.1.2 Indirect causes of land degradation

Population increase, land shortage, insecure land tenure, poverty and economic pressure are indirect causes of land degradation [32]. Population growth has long been considered a prime cause of environmental degradation [9]. It forces farmers to cultivate marginal land. With current trend of population growth there is a poor prospect for ecological sustainability and economic viability of the current agricultural practice unless an effort is made to integrated development in family planning, environmental rehabilitation, and agriculture supported with enabling policy [32].

A study made in north western Ethiopian highlands by [37] concluded the absence of sound land use tenure policies (frequent changes in the tenure systems and frequent distribution of land), population pressure, weak economic development strategies, unstable institutional frame works, and weak link between research and extension have all been found to be root causes of land degradation and are major policy constraints that discourage the farmer from making any sort of investments in the land to use it in a suitable way. When families believe that the land tenure system is unfavorable to them, they are reluctant to invest in good agricultural practices, such as soil and water conservation and management. In similar way, in Ethiopia with the lack of land ownership, farmers have the tendency to make the land less attractive to others [33]. The current land policy of Ethiopia, i.e., the right to use and transfer to their children is expected to affect long term investments including construction of conservation bunds, planting trees, short term fallowing and alike [69]. In addition to insecure tenure, communal grazing land and wooded areas for the extraction of firewood give rise to land degradation [36].

2.3.2 Consequences of land degradation

According to UNCCD, the consequences of land degradation include undermining of food production, famine, increased social costs, decline in the quantity and quality of fresh water supplies, increased poverty and political instability, reduction in the land's resilience to natural climate variability and decreased soil productivity [56]. Land degradation effects on agricultural productivity are manifested through their impacts on both, the average and variance of yield, as well as the total factor productivity of agricultural production [33]. It affects agricultural

productivity, leads to clearance of forests and native grasslands as existing land loses productivity, places demands on other natural resources to repair the land. These impacts are translated into economic costs in the form of loss of income (or consumption), increased income risk and increase costs of production.

Soil degradation has resulted in decreased food production, droughts, ecological imbalance and consequent degradation of the quality of life. The SCRP has estimated that about 1.5 billion tones of soil are eroded every year in Ethiopia [32]. Similarly, the Ethiopian high lands reclamation study estimated that between 1985 and 2010 the rates of land degradation will cost 15.3 billion Ethiopian Birr, most of which (78 percent) is due to crop failure or low yields and 22 % is due to decreased livestock population [68]. As commonly known degraded soils rarely respond to mineral fertilizers, have very poor water-holding capacity, and totally have low productive capacity that manifests itself through decreased food production [36]. In addition to its natural capital asset depleting effect, soil erosion also induces immediate on site effects, those that happen at the site where erosion occurs, and off-site effects which have positive or negative effects as the soil leaves the boundary or the field due to erosion and enters another field or watershed [76].

2.4 Rehabilitation strategies of degraded lands in Ethiopia

2.4.1 Soil and Water Conservation Practices

Ethiopia has been seriously affected by soil erosion for centuries. To achieve sustainable development, ecologically friendly and locally acceptable technologies need to be developed, transferred and adopted. Natural resources can potentially be used in a sustainable way through appropriate technology. Following the sustainability pattern, "appropriate", would require that a technology should be ecologically protective, socially acceptable, economically productive, viable and reduces risk [43]. Management of watersheds can be made possible by using a variety of technologies such as vegetation conservation like grass contours, alternative tillage techniques and physical structures including terraces, micro basins, stone and soil bunds, *fanya juu* (throw up hill), gabion box, etc [34].

To combat the land degradation problem, the Ethiopian government launched a massive soil conservation programme in the middle of 1970's. The following physical and biological conservation measures were carried out between 1976 and 1992 such as 78,000 ha of soil and stone bunds; 253,000 ha of hill side terraces and afforestation ;15,400 km of check dams in gullied lands ; 410,000 ha of closed areas of natural regeneration (area enclosure);465,000 ha of land planted with different tree species; 580,000 ha of bench terraces; National conservation strategy has been completed and ratified; Action plan to combat desertification is under way; National population policy is adapted; Disaster prevention and preparedness programme has been approved and implemented; Ethiopian Forestry Action plan has been prepared; Environment Protection Agency has been established; and Agricultural development and environment rehabilitation are given first priority in the Government of Ethiopia's Economic Development Policy ([41]; [42]; [18]; [24]).

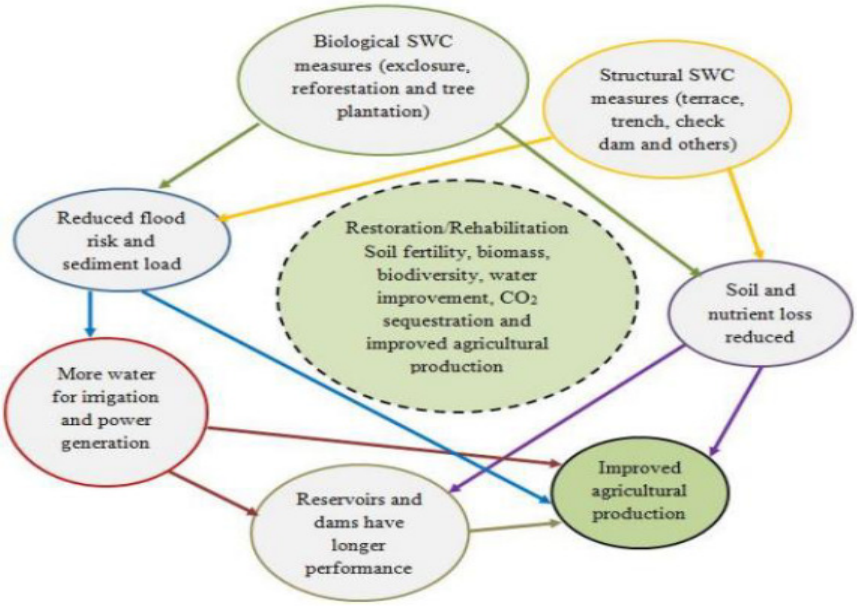

Figure 1: Conceptual framework demonstrating implication of SWC measures in degraded land rehabilitation [22].

Degraded soils are a major constraint to agricultural production and food security in the southern Ethiopian Highlands. Despite experiencing problems with degraded soils and food insecurity, and acknowledging the

potential benefits of certain technologies, many farmers in Areka may decide not to integrate these techniques into their production system. Soil conservation measures often reduce the amount of available farmland and incur additional costs. More farmers may be willing to adopt soil and water conservation measures if they provide immediate additional benefits, such as the potential to generate extra income [8] & concluded in the table below.

Table 6. Perceptions of integrated soil fertility management measures according to different socio-economic groups[8]

Practice	*Wealth group I*		*Wealth groups III &IV*	
	Advantages	*Disadvantages*	*Advantages*	*Disadvantages*
Legume cover crops	• Enhance soil fertility • Provide fodder • Conserve soil moisture	• Compete for land • No immediate benefit	• Protect soil from sunlight and runoff	• Occupy space for long time • No food value
Crop rotation	• Enhance soil fertility • Less fertiliser requirements • Pest control	• None	• Enhances soil fertility • Improves yield	• None
Incorporating crop residues	• Improves soil fertility • Increases yield	• Shortage of animal feed	• Improves soil fertility	• Shortage of fuel and fodder
Soil bunds	• Reduce runoff • Possible to plant grasses & perennials	• Require a lot of labour • Ploughing with oxen difficult	• Erosion control	• Require a lot of labour • Take up land
Increased vegetative cover	• Controls runoff • Provides fodder and fuelwood • Provides litter for green manure	• Makes it difficult to control perennial weeds	• Increases availability of fodder • Controls runoff	• Competes for land and moisture
Mulch	• Conserves moisture • Improves soil fertility	• Reduces supply of fuelwood and fodder	• Conserves moisture • Improves fertility	• Attracts termites
Minimum tillage	• Reduces labour and costs • Reduces erosion	• Hard to control weeds • Crops establish poorly • Hard to cultivate	• Reduces cost of hiring oxen	• More weeds • Crops establish poorly • Crop selective

2.4.2 Land rehabilitation efforts with area exclosures

In fact, in a country like Ethiopia, where vast degraded ecosystems and a rapidly growing human population occur, and where all livelihood and economic development are to continue to emerge from agriculture and biological resources, the establishment of exclosures is one of the strategies widely used for rapid rehabilitation of degraded lands in the tropics, which is also true in Ethiopia. Area exclosures can be defined as a degraded land that has been excluded from human and livestock interferences, for rehabilitation [17]. The principle is that the two main causes of land degradation are human and animal interference [66]. In order to foster rehabilitation of exclosed areas, in some areas soil and water conservation activities are practiced side by side with exclosures, while in another tree plantings exist. Now days, area exclosure approach is extensively applied in northern Ethiopia to replenish the vast denuded hillsides in line with the need to provide livestock fodder and other tree products. To this effect, excluding areas has been instrumental towards materializing the major goal; achieving conservation based sustainable agriculture. It is also a means to maintain biodiversity in the dry lands of the region within the rural community [60]. These exclosure areas have shown their capacity to restore vegetation, reduce soil erosion and in some areas to improve wildlife resources as well [47].

The main objective of establishing such enclosures is to improve the overall ecological conditions of degraded areas so that they can provide better socioeconomic benefits to the local communities. Establishing enclosures is considered advantageous since it is a quick, cheap and a lenient method for the rehabilitation of degraded lands [15]. Past reforestation and afforestation programs in the degraded areas have often been unsuccessful with no or very low survival of the planted trees. As part of their fight against land degradation, communities have started establishing enclosures, with the hope of preventing further degradation and promoting their re-vegetation. Despite the fact that enclosures have proved instrumental in the re-vegetation and rehabilitation of degraded lands, knowledge on the diversity and status of regeneration of the developing flora as well as the actual and potential socioeconomic benefits [81].

2.5 Conclusions and Future Directions

2.5.1 Conclusions

Throughout the world today, depletion of natural resources is among the major problems facing human beings. The Ethiopian highlands are affected by deforestation and degraded soils, which have eroded the resource base and aggravated the repeated food shortages caused by drought. Although the Highlands occupy 44% of the total

area of the country, 95% of the land under crops is located in this area, which is home to 90% of the total population and 75% of livestock. Declining vegetative cover and increased levels of farming on steep slopes have eroded and depleted soils in the area, so that soil degradation is now a widespread environmental problem. Farmers also have to cope with nutrient mining caused by insufficient application of fertilizers, shorter fallow periods and low levels of soil organic matter.

The most frequently cited causes include continuous cropping with short or no fallowing triggered by high population pressure, overgrazing, cultivation of highly inclined and marginal lands without adequate erosion-controlling measures, insufficient drainage of irrigation water and deforestation. World- wide inappropriate agricultural practices account for 28 percent of the degraded soils. Therefore, to minimize or avoid the current and potential undesirable consequences, proper attention must be given to the degraded areas in the country. Rehabilitation strategies of degraded lands improve the overall ecological conditions of degraded areas so that they can provide better socio-economic benefits and environmental services to the local communities. And also increase of plant as well as animal biodiversity with time and after the establishment of rehabilitation measures on degraded lands. In areas where degraded lands and rehabilitation measures have been established, particularly in the northern parts of the country, enclosures are among the green spots with considerable species diversity.

Rehabilitation of degraded lands requires designing economically feasible, socially acceptable and ecologically viable management and conservation strategies. Rehabilitation further improve soil quality, should be carefully evaluated because it may decrease the present support for exclosures in the local population. Exclosures are not only effective in restoring vegetation, but also in improving soil nutrient status and reducing erosion. Reversing the degradation process requires comprehensive and cost effective programme of conservation practices.

2.5.2 Future directions

For env'tal rehabilitation to be better attained and sustained in successful way:

- Bottom-up participatory planning, implementation and monitoring by the real stake holders at grassroots level.
- Planning and integrating proper land use, farming practices, and appropriate technologies at grassroots for each specific agro-ecological zone.
- Prepare and implement a national framework for guiding rehabilitation measures on the degraded lands adaptation and mitigation.
- Invest in new afforestation programs, reforestation, and sustainable management of the remaining forests.
- Implement physical and biological measures to minimize soil loss.
- Increase SOM content by incorporating crop residues and manure into the soil and growing legume cover crops and improve the water holding capacity of the soil by contour ploughing, minimum tillage and adding organic matter;
- Strengthen cooperation among policy makers, NGOs, research institutions, and the media.
- Ensure community participation, especially local people in designing rehabilitation measures.

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