

Review

Land degradation and possible mitigation measures in Ethiopia: A review

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Land degradation is considered an important topic of the 21st century, associated with the decline in soil fertility, and has become a serious threat to agricultural productivity in sub-Saharan Africa. Land degradation is widely recognized as reducing agricultural potential and contributing to ongoing food insecurity and rural poverty. The economy of Ethiopia is primarily based on agriculture, and Ethiopia has experienced significant land degradation. Land degradation refers to the temporary or permanent lowering of the productive capacity of land. Common forms of land degradation in Ethiopia include desertification, soil erosion, soil fertility decline, waterlogging, salinization, and a lowering of the water table. Causes of land degradation include population pressure, deforestation, unsustainable agricultural practices, overgrazing, climatic shocks, limited adoption of soil conservation practices, invasive alien species, fires, mining and poverty. The implementation of best management practices (BMP), such as agronomy measures, organic fertilizers, agroforestry practices, minimum soil disturbance, area closure, water management, hillside terraces, fanya-juu terraces, soil bunds, stone bunds, afforestation, and reforestation, are important mitigation measures for land degradation. The implementation of multilateral environmental agreements for achieving zero net land degradation may also be used as a mitigation strategy for addressing land degradation.

Key words: Land degradation, best management practices, multi-lateral environmental agreements, agricultural productivity.

INTRODUCTION

Land degradation and the consequent decline in soil fertility have become a serious threat to agricultural productivity in sub-Saharan Africa (Stoorvogel and Smaling, 1990). The decreasing fertility of soils is considered a major cause of reduced crop yields and per capita food production in Africa. Decreasing soil fertility, coupled with increasing population pressure, is one of the

primary factors contributing to the gap between the demand for and supply of food (Henao and Baanante, 2006). Ethiopia has experienced significant environmental degradation, including soil fertility decline due to natural factors, unsustainable use of its natural resources, unsound ecological practices, and population pressure. Among the detrimental consequences of

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environmental degradation, land degradation stands out as the most pressing issue in Ethiopia. Land degradation is one of the most significant threats to the fundamental resource of the population, particularly in countries like Ethiopia (Bielli et al., 2001).

The Ethiopian economy is predominantly based on agriculture, providing employment for over 80% of the labor force and contributing to 46.3% of the Gross Domestic Product (GDP). Agriculture in Ethiopia is not just an economic activity; it is a way of life upon which the welfare of society depends. This heavy reliance makes the economy vulnerable to problems associated with land degradation (Wagayehu, 2003). Despite a significant portion of the population depending on agriculture for their livelihood, land degradation remains a leading cause of poverty. Farmers struggle to produce enough to invest in land protection, resulting in increasing land resource degradation, primarily due to erosion (Teklu and Gezahegn, 2003). Even though the government of Ethiopia has implemented various interventions, such as mass mobilization and soil and water conservation campaigns resulting in terraces, soil bunds, area closures, and the planting of millions of tree seedlings, the country still loses a considerable amount of fertile topsoil. The threat of land degradation continues to grow at an alarming rate (Belay and Eyasu, 2019). This paper gives detailed review of land degradation and management in Ethiopia with particular emphasis on forms of land degradation, causes of land degradation and Best Management Practices (BMP) and International Agreements against land degradation so as to improve sustainable agriculture.

OVERVIEW OF LAND AND LAND DEGRADATION

Land and its functions

According to the United Nations Convention to Combat Desertification (UNCCD, 2012), land is defined as "the terrestrial bio-productive system that comprises soil, vegetation, other biota, and the ecological and hydrological processes that operate within the system." Land plays a central role in the "nexus" that links energy, food, water, and environmental health in an interdependent loop. The Food and Agriculture Organization (FAO) defines land as all-natural resources contributing to agricultural production, including livestock production and forestry. According to this definition, land encompasses climate and water resources, landform, soils, and vegetation, including both grassland resources and forests. Land serves as earth's infrastructure for life. The rate and quality of production derived from land depend on its major components, with soil and its fertility being of utmost importance. Soil organic matter, which originates from the vegetation growing on soil, is the primary component that regulates soil fertility (FAO, 1995; FAO/UNEP, 1999).

Land is used to meet societal demands, providing various services such as the production of food, fiber, fuel, and other biotic materials for human use. It also offers biological habitats for plants, animals, and micro-organisms, serves as a source and a sink for greenhouse gases, regulates the storage and flow of surface water and groundwater, acts as a buffer, filter, or modifier for chemical pollutants, and provides physical space for settlements, industry, and recreation (De Groot et al., 2002).

Concepts of land degradation

Land degradation is considered a critical issue of the 21st century due to its implications for agronomic productivity, the environment, and food security (Eswaran et al., 2001). It is estimated that up to 40% of the world's agricultural land is seriously degraded (Bai et al., 2008). As discussed earlier, land degradation is one of the adverse outcomes of environmental degradation, which involves the gradual destruction or reduction of the quality and quantity of human and animal activities or natural processes, such as water erosion and wind (Johnson et al., 1997). It encompasses any change or disturbance to the land that is perceived as harmful or undesirable, excluding natural hazards as a cause. However, human activities can indirectly impact phenomena like floods and bushfires.

Land degradation is defined as the long-term loss of ecosystem function and productivity caused by disturbances from which the land may not recover (Bai et al., 2008). It also refers to the reduction or loss of the biological or economic productivity and complexity of various types of land, including rain-fed cropland, irrigated cropland, range, pasture, forest, and woodlands, resulting from land use or a combination of processes, including those arising from human activities and habitation patterns. These processes include soil erosion caused by wind and/or water, deterioration of the physical, chemical, and biological properties of soil, and long-term loss of natural vegetation (UNCCD, 2012).

According to UNEP, land degradation is the temporary or permanent reduction in the productive capacity of land. It encompasses various forms of soil degradation, adverse human impacts on water resources, deforestation, and the lowering of the productive capacity of rangelands. Land degradation is a process in which human-induced processes act upon the land, affecting the value of the biophysical environment (Arthur et al., 1995). While the terms "land degradation" and "soil degradation" are often used interchangeably, land degradation has a broader scope, encompassing soil, water, climate, and fauna and flora. Soil degradation, on the other hand, refers more specifically to water erosion, wind erosion, as well as chemical, physical, and biological degradation (including the loss of organic matter) (Hurni, 1996). Land degradation occurs slowly and cumulatively,

with long-lasting impacts on rural populations, making them increasingly vulnerable (Muchena, 2008). The UN Convention to Combat Desertification (CCD), of which Kenya is a signatory, recognizes land degradation as a global development and environmental issue.

Common forms of land degradation in Ethiopia

Inappropriate land use can lead to soil degradation in Ethiopia. Poor farming techniques often contribute to land degradation. Leaving fields bare or plowing them up and down the sides of a hill can result in severe soil erosion during heavy rainfall because the soil lacks stabilizing elements. When the remnants of crops and animal manure are plowed back into the soil, they serve to replenish and fertilize it. However, if the crops are harvested for animal feed and the manure is burned as fuel, the soil would not have a way to replenish itself, leading to a decline in fertility. Ethiopia is reported to have the highest rates of soil nutrient depletion in sub-Saharan Africa, with soil erosion estimated to average 42 tons/ha/year on cultivated land (Stoorvogel and Smaling, 1990). Ethiopia has a long history of drought, which has significantly contributed to land degradation. Additionally, the combined effects of deforestation, overgrazing, the expansion of cropland, and unsustainable use of natural resources have exacerbated land degradation (Descheemaeker et al., 2011).

Desertification

Desertification is a specific form of land degradation that occurs in dry climates (arid, semi-arid, and dry sub-humid areas). It represents a persistent decline in the services provided by healthy land, particularly in terms of food production. Given the extremely slow rate of soil formation, once the physical, biological, and chemical properties of soils deteriorate, their natural regeneration becomes practically unattainable (UNCCD, 2012). Desertification takes place when productive lands are transformed into nonproductive desert areas due to poor land management. In Ethiopia, especially in semi-arid regions, desertification is expanding over time, primarily due to deforestation and the resulting land degradation caused by population growth and uncontrolled logging.

Soil erosion (water erosion and wind erosion)

The removal of soil particles by the action of water is known as water erosion. It is typically observed as sheet erosion (uniform removal of a thin layer of topsoil), rill erosion (small channels in the field), or gully erosion (large channels similar to incised rivers). One significant aspect of water erosion is the selective removal of the finer and more fertile fraction of the soil. Human-induced

intensification of landslides, caused by activities like vegetation clearance and road construction, is also a contributing factor (Michael and Murnaghan, 2000). The removal of soil particles by wind action is termed wind erosion, which often results in sheet erosion, where soil is removed in thin layers. In some cases, wind erosion can create hollows and other features. Wind erosion is most likely to occur with fine to medium-sized sand particles, especially in dry regions.

Soil fertility decline

Soil fertility decline is a term commonly used to refer to the more precise description of the deterioration (or degradation) in soil's physical, chemical, and biological properties. While the decline in fertility is indeed a significant effect of erosion, in this context, the term encompasses the broader effects of processes other than erosion (Stoorvogel and Smaling, 1990). The primary processes involved in soil fertility decline are as follows:

- (1) Reduction in soil organic matter: This leads to a decrease in soil biological activity.
- (2) Degradation of soil physical properties: This occurs due to the reduction in organic matter, which can affect soil structure, aeration, and water-holding capacity.
- (3) Changes in soil nutrient content: These changes can result in deficiencies or toxic levels of nutrients essential for healthy plant growth.
- (4) Buildup of toxic substances: This can occur due to pollution or incorrect application of fertilizers.

Waterlogging

Waterlogging refers to the decline in land productivity resulting from the rise of groundwater close to the soil surface. This can happen due to a rise in the groundwater level near the soil surface or inadequate drainage of surface water, often stemming from poor irrigation management. It also includes the severe form known as "ponding," where the water table rises above the soil surface. Waterlogging is closely linked to salinization, both of which can be brought about by incorrect irrigation management. As a result of waterlogging, the root zone becomes saturated with water, leading to oxygen deficiency (Michael and Murnaghan, 2000).

Salinization

Salinization is the accumulation of soluble salts (CO_3 and SO_4) in the upper layer of soil, primarily due to excessive fertilizer use and over-irrigation. Salinization is used in a broad sense to encompass all types of soil degradation resulting from an increase in soil salts. It covers true salinization, characterized by the buildup of free salts, as well as codification (also known as alkalization) and the

Table 1. Major causes of land degradation in Ethiopia.

Causes of land degradation	Details about each causes
Population pressure	As the country's population continues to grow, more people are converting ecologically sensitive landscapes into farmlands. Waste products, rubbish from factories, mines and households pollutes the land and leaves its toxins within the soil
Deforestation	The conversion of forests and woodland to cropland, and harvesting of forests for fuel wood to meet the energy needs of a rapidly growing population
Unsustainable agricultural practices	Shifting cultivation, and salinization of the soil and chemical pollution through the use of agro-chemicals
Overgrazing	Due to livestock pressure dwindling grazing lands because of inadequate improved fodder
Climatic shocks	Recurrent droughts, famines, and extreme weather events associated with climate change, are compounding the land degradation phenomenon
Limited adoption of soil conservation practices	Much land degradation in Ethiopia can be attributed to the absence of adequate soil conservation practices
Invasive Alien Species	Invasive species are destroying or displacing indigenous species through rapid reproduction and expansion, forcing lands to be abandoned and fall into ecosystem decline
Fires	Includes bush and veld fires, caused by people, which strip the soil of the plant material thus enhances soil erosion
Mining	This damages the soil and the underlying structure of the land. Chemicals used or mined themselves pollute soil and water courses
Poverty	It forces millions of people to destroy the resources that are around them in order just to survive. Poor people often do not have access to the best land, leaving them to depend on the most fragile areas and resources

Source: Adugnaw (2014), Berry (2003), and Michael and Murnaghan (2000).

dominance of the exchange complex by sodium. Salinization generally involves an increase in salt in the soil water solution or sodication, which is an increase in sodium cations (Na) on the soil particles (Michael and Murnaghan, 2000). In Ethiopia, salinization is mainly a result of improper planning and management of irrigation schemes.

Lowering of the water table

Lowering of the water table is a self-explanatory form of land degradation that occurs when tube well pumping of groundwater for irrigation exceeds the natural recharge capacity. This means that groundwater extraction surpasses the natural replenishment rate of the water table. This phenomenon is observed in areas with non-saline groundwater, where groundwater is extracted for urban and industrial purposes (Michael and Murnaghan, 2000).

Causes of land degradation in Ethiopia

Studies conducted in various regions of Ethiopia have highlighted the increasing issue of land degradation, primarily driven by the growing population of the area (Fitsum et al., 1999; Temesgen et al., 2014). In parallel, Mulugeta (2004) argues that land degradation is a biophysical process influenced by socioeconomic and political factors, in which subsistence agriculture, poverty, and illiteracy play significant roles in causing land and environmental degradation in Ethiopia. Table 1 presents the identified causes of land degradation in Ethiopia by scholars.

Possible measures to combat land degradation in Ethiopia

Implementations of best management practices

According to FAO (2011), to reduce rural poverty and

maintain food security, it is essential to maintain soil fertility and transform agricultural systems to increase the productive capacity and stability of smallholder crop production. Therefore, there is a growing focus on alternative means of intensification, particularly the adoption of soil and water conservation (SWC) practices. Berry (2003) emphasizes that most efforts to combat land degradation involve developing a long-term set of locally acceptable land management rights and responsibilities. These efforts should prioritize the provision of fuel on a regional basis through woodland conservation, enhance extension capacity, especially in the context of sustainable land management, promote diversified rural enterprises within an improved framework of local and regional markets, engage local farmers and herders in addressing local land degradation issues and remediation, promote afforestation and reforestation over degraded land, and utilize drip irrigation to prevent soil salinization.

SWC measures represent one of the best management practices for maintaining or enhancing soil productivity by preventing or reducing erosion, conserving soil moisture, and maintaining or improving soil fertility. SWC measures effectively reduce soil and land degradation caused by both physical factors (such as wind and runoff) and chemical factors (including nutrient leaching and loss of organic matter). When sustainably managed, soil provides essential land and ecosystem services (UNCCD, 2012).

The implementation of SWC measures is largely influenced by economic status, public awareness, and the educational level of stakeholders. The main prerequisite for achieving sustainable agricultural development is the formulation of appropriate resource management policies supported by the farming community, who are willing and able to respond (Taye, 2006). Table 2 provides an overview of various SWC measures that have been popularized among the farming community.

Implementation of multi-lateral environmental agreements against land degradation

International conventions addressing land degradation emphasize that this issue extends beyond Ethiopia and is a significant global problem. Consequently, land degradation is a central concern in various international conferences. Principle 2 of the United Nations Conference on the Human Environment, known as the Stockholm Declaration, emphasizes that the earth's natural resources, including air, water, land, flora, fauna, and representative samples of natural ecosystems, must be safeguarded for the benefit of present and future generations through careful planning and management (UNEP, 1972).

In the United Nations Conference on Environment and Development, Agenda 21 - Chapter 3/3.2, which aims to

combat poverty, manage resources sustainably, and establish environmental policies primarily focused on resource conservation and protection, it is essential to consider those who depend on these resources for their livelihoods. Neglecting this aspect could have adverse effects on poverty and the long-term success of resource and environmental conservation efforts (UNEP, 1992).

The World Summit on Sustainable Development (WSSD) in Johannesburg, South Africa in 2002, focused on achieving sustainable development through increased agricultural productivity and ecosystem management. Nations also agreed on sustainable development goals at the Rio+20 Summit in June 2012. It is now an opportune time to establish a Sustainable Development Goal at Rio+20 aimed at achieving zero net land degradation and zero net forest degradation by 2030 to ensure the continued availability of productive land for present and future generations (UNEP, 2012).

According to Tsegai and Merhatbeb (2009), international communities should act on the following key conventions and proclamations to reduce and mitigate land degradation.

- (1) Implementation of Ethiopian Biological Diversity Convention Ratification Proclamation No. 98/1994, Neg. Gaz., Year 53, No. 88;
- (2) Implementation of Sustainable Development Goal at Rio+20 for Zero Net Land Degradation in 2012.
- (3) Implementation of the First United Nation Conference Environment and Development, Held in Stockholm in June 1997.
- (4) Implementation of the Rio Declaration on Environment and Development, Held in Rio de Janeiro from 3 to 14 June 1992.
- (5) Implementation of World Summit on Sustainable Development (WSSD), Johannesburg, South Africa in 2002.

CONCLUSION AND RECOMMENDATIONS

Being a common problem in Ethiopia, land degradation puts disastrous impact on the socio-cultural environment and ecological setting of the country. The major causes include rapid population increase, severe soil loss, deforestation, low vegetative cover and unbalanced crop and livestock production. To control land degradation, conservation measures throughout history are mainly focused on physical conservation structures which have less contribution for the addition of nutrients removed and to control soil erosion as compared to vegetation measures. However, as can be indicated in main text, land degradation can be prevented through different mechanisms depending on the nature and form of degradation.

In Ethiopia, land degradation has become a serious problem affecting all spheres of social, economic and political life of the population. It is one of the major

Table 2. Best Management Practices to combat land degradation.

Mitigation measures of land degradation (LD)	Details about each mitigation measures
Agronomy measures	Cover crops, Crop rotations and intercropping, with nitrogen fixing crops, Improved fallow rotations
Organic fertilizers	Compost, Animal and green manure.
Agroforestry practices	Trees on cropland (contours, intercropping), Bush and tree fallows, Live barriers/buffer strips with and woody species
Minimum soil disturbance	Minimum tillage, MULCHING
Area closure	Fencing an area (free from touch of animals and humans) on degraded hillsides
Water management	Terraces, contour farming, water harvesting and conservation
Hillside terraces	Earth embankment or a combination of ridge and channel constructed across steeply sloping sites to address severe erosion
Fanya-juu terrace	Terraces formation by throwing the soil up the hill. The terraces formed are ideal for fodder grasses and help prevent soil erosion
Soil bunds	Built by moving and compacting soil downhill for an area of slopes up to 15 to 30%
Stone bunds	The stone bunds form a barrier that slows down water runoff
Afforestation and reforestations	The establishment and reestablishment of a forest or stand of trees in a certain area respectively to intercept rainfall, detain surface runoff, allow more time for infiltration, and restore the disturbed areas

Source: Adugnaw (2014), Nyssen (2007), Taye (2006), MoARD (2005), and Million (2003).

challenges to agricultural development and food security of the country. Ethiopia and other international community should commit itself to land degradation by setting sustainable development goals on land use, with targets towards achieving zero net land degradation. Therefore, to enhance agricultural production and realize food security in Ethiopia, we have to prevent land degradation and restore/rehabilitate degraded lands. Mitigation of land degradation in Ethiopia needs collaborations of national and international organization. To enhance agricultural productivity by combating land degradation, the following recommendations should be implemented in Ethiopia:

(1) Institutional Collaboration: Foster collaboration between government bodies such as the Ministry of Agriculture, the Ministry of Environment, the Conservation Strategy of Ethiopia (CSE), and other governmental and nongovernmental institutions to prevent and combat land degradation.

(2) Awareness and Training: Focus on raising awareness, providing continuous training on sustainable land management, and creating opportunities for alternative

livelihoods through livestock, beekeeping, and poultry.

(3) Land Rehabilitation Practices: Promote efforts for land rehabilitation through various interventions, including physical, biological, and agronomic approaches.

CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

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