

Review Article

Causes and Consequences of Land Degradation in Ethiopia: A Review

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Abstract

The term "land degradation" refers to the deterioration of the land's quality and that of its surrounding components due to either natural or artificial factors. The most frequent cause of land deterioration in Ethiopia is water-induced soil erosion. Due to decreased agricultural soil fertility, land degradation has a detrimental effect on Ethiopia's economy as well as agricultural production. It is now a significant issue impacting all aspect of Ethiopians' social, political, and economic lives. It is one of the main obstacles to the nation's agricultural growth and food security. Rapid population growth, significant soil erosion, deforestation, overgrazing, insufficient vegetative cover, uneven crop production on steep slopes, erosive rainfall patterns, a lack of fallowing, and inadequate conservation measures are the main drivers of land degradation in Ethiopia's highlands. The consequences of land degradation include the loss of fertile soil, which reduces the amount of land that can be used for agriculture. The state of family food security is negatively impacted by land degradation, which also directly lowers livelihoods in rural areas and has catastrophic effects on Ethiopia's sociocultural context and ecological setting. Lower crop yields are the direct result of soil degradation, and agricultural households experience increased rates of poverty as a result.

Keywords

Land Degradation, Population Growth, Food Security

1. Introduction

1.1. Background and Justification

Land is one of the most significant natural resources; it includes soil as well as many other dimensions and interactions with vegetation [1]. Like air and water, land is essential to humankind, but one of the most pressing environmental issues facing the world today is the deterioration or loss of its productive capacity for the present and future. If remedial action is not taken quickly, this problem will only get worse and affect everyone by becoming more severe and extensive in

different areas [2, 3].

Around 40% of the earth's surface is currently affected by this problem, which affects everyone due to food insecurity, rising food prices, climate change, environmental hazards, and the loss of biodiversity and ecosystem services. An additional 12 million hectares of land are degraded annually [4, 5, 9].

According to Kaiser [6] land degradation is the deterioration of the land's quality and that of its surrounding elements due to natural or man-made causes. Increasing salinity and

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sodicity, erosion, uncontrolled floods, changed soil nutrient status, and decreased soil surface stability are just a few of the ways it lowers the quality of the soil and the surrounding ecosystem [7].

This environmental process involves changes in the chemical, physical, and biological properties of land that lead to the loss of the land's biological, economical, and quality attributes. These changes can be brought about by a variety of factors, such as soil erosion, loss of organic matter in the soil, soil acidity, deforestation, desertification, salinity, soil compaction, and other phenomena that render agricultural land unsuitable for crop production [8, 9].

Billion people worldwide are either directly or indirectly impacted by this phenomenon, which has the potential to cause overuse of soil resources, a decline in ecosystem productivity, changes in the composition of vegetation, and/or the loss of rural livelihoods [10]. Deforestation and overgrazing by livestock are two examples of land use practices that push the land beyond its productive capacity. Land degradation, on the other hand, describes how one or more of the land resources soil, water, vegetation, rocks, air, climate, and relief have changed for the worse. It lacks a single easily identifiable feature [7, 10].

According to Gibson and Salmon [11], the worldwide degraded area's estimated size varies from less than 10 to more than 60 million km². Land degradation affects millions of people worldwide, and by 2050, it may have gotten worse [12]. The Food and Agriculture Organization estimates that by 2050, nearly 90% of the Earth's soil may have deteriorated from its current state of 33%. Over 2.6 billion people are impacted by human-induced land degradation, which affects over 29% of the world's land. Global land degradation is mostly caused by water-induced soil erosion. It lowers biodiversity, productivity capacity, and environmental services as well as food access.

Because it reduces the capacity of the land to absorb carbon dioxide and releases greenhouse gases (GHGs), land degradation is also thought to be a driver of climate change. With over 100 million inhabitants, Ethiopia is one of the most populous nations in Africa [13]. Despite this, over 85% of the country's land is deteriorated to some degree, making land degradation a significant issue. The loss of ecosystem services is only represented by roughly 51% of land degradation. According to [14], the remaining 49% is the loss of ecosystem services that are cultural, regulatory, and supportive.

The most frequent cause of land deterioration in Ethiopia is water-induced soil erosion. 80% of the population is employed in rain-fed agriculture, which is the cornerstone of Ethiopia's economy. One of the biggest development challenges facing Ethiopian agriculture is environmental degradation, which is demonstrated by the depletion of land and water resources as well as the loss of biodiversity [14]. One of the main factors contributing to poor and falling agricultural output, ongoing food insecurity, and rural poverty is land degradation. Furthermore, the kind of plants that could be

cultivated there, the amount of surface water that could be used for drinking, the depletion of aquifers, and the loss of biodiversity were all directly impacted by land degradation.

The main reasons include imbalanced agricultural and animal production, deforestation, significant soil erosion, fast population increase, and poor vegetative cover. According to Temesgen [15], topography, soil types, and agro-ecological parameters are additional elements influencing the processes of land degradation in Ethiopia that are impacted by human activity. The historical growth of agricultural and human habitation in the highland areas of the nation is the cause of land degradation [16]. Based on satellite imagery, recent estimates reveal that hotspots for land degradation over the past three decades have covered over 23% of the nation's geographical area, primarily in sizable portions of Gonder, Wollo, and Tigray, among other regions [17].

Due to severe climatic circumstances, including global climate change and the ensuing changes in land-use patterns brought about by agricultural intensification, land degradation processes have increased, and resulting in yield losses in many areas of semi-arid and arid Ethiopia [18]. The focus of this essay was on Ethiopian land degradation: its causes and effects.

1.2. Objective of Review

To review the cause and consequences of land degradation in Ethiopia.

2. Methodology of Review

The core of this work is derived from several sources, including papers, eBooks, conferences, journals, theses, and reports about land degradation in Ethiopia.

3. Discussion

There are six primary forms of land degradation found in Ethiopia and other Sub-Saharan African nations. The most common forms of land degradation among them are wind erosion (38%) and water erosion (46%) with soil deterioration (16%) following closely behind. The loss of habitat, particularly forests and woods, a reduction in soil fertility, salinization, and water logging are some other forms of land degradation.

Water-induced soil erosion is by far the biggest issue with land degradation. In addition to removing nutrients, water erosion can also cause the root growth zone, thickness, and water storage volume to decrease. According to the FAO's Global Forest Resource Assessment [19], the average soil loss on cultivated lands was estimated to be 42 t/ha/year; in highly erodible and intensively cereal-cultivated fields, the average soil loss ranged from 300 to 400 t/ha/year.

3.1. Cause of Land Degradation

The complicated process of land degradation has been fueled by both natural and artificial factors. The main causes are natural phenomena like drought and salinity, which are examples of extreme weather conditions that are a part of the process of climate change. In the meantime, wrong farming methods, pollution, excessive grazing, deforestation, urbanization, population increase, etc. are all results of human activity. Biophysical factors (land use that is not environmentally suitable for sustainable use), socioeconomic factors (poor land management practices, land tenure, marketing, institutional support, income, and human health), and political factors (lack of incentives and political instability) were identified as the causes of land degradation [20].

The following factors contribute to land degradation in Ethiopia: increased agricultural production, recurrent cultivation, removal of dung and residues, monocropping as opposed to intercropping, extraction of wood, increased infrastructure, unpredictable rainfall, accelerating population growth, deforestation, erosion of soil and water, loss of biodiversity, low technology, insufficient extension services, political unrest and civil wars, and a lack of awareness and consciousness [21]. Land degradation may also result from farmers' ignorance of soil erosion and declining soil fertility. Ethiopia is experiencing severe land degradation as a result of human and natural activity. Deforestation, excessive grazing, a lack of soil and water conservation measures, a lack of application of nutrients and organic matter, and the burning of manure and agricultural wastes are some of the well-known immediate causes of land degradation and a decrease in the fallow season [22].

Similar to this, the main reasons include imbalanced agricultural and livestock production, fast population increase, significant soil erosion, deforestation, and poor vegetative cover. Furthermore, the degradation processes driven by humans were modified by topography, soil types, and agro-ecological characteristics [15]. The underlying causes of land degradation were socioeconomic and institutional variables, which had an influence on farmers' decisions on land use and land management techniques [23].

The strategies practiced prior by the government to tackle the problem were the soil and water conservation measures to some extent, but they were not fully practiced due to the fact that people did not have full knowledge about them, and the extension agents did not continually follow them due to the area lacking roads. Even though the people were not engaged in other activities outside of agriculture, they sold wood and charcoal to survive themselves and their families [24].

The requirement to raise farmers' awareness of the issue of soil erosion by educating them about the benefits and risk-reduction features of soil conservation techniques. This was significant because farmers' adoption of soil conservation methods is positively impacted by their level of understanding and awareness of the need to limit soil erosion. In order to

promote their adoption and guarantee their sustainability, it was crucial to create soil conservation techniques that integrate cutting-edge scientific understanding with traditional technological know-how [25]. In the highlands of Ethiopia, the following are common sources of land degradation.

3.1.1. Causes of Land Degradation Induced by Humans

Poor agricultural techniques, population pressure, overgrazing, over cultivation, soil erosion, deforestation, issues with salinity and alkalinity, and rural families' use of crop leftovers and animal dung as fuel are the main human-caused causes of land degradation in Ethiopia. Other man-made land degradation includes limited application of external plant nutrients, limited recycling of dung and crop residues to the soil, production on steep slopes and fragile soils with inadequate investment in soil conservation or vegetation cover, and declining use of fallow.

Proximate issues include poverty, population pressure; high input and financing prices, low agricultural production profitability, and farmers' ignorance of alternative technologies are also contributing factors to the cause. Furthermore, farmers are compelled to mine soil and cut down trees in order to exist in a subsistence economy, which degrades the land [26]. Population growth, the spread of agriculture into forests and marginal areas, poverty, issues with land tenure and government policy, political unrest and land management, overgrazing, unsuitable agriculture, and the large-scale development of irrigated agriculture are some of the factors contributing to land degradation [27].

(i). Socio-Political-Economic Factors

One of the main factors contributing to Ethiopia's land degradation is the country's accelerating population expansion. This is due to the fact that, given current technological levels, a growing population necessitates more agricultural productivity, which calls for more land. Obtaining this additional land for farming is a difficult undertaking that has led to the extension of farming operations into marginal regions vulnerable to erosion, significant deforestation, a reduction in fallow times, and ongoing cultivation [28, 29]. Rapid population expansion (human and livestock), poverty, land tenure instability, restrictions in institutional capability and setup, restricted access to inputs and credit services, lack of awareness creation, and resistant to embrace introduced technology.

The highland regions have thus been particularly vulnerable to climate change and land degradation. Furthermore, the majority of the reasons of land degradation in the nation are related to both the country's past and present political economics [30, 31]. Ethiopia's high population density causes pollution, aquifer depletion, water channels drying up, and decreased surface water levels [32]. Due to human activities including urbanization, industrialization, and agricultural practices, Ethiopia's large population applies chemical fertilizers and pesticides, which deteriorates fresh water quality

and causes surface and ground pollution by pollutants [33].

A significant contributing factor to the current condition of land degradation in Ethiopia is exploitative subsistence agriculture, which provides employment for 85% of the country's expanding population [34]. Analogously, research carried out in Ethiopia's Dera District by Temesgen [15] demonstrated a rise in land degradation, mostly due to the region's expanding populace. An additional study by Taffa [35] showed that low land management, improper tillage operations, community attitudes regarding the effects of land degradation on agricultural productivity, and farmers' ignorance of the primary biological, physical, and mechanical methods of land conservation are the main causes of the high velocity of land degradation.

The highest Pamir and Pamir Alai mountains have seen land degradation due to a variety of human activities, the most significant of which are thought to be an excessive dependence on peat, manure, bushes, and fuel wood to fulfill household energy demands. Poor soil and water management in plots used for irrigation rain-fed crop production systems. Poor pasture management, especially the overgrazing of pasture lands near the hamlet. Deficient design and upkeep of irrigation systems [36].

The country has already lost its forest resources, mostly as a result of population pressure. The high pace of population increase forced steep, vulnerable terrain to be integrated into farming, speeding up the rate of soil erosion [37]. The primary driver of this deforestation is the growing population, which raises the need for additional land for agriculture, fuel wood, building materials, and other forest products [38]. Population is growing daily, which has led to severe soil erosion, fast deforestation, and frightening environmental deterioration. Soil erosion creates severe limitations for sustainable agricultural land use as it reduces farm soil productivity and food security [39]. Socioeconomic and institutional factors are the underlying causes that affect land degradation through their impacts on farmer's decisions with respect to land use and land management practices. For example, the absence of a comprehensive land use and administration policy, proclamations, laws, regulations, and master land use plans developed in a participatory manner at the federal, regional, and community levels are the major factors that have contributed to the unchecked land degradation in the country [34].

(ii). Extensive Deforestation and Forest Degradation

Ethiopians are now cutting trees for fuel wood, fodder, agricultural cultivation, grazing, and home construction [40]. Deforestation occurs when trees are cut down or removed from a forest or wooded region for a variety of reasons, most often for economic gain. It is one of the main concerns of the twenty-first century and a contributing factor to the widespread deterioration of land. Several of our country's continents experienced situations brought on by soil degradation hundreds of years ago [41].

This is brought on by the spread of agriculture, illicit logging and wood product exploitation, wildfires, haphazard human resettling, increased investment, and other development-related activities. The main causes of forest fires and degradation include also hunting, pastoral activities, charcoal production, and the harvesting of forest honey [42]. The conversion of forests to non-forest uses, such road building and agriculture, is known as deforestation. The land becomes more susceptible to issues like erosion, desertification, and ecosystem collapse when a specific region is cleared of trees and the native vegetation is ruined or destroyed. The primary function of vegetation cover is to facilitate soil formation and soil aggregation. Because of this, its removal has a significant impact on the soil's ability to retain water, support biological activity, and aerate.

(iii). Inappropriate Land Use and Cropping Systems

In many regions of the world, overgrazing is one of the main factors contributing to the process of land degradation. This particular method has a direct impact on the amount and quality of the plant cover, which is essential to the land's value and survival. It has been determined that overgrazing is mostly to blame for the Mongolian steppe's deterioration and, to some extent, for desertification. Animal dung and agricultural wastes burning, decreasing fallowing times and crop rotation system limits, overgrazing and marginal land agriculture, and careless irrigation water usage are some of the issues.

When cattle congregate around drinking holes, overgrazing of the vegetation is especially harmful, causing the land to be destroyed in the vicinity of wells and settlements. The organic matter and physical characteristics of the soil decrease as a result of erosion and plant cover deterioration, decreasing the soil's ability to withstand decay. When plant and soil qualities do not return to their pre-degradation state during periods of regular rainfall, degradation takes place. It has been shown that unsustainable agricultural methods are the biggest contributors to land degradation. This is especially true in densely populated areas, where population expansion puts enormous strain on finite land resources [43].

Chemical spills and industrial pollution are only two examples of the many types of pollution that may seriously harm soil and land. In particular, the radioactive waste products from nuclear power plants can persist for many years and represent a serious danger to the soil's quality. There are examples of these wastes being attempted to be disposed of by being buried under the earth all around the world. However, in an effort to boost agricultural productivity, more chemical pesticides and fertilizers are applied, which pollutes the surrounding waterways and land [44].

The beneficial bacteria and other vital microorganisms that are required for fertility in the soil are killed by pollutants from the land. Nutrient losses from the soil are also caused by the complex forms of the fertilizer's compounds denaturing vital soil minerals.

(iv). Traditional Farming System

Farmers cultivate areas that have no potential for producing crops, such as ponds, slopes, and mountain tops [69]. It describes an approach to farming that farmers are taking without fully understanding the relationship between crop soil requirements and without taking a number of extremely important soil and water conservation steps that could jeopardize the benefits to future generations and the preservation of land resources. Top soil is the stratum of soil that is most fertile. A regressive agricultural system will degrade this, making the soil extremely unproductive for growing crops. Water and wind have the power to erode away soil. Hills and flat areas may lose loose dirt due to strong winds. In most cases, water erosion happens on slopes and the more severe the slope, the more severe the erosion is [45].

3.1.2. Natural Causes of Land Degradation

Natural elements that contribute to land degradation include rough terrain, steep gorges, incised valleys, rolling plains, erodible soil types, intense temperature and rainfall events, and agroecological characteristics. Due to the abundance of natural resources, including as rich soil and water supplies, the country's highland areas have seen a significant concentration of human habitation. The majority of the time,

human-caused and natural factors combine to generate land degradation.

This is due to the fact that human behavior that is unchecked and unsustainable exacerbates the underlying factors that lead to land degradation, such as climate change and other geographical phenomena. Due mainly to agricultural tillage and grazing pressure, human activity has significantly accelerated the pace of deterioration. Land degradation can be attributed to several natural processes like as intense rainfall, different soil types, topography, volcanic eruptions, earth quacks, and steep terrain. These are a few instances of how they are related to the deterioration of land and the depletion of nutrients and soil quality. The process of erosion by water begins when a raindrop with enormous force strikes exposed, unprotected soil.

In general, the main variables influencing land degradation are the distribution, frequency, intensity, and timing of the energy produced by rainfall. Compared to heavy rainfall, which is equally dispersed throughout the water shed and accumulates in a few months, gentle rainfall occurs more often throughout the year and results in less soil degradation. More deterioration results from more frequent rainfall than from fewer. Higher intensity rain contributes to more land degradation than lower intensity rain [46, 47].

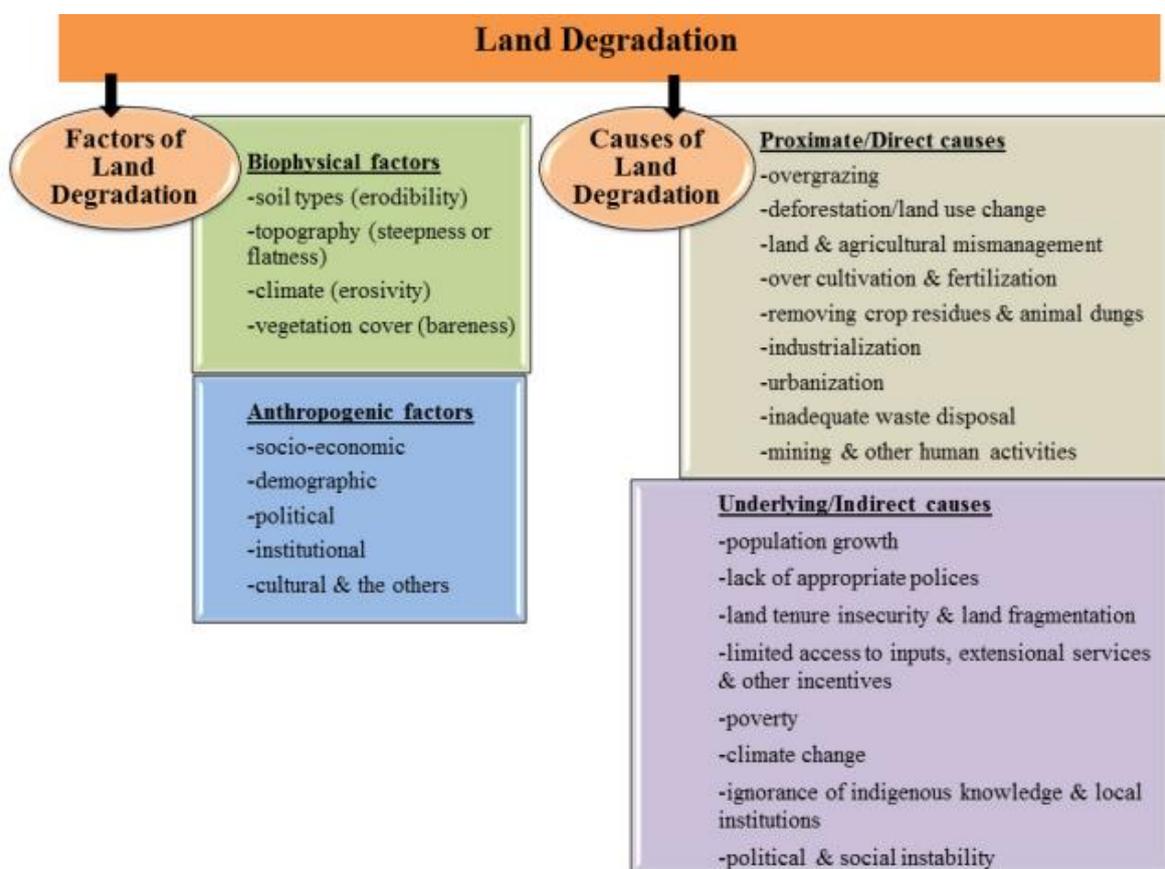


Figure 1. Factors and causes of land degradation (Source: [48]).

3.2. Consequences of Land Degradation

There are several ways that land degradation can be shown: prickly weeds taking over once-rich meadows, water courses drying up, walkways growing into gullies, and thin, stony soils. According to Berry [49], all of these expressions have the potential to have detrimental effects on the environment for both land users and those who depend on the products of a healthy landscape for their livelihood. In Ethiopia, land degradation has an impact on people's social, economic, and political life in every province [50].

Among the issues that all Ethiopians face on a daily basis are poverty, diminishing agricultural production, and land degradation [51]. The process of land degradation seems to be more severe in developing nations, which has important ramifications for mitigating and adapting to climate change. This was due to the fact that the depletion of soil organic matter and biomass impacts the soil's health and capacity to retain water and nutrients, as well as releasing carbon into the atmosphere [23].

Ethiopia is experiencing a number of negative effects from land degradation, such as decreased soil productivity, famine, higher social costs, a reduction in the amount and quality of fresh water supplies, an increase in poverty and political unrest, and a weakening of food production. The productivity of the soil is directly impacted by land degradation, which has an effect on human wellbeing. The negative physico-chemical soil qualities that arise from soil deterioration due to erosion and fertilizer loss significantly reduce agricultural production.

Reduced soil depth, decreased soil water storage capacity, and nutrient losses are the main causes of soil degradation and its detrimental effects on soil production [23]. Deforestation and soil erosion increase the buildup of greenhouse gases in the atmosphere, which in turn contributes to climate change by decreasing carbon sequestration.

It can also result in losses of ecosystem services and biodiversity, which are hard to quantify since they aren't often valued, purchased, or sold therefore aren't well represented in loss estimates [23]. Because of a confluence of economic (poor, insecurity, and a lack of infrastructure) and resource (soils and precipitation) variables, the consequences of land degradation are particularly severe in specific regions and local areas. Area degradation, which includes soil erosion, deforestation, decreased productivity, and decreased grazing area, is one of the major issues impacting agricultural output in Ethiopia. These causes also have an impact on the nation's economy. Furthermore, in some nations, land degradation has had an influence on the ecology and the economy. These effects may be detrimental to national, regional, and international growth as well as having a large negative impact on the populace.

According to Temesgen [52], Ethiopia has among of the worst soil degradation in the world, and the country's expanding population's concentrated reliance on a strict kind of agriculture combined with antiquated methods of invention

has a greater impact on soil erosion. On the limited land, the population has grown quickly, and each piece of land is farmed for food production without adequate management, which eventually causes soil erosion [15].

Food security and quality of life are negatively impacted by land degradation, particularly in emerging nations like Ethiopia. It has a negative effect on societal welfare, the environment, and agricultural productivity. It has detrimental effects on people, groups, and countries overall. It has serious repercussions for the ecosystem in addition to impairing the land's ability to produce food and fiber. Numerous studies have pointed out and discussed the effects of land degradation from various perspectives. For example, 89.4% of households stated that production declines as a result of land degradation, according to Yenealem [53].

Furthermore, Temesgen [15] reports that 68.9% and 63.3% of participants in a 2014 research stated, respectively, that soil degradation had an impact on migration and poverty. The process by which rock and soil are taken from the earth by natural processes like wind or water movement is known as soil erosion. Weathering and related erosion are caused by a variety of physical, chemical, and biological processes. Widespread soil erosion from land regions has already had a negative impact on all ecosystems, both natural and man-made, including forests and crops.

Because of this, one of the world's most important environmental issues is soil erosion, which results in the loss of nutrients. This is how land deterioration manifests itself. Food insecurity, poverty, and low agricultural production in Ethiopia are caused by land degradation [54]. Land degradation is having a major negative impact on the productivity of the Ethiopian economy, which is based more than 85% on agriculture.

Basic plant nutrients like calcium, phosphorus, nitrogen, and potassium are also lost as soil erodes. According to [46], the amount of nutrients in eroded soil is usually three times higher than that of the soil that remains on eroded land. Diminished Crop Yield Soil erosion lowers biomass production in ecosystems by reducing soil organic matter and over-soil quality; in the end, this has a significant impact on the variety of plants, animals, microorganisms, and other forms of life found in ecosystems [55].

The silting up of reservoirs is another issue caused by erosion. Reservoirs situated in the course of rivers or streams frequently become silted up as a result of runoff water containing silt. Since the water in the reservoirs is almost still, a significant amount of the soil that the streams carried with them has disappeared. The bottom part of the reservoir receives the majority of the silt, clay, and organic debris that are still in the suspension [56].

The productivity of the soil is directly impacted by land degradation, which has an effect on human wellbeing. Crop production is significantly lowered as a result of unfavorable physico-chemical soil qualities brought on by nutrient loss

and soil erosion. Reduced soil depth, decreased soil water storage capacity, and nutrient losses are the main causes causing soil degradation and lowering soil production [23]. One of the main reasons for Ethiopia's poor and, in many cases, deteriorating agricultural output, ongoing food insecurity, and rural poverty is land degradation [57]. Deforestation and deteriorated soils in the Ethiopian highlands have weakened the foundation of available resources and made the drought-related food shortages that occur often worse [58].

Due to decreased grazing supplies, loss of nutrient-rich plants, and extinction of grass species, land degradation decreased cattle productivity [59]. Increased runoff and decreased infiltration are two factors contributing to the flooding problem as a result of land degradation. The productivity of agriculture, livestock and human health, and economic ventures like ecotourism are all negatively impacted by deforestation and desertification [60]. Land degradation was the most prevalent environmental issue in Ethiopia. Various factors, including deforestation, population pressure, soil degradation, and a low level of rural economic diversification, have complicated the situation and either directly or indirectly contributed to the resulting scarcity of land [24].

3.2.1. Reduced Crop Yields and Threats to Food Security

Water or wind erosion, water logging and salinization, soil compaction, and other processes cause harm to the structure of the soil and result in the loss of soil nutrients. The nation's deteriorating fertility and soil erosion pose a major threat to agricultural output and economic expansion due to land degradation. Because of its detrimental effect on agricultural efficiency, this is a major global concern. Degradation of the soil has led to reduced food production, ecological imbalances, droughts, and a general decline in living quality. Its effects on yield variation and average, as well as the overall factor productivity of agricultural production, demonstrate its influence on agricultural productivity.

It also negatively affects nutritional safety and environmental conditions. According to Eswaran [61], it divides negative impacts on socioeconomic conditions and agriculture, expressing challenging scenarios for ecological expansion. Reduced agricultural yields due to a lack of nutrients in the soil are one of the devastating effects of land degradation. Widespread human activity has had an influence on the land, sometimes impairing ecological services and agricultural output. Farmers typically apply fertilizer to address this issue and compensate for the deterioration. Nevertheless, regardless of the use of fertilizer, lower agricultural yields are linked to increased levels of land degradation [62].

When a piece of land becomes degraded, farmers forsake it and move on to clear new territory, leaving the degraded land as a negative externality. Erosion is associated with farmland production loss, pollution of surrounding water bodies and wetlands, and both [63]. Agriculture is affected by land degradation, and as a result, those who work in the field are most

affected by its social and economic ramifications. Agricultural value is reduced by 7% due to land deterioration.

This decrease is equal to \$7.63 per hectare in monetary terms. In the event that every agricultural land is deteriorated, the nation will lose \$267 million. This loss is significant since agriculture employs 85% of the population. Two useful indicators of land degradation are bequest variables and the energy type utilized in cooking stoves. A two-pronged strategy to stop deforestation and spread more effective stove technology is suggested by the relevance of the energy type utilized in cooking stoves.

3.2.2. Loss of Economic Value

When land becomes less productive, it requires more natural resources to be replenished. Economic costs result from these effects in the form of decreased income (or consumption), elevated income risk, and higher production costs. The land and the ecological services it is surrounded by have economic worth. Significant co-benefits that are quantifiable in terms of money would also be provided by the continuous availability of fertile land and soil. An estimate indicates that salinization, soil erosion, and other degradation processes cause the irreversible loss of 5-7 million hectares of arable land year around the world [64].

According to Sutton, the assessment of land degradation indicates that humans have lost \$6.3 trillion year in the value of ecosystem services as a result of compromised ecosystem function. Remaining ecosystem services account for a far higher percentage of the world GDP (~10%) and there is considerably more to the economics of land degradation than just the market worth of agricultural goods. Crop output might rise by up to USD 1.4 trillion with the adoption of sustainable land management [65]. Food and water security may be increased and value up to USD 480 billion can be created through cost-effective carbon storage, which involves increasing carbon stocks in land and soil [65].

3.2.3. Poverty

Without a doubt, there is a direct correlation between the rate of soil degradation and the severity of poor conditions worldwide. There is undoubtedly a strong correlation between the two factors, even though some authors contend that the connections are ambiguous [66]. Millions of impoverished people in developing nations rely on the quality of the land for their agricultural endeavors and means of subsistence. In actuality, because impoverished households are unable to make investments in the preservation and enhancement of natural resources, poverty exacerbates land degradation. However, as a result of soil degradation, agricultural output is poor and falling, which exacerbates poverty [66].

Additionally, Heger [67] demonstrated the significance of land improvements in reducing poverty in rural regions, especially in sub-Saharan Africa. They also came to the conclusion that land improvements benefit the poor since they have a greater impact on reducing poverty in poorer locations.

In addition, land has been viewed as a platform for most activities, a need for food and shelter, a natural holding place for waste and water, and a significant contributor to the availability of clean air [68].

It is the primary source of revenue for the agricultural community and an essential natural resource for both survival and success. Since farming is the only source of income for the community, it gives them a sense of stability.

3.2.4. Environmental Consequences

The loss of trees is the cause of land degradation's impact on the ecosystem [21]. Any change in the livestock industry has an impact on the overall level of living of rural residents since land degradation also causes a decrease in the number and quality of cattle. In areas with low agricultural and livestock productivity, land degradation also raises the unemployment rate and outmigration rate. Reduced farm size due to insufficient land for agriculture results in hidden unemployment.

One essential component of the climate system is the land surface. Land degradation has serious negative effects on the environment, such as increasing soil erosion, declining biodiversity, deteriorating water quality, and a drop in ecosystem services and their associated values.

In 2018 Pacheco, degradation of land decreases the soil's capacity to absorb carbon, which intensifies climate change. Climate change, in turn, makes land degradation worse. Its effects can be extensive, resulting in biodiversity loss, habitat damage, and decreased soil fertility. Specifically, the dynamic structure of the low-level atmosphere is connected to deforestation due to land degradation, sensible heat flow, and surface evapotranspiration [20].

These variations in the atmospheric column may have an impact on localized and perhaps global atmospheric circulation. As stated in the World Meteorological Organization [20], "changes in forest cover in the Amazon basin affect the flux of moisture to the atmosphere, regional convection, and hence regional rainfall."

A definition of land degradation provided by the UNCCD describes it as a worldwide environmental problem that involves a decline in the productivity of ecosystem goods and services derived from land, as well as a reduction in the biological or economic productivity of land relative to background thresholds of land deterioration. This presents insurmountable challenges to both ecological and human systems [70, 9]. The loss of trees is the cause of land degradation's impact on the ecosystem [21].

Any change in the livestock industry has an impact on the overall level of living of rural residents since land degradation also causes a decrease in the number and quality of cattle. In areas with low agricultural and livestock productivity, land degradation also raises the unemployment rate and outmigration rate. Reduced farm size due to insufficient land for agriculture results in hidden unemployment.

Cultivation, ecology, productivity, environment, nutritional

value, and biodiversity were all directly impacted by land degradation. It also affects the biophysical environment by causing natural or anthropogenic disturbances to the land. Earthquakes, tidal waves, erosion, water overflows, and cyclones are examples of natural causes. The environment is most greatly impacted by degradation caused by human activity [71].

3.2.5. Ecological Impact of Land Degradation

Through a variety of direct and indirect processes that impact a wide range of ecosystem functions and services, land degradation has many and complicated effects on the global environment [72]. Rapid habitat and biodiversity loss, altered water flows, and sedimentation of reservoirs and coastal zones are the main effects of land degradation on the ecosystem. The consequent ecological effects of land degradation in Ethiopia include diminished amounts of surface water, less potable water available, depletion of aquifers from inadequate recharge, loss of biodiversity, and changes in the chemical, physical, and/or biological properties of the soil, all of which have an immediate impact on the kinds of plants that are grown there [49]. Biological resources and agricultural output are being jeopardized by soil degradation. Additionally, land degradation disrupts ecosystems' capacity to provide and regulate services, particularly the hydrological, global carbon, and nutrient cycles [72]. Generally speaking, there are several regional and worldwide environmental effects of land degradation. First, the biodiversity of the world is impacted by the deterioration of forests and woods. Second, the flow of important rivers is being affected by changes in wetlands and forest cover. Third, extensive deforestation alters air circulation and albedo patterns, which may have an impact on global climate change.

Fourth, excessive siltation in rivers and inland lakes due to soil erosion can result in eutrophication and issues with water quality as well as a decrease in the lakes' ability to store water [73].

3.2.6. Migration, Security Problems, and Social Unrest

Long-term land damage can result in social unrest and security issues for the countries since land degradation exacerbates environmental strains brought on by rising human demand on the land. Particularly, those who are impoverished, women, and kids may be the ones that suffer from this volatility the most. The deterioration of arable land and soil fertility, the loss of water resources, the decline in cattle, the increase in the unemployment rate and outmigration, the conflict between pastoralists, the depletion of forests and vegetation, the decrease in agricultural production,

The main effects of land degradation in Ethiopia are raising agricultural input costs, a decline in the amount of plants cultivated, aquifer depletion, biodiversity loss, a drop in the amount of drinkable water, and shortages of timber, climate change, and desertification. Due to intense rivalry for scarce

resources and the maintenance of livelihoods, a large number of individuals may choose to participate in illegal and anti-social behavior. Indeed, significant internal conflicts and migration may result from land deterioration [74].

According to McLeman [74], households who rely signif-

icantly on basic commodities and services frequently migrate in search of better opportunities for their lives. In recent times, there has been a notable surge in the number of rural-urban migrations, and a permanent alteration of landscapes due to the abandonment of ancestral lands by rural people [60].

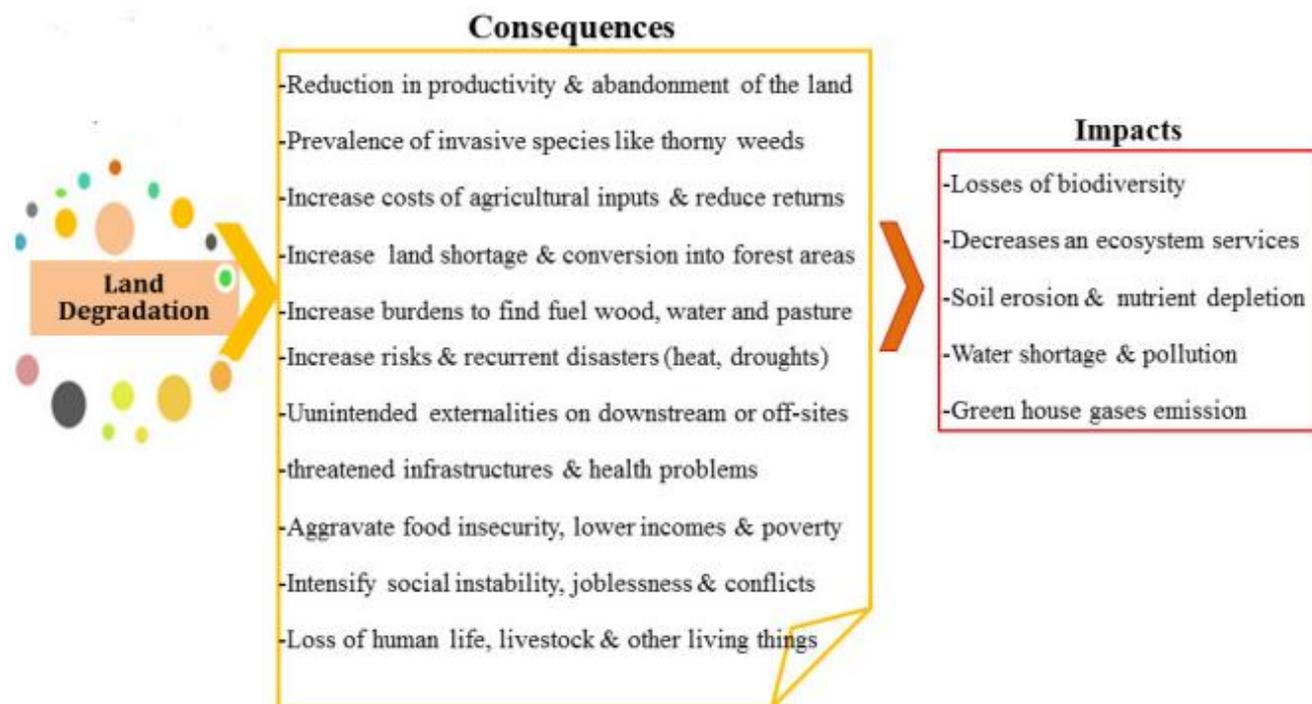


Figure 2. Consequences of land degradation (Source: [48]).

4. Summary and Conclusion

Land degradation is a prevalent environmental issue in Ethiopia. Both manmade and natural forces are the main causes of land degradation in Ethiopia. Ethiopia's fast population growth, severe soil loss, deforestation, low vegetative cover, low technology, inadequate extension services, political unrest, overgrazing, traditional farming methods, strong winds, intense rainfall, drought, landslides, absence of comprehensive land use, lack of developed land use plans, and uneven crop and livestock production are some of the factors contributing to land degradation.

Agro-ecological characteristics, topography, and soil types are additional variables influencing the processes of land degradation in Ethiopia that are impacted by human activity. Desertification and the loss of agricultural biodiversity are made worse by unsuitable land-use regimes and land-tenure laws. In the Ethiopian highlands, overgrazing, fallowing, deforestation, farming on steep slopes, erosive rainfall patterns, and inadequate conservation measures are the main drivers of land degradation. The main causes of land degradation in Ethiopia are improper land use practices and the pressure of an expanding population.

This is due to the fact that, given current technological levels, a growing population necessitates more agricultural productivity, which calls for more land. The loss of soil nutrients, the effects of soil erosion, crop yield reduction, reservoir silting up, and the perpetuation of poverty are all consequences of land degradation on agriculture. It also reduces ecosystem resilience and the supply of environmental services. Aquifer depletion, decreased surface water volume, diminished clean water availability, and loss of biodiversity are all consequences of land degradation, which directly impacts agricultural crops and plants. It makes it harder to produce enough food to sustain the growing population since it lowers the land's capacity for production.

It also makes farmers more vulnerable to food shortages and puts the people's basic existence in jeopardy. The primary cause of food insecurity within the nation is mostly associated with the ongoing issue of degradation. Furthermore, the kind of plants that could be cultivated there, the amount of surface water that could be used for drinking, the depletion of aquifers, and the loss of biodiversity were all directly impacted by land degradation. Lower crop yields are the direct result of soil degradation, and thus raise the poverty rate among agricultural households. Reductions in animal output and crop yields indicate the grave effects of soil degradation on rural popula-

tions' means of subsistence.

Ethiopia's collective struggle with soil degradation has disastrous effects for the nation's ecology, atmosphere, production, and standard of living. Through nutrient loss, erosion, and unsuitable land use regimes that negatively impacted soil characteristics, this degradation had an effect on soil productivity and significantly reduced agricultural crop yield. Due to deterioration brought on by unsustainable farming methods and deforestation, the amount of arable and grazing land is generally decreasing.

In addition, a large amount of the remaining arable and grazing land is severely stressed due to various factors such as compaction from livestock and farm equipment, excessive use of pesticides and fertilizers, acidification, alkalization, or salinization, nutrient depletion, erosion from water and wind, and failing drainage systems.

Abbreviations

UNCCD: United Nations Convention to Combat Desertification

IFPRI: International Food Policy Research Institute

FAO: Food and Agriculture Organization

WMO: World Meteorological Organization

Conflicts of Interest

The authors declare no conflicts of interest.

References

- [1] Stavi, I. and Lal, R., 2015. Achieving zero net land degradation: challenges and opportunities. *Journal of Arid Environments*, 112, pp. 44-51. <https://doi.org/10.1016/j.jaridenv.2014.01.016>
- [2] de Jong, R. *et al.* (2011) 'Quantitative mapping of global land degradation using Earth observations', *International Journal of Remote Sensing*, 32(21), pp. 6823–6853. <https://doi.org/10.1080/01431161.2010.512946>
- [3] Jamal, s., Javed., A., Khanday., Y., 2016. Evaluation of land degradation and socio-environmental issues: a case study of semi arid watershed in Western Rajasthan. *J Environ port* (Irvine, Calif).
- [4] Kapur, R., 2016. Natural resources and environment issues. *J Ecosyst* 6: 2-5.
- [5] Pacheco FAL, Fernandes LFS, Junior RFV, Valera CA, Pissarra TCT (2018) Land degradation: multiple environmental consequences and routes to neutrality. *Curr Opin Environ Sci Health* 5: 79–86.
- [6] Kaiser, M. S. (2021). Land Degradation: Causes, Impacts, and Interlinks with the Sustainable Development Goals. In: Leal Filho, W., Azul, A. M., Brandli, L., Özuyar, P. G., Wall, T. (eds) *Responsible Consumption and Production*. Encyclopedia of the UN Sustainable Development Goals. Springer, Cham. https://doi.org/10.1007/978-3-319-71062-4_48-1
- [7] D'Odorico P., Ravi S., 2016. Land Degradation and Environmental Change. In: Shroder J. F. (Ed.), *Biological and Environmental Hazards, Risks, and Disasters*. 1st Edition, Elsevier, pp. 219-228. <https://doi.org/10.1016/B978-0-12-394847-2.00014-0>
- [8] Turner, KG., Anderson, S., Gonzales-Chang, Costanza, M., Courville, R., et al. 2016. A review of methods, data, and models to assess changes in the value of ecosystem services from land degradation and restoration. *Ecological Modelling* 319: 19-207.
- [9] Getachew Bar and Isral Zewdie (2022) Review On Land Degradation and Its Management, *Global Journal of Agricultural Research*, Vol. 10, No. 3, pp. 38-46.
- [10] Jendoubi, D., Liniger, H., and Ifejika Speranza, C.: Impacts of land use and topography on soil organic carbon in a Mediterranean landscape (north-western Tunisia), *SOIL*, 5, 239–251, <https://doi.org/10.5194/soil-5-239-2019> 2019.
- [11] Gibbs, H. K., & Salmon, J. M. (2015). Mapping the world's degraded lands. *Applied Geography*, 57, 12–21. <http://dx.doi.org/10.1016/j.apgeog.2014.11.024>
- [12] FAO, 2015. Status of the World's Soil Resources – Main Report. Food and Agriculture Organization of the United Nations and Intergovernmental Technical Panel on Soils, Rome, Italy.
- [13] Central statistical agency (CSA) (2017). Agricultural Sample Surveys 2017/2018 (2010 E.C.), Volume 1. Report on area and production of major crops. Addis Ababa, Federal Democratic Republic of Ethiopia.
- [14] Gebreselassie, S., Kirui, O. K., Mirzabaev, A. (2016). Economics of Land Degradation and Improvement in Ethiopia. In: Nkonya, E., Mirzabaev, A., von Braun, J. (eds) *Economics of Land Degradation and Improvement – A Global Assessment for Sustainable Development*. Springer, Cham. https://doi.org/10.1007/978-3-319-19168-3_14
- [15] Temesgen Gashaw, Amare Bantider and Hagos G/Silassie, 2014. Land Degradation in Ethiopia: Causes, Impacts and Rehabilitation Techniques. *Journal of Environment and Earth Science*. ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online), Vol. 4, No. 9, pp94-104. www.iiste.org
- [16] Nyssen J, Frankl A, Zenebe A, Deckers J, Poesen J (2015) Land management in the Northern Ethiopian highlands: local and global perspectives; past, present and future. *L Degrad Dev* 26: 759–764. <https://doi.org/10.1002/ldr.2336>
- [17] Tesfa A, Mekuriaw S (2014) The effect of land degradation on farm size dynamics and crop-livestock farming system in Ethiopia: a review. *Open J Soil Sci* 4: 1–5. <https://doi.org/10.4236/ojss.2014.41001>
- [18] Zewdu, S., Suryabhagavan, K. V. and Balakrishnan, M., 2016. Land-use/land-cover dynamics in Sego Irrigation Farm, southern Ethiopia: A comparison of temporal soil salinization using geospatial tools. *Journal of the Saudi Society of Agricultural Sciences*, 15(1), pp.91-97., <http://dx.doi.org/10.1016/j.jssas.2014.03.003>

- [19] FAO (2015) Global forest resource assessment 2015. Desk reference. Rome, Italy.
- [20] WMO, 2005. Climate and land degradation. World Meteorological Organization, WMO-n 989, ISBN 92-63-10989-3.
- [21] Birhanu A (2014) Environmental degradation and management in Ethiopian highlands: review of lessons learned. *Int J Environ Prot Policy* 2: 24–34.
<https://doi.org/10.11648/j.ijep.20140201.14>
- [22] Urgessa, A. A. 2016. Land degradation and adaptive mechanism in northeastern Wollega, Ethiopia. Thesis submitted to Department of Geography and Environmental Studies Presented in fulfillment of the requirement for the degree of Doctor of Philosophy (PhD) in Geography and Environmental Studies (specialization in Natural Resources Management and Environment) Addis Ababa University Addis Ababa, Ethiopia June 2016.
- [23] Mohammed Gedefaw, Teshome Soromessa, 2015. Land degradation and its impact in the highlands of Ethiopia: Case study in Kutaber woreda, South Wollo, Ethiopia. Full Length Research Paper. ISSN: 2408-6886 Vol. 3 (8), pp. 288-294, *Global Journal of Agriculture and Agricultural Sciences*.
- [24] Feyera Deresa and Tsetadirgachew Legesse, 2015. Cause of Land Degradation and Its Impacts on Livelihoods of the Population in Toke Kutaye Woreda, Ethiopia. *International Journal of Scientific and Research Publications*, Volume 5, Issue 5, May 2015 ISSN 2250-3153, www.ijsrp.org
- [25] Tesfaye Samuel Saguye, 2017. Analysis of farmers' perception on the impact of land degradation hazard on agricultural land productivity in Jeldu district in West Shewa Zone, Oromia, Ethiopia. Full Length Research Paper, Vol. 9(6), pp. 111-123, <https://doi.org/10.5897/JAERD2017.0854>
- [26] Hurni H, Solomon A, Amare B, Berhanu D, Ludi E, Portner B, Birru Y and Gete Z, 2010. Land Degradation and Sustainable Land Management in the Highlands of Ethiopia. In Hurni H, Wiesmann U (Ed) with an international group of coeditors. *Global change and sustainable development: A synthesis of regional experiences from research partnerships*. Geographical Bernensia. 5: 187-201.
- [27] Gashaw, T., Behaylu, A., Tilahun, A. and Fentahun, T., 2014. Population growth nexus land degradation in Ethiopia. *Population*, 4(11), p. 54.
- [28] Gogoi L (2013) Degradation of natural resources and its impact on environment: a study in Guwahati City, Assam, India. *Int J Sci Res Publ* 3: 1–7.
- [29] Hussein, A., 2021. Major causes and effects of land degradation and rehabilitation practices in Ethiopia: Systematic review. *Journal of Earth Science and Climatic Change*, 12(11), pp. 1-5.
- [30] Bekele, M., Tesfaye, Y., Mohammed, Z., Zewdie, S., Tebikew, Y., Brockhaus, M. and Kassa, H., 2015. *The context of REDD+ in Ethiopia: Drivers, agents and institutions* (Vol. 127). CIFOR.
- [31] Gadisa Chimdesa (2017). The Political Economy of Deforestation and Forest Degradation in Ethiopia: Review Article. *J. of Resources Development and Management*, Vol. 29, pp. 38-43.
- [32] Teklu E, Gezahegn A (2003). Indigenous Knowledge and Practices for Soil and Water Management in East Wollega, Ethiopia, Conference on International Agricultural Research for Development.
- [33] Gidey, G., Goitom, G., GASHU, G., GEBRE, A. and DER-ESSA, S., 2020. Rapid Population Growth as Foremost Cause of Land Degradation in Ethiopia: A Review. *POPULATION*, 10(9).
- [34] Gebreyesus, K. M., 2011. *Analyzing the Impact of Land use and Climate changes on Soil erosion and Stream flow in the Upper Gilgel Abbay Catchment, Ethiopia* (Doctoral dissertation, School of Graduate studies, Arba Minch University).
- [35] Kland, 2008. National action program on desertification report. Desertification control 3: 2-9.
- [36] Taffa T. 2008. Soil and Water Conservation for Sustainable Agriculture. Soil conservation research report 35. UN published document University of Berne Switzerland.
- [37] Betru, N., Jawad, A. and Nyborg I., 2005. Exploring ecological and socio-economic issues for the improvement of area enclosure management. A case study from Ethiopia. DCG.
- [38] Gete, Z., 2000. Landscape dynamics and soil erosion process modeling in the northwestern Ethiopian highlands. PhD Dissertation, African studies series A16, Geographica Bernensia, Berne.
- [39] Abebaw, W. A., 2019. Review on impacts of land degradation on agricultural production in Ethiopia. *J. Resour. Dev. Manag.* 57. <https://doi.org/10.7176/JRDM>
- [40] Gedefaw, M. and Soromessa, T. 2015. Land degradation and its impact in the highlands of Ethiopia: Case study in Kutaber wereda, South wollo, Ethiopia. *Global Journal of Agriculture and Agricultural Sciences* 3(8): 288-294.
- [41] Esdoman, 2006. The Effects Deforestation on Land Degradation. Implication for Sustainable land Management. PhD Thesis. Swedis university of Agricultural Science. Uppsala, Sweden.
- [42] Hagos G. (2014). Land Use-Land Cover dynamics of Huluka watershed, Central Rift Valley, Ethiopia. Department of natural Resources, Adigrat University, Ethiopia. *International Soil and Water Conservation Research*, Vol. 2, No. 4, 2014, pp. 25-33.
- [43] Hilker T, Natsagdorj E, Waring RH, Lyapustin A, Wang Y (2013) Satellite observed widespread decline in Land Degradation: Causes, Impacts, and Interlinks with the Sustainable Development Goals 11 Mongolian grasslands largely due to overgrazing. *Glob Chang Biol* 20(2): 418–428.
- [44] Alloway, B. J., 2013. Sources of heavy metals and metalloids in soils. *Heavy metals in soils: trace metals and metalloids in soils and their bioavailability*, pp. 11-50.
- [45] Vote berg, 2009. The impact of traditional farming system on land degradation. The Case of Farmers in the Nile Basin of Ethiopia. IFPRI Discussion Paper 01032.

- [46] Abiye, W., 2022. Soil and water conservation nexus agricultural productivity in Ethiopia. *Advances in Agriculture*, 2022.
- [47] Narayana, D. V., and Babu, R., 2000. Estimation of Soil Erosion in India J. Jrrig. Drain. Engg Log (4): 419-434.
- [48] Abdeta, G. C., Geleto, G. M. and Dilla, E., 2018. Farmers' Perception on Land Degradation and Adoption of Soil-Water Conservation Measures in Ethiopian Highlands. *J. Res. Dev. Manag*, 40, pp. 36-54.
- [49] Berry L., 2003. Land degradation in Ethiopia: its impact and extent in Berry L, Olson J. and Campbell D (Ed): Assessing the extent, cost and impact of land degradation at the national level: findings and lessons learned from seven pilot case studies. Commissioned by global mechanism with support from the World Bank.
- [50] Debie, M. 2018. Perceived Impacts of Land Degradation on Livelihood of Farming Communities in Upper Gumara Catchment Northern, Ethiopia. Addis Ababa University.
- [51] Haregeweyn N, Nyssen J, Poesen J, Schu B (2015) Soil erosion and conservation in Ethiopia: a review. *Prog Phys Geogr* 39: 750–773. <https://doi.org/10.1177/0309133315598725>
- [52] Temesgen G (2015). Soil Erosion in Ethiopia: Extent, Conservation Efforts and Issues of Sustainability. *Pjpalgo Journal of Agriculture*. 2(2), pp 38-48.
- [53] Kassa, Y., Beyene, F., Haji, J. and Lejese, B., 2013. Farmers perceptions of the impact of land degradation and soil and water conservation measures in west Hareghe zone of oromia national regional state, Ethiopa. *Journal of Biology, Agriculture and Healthcare*, 3(11), pp. 12-19.
- [54] Tadesse, M. and Belay, K., 2004. Factors influencing adoption of soil conservation measures in southern Ethiopia: the case of Gununo area. *Journal of Agriculture and Rural Development in the Tropics and Subtropics (JARTS)*, 105(1), pp. 49-62.
- [55] LeeE, 2006. Soil Fauna and Soil Structure. *Austsoil resources* 27; 745-76.
- [56] Gray, D. M, and Leiter A. T, 2002. The Threat of Soil Erosion to Long-term Crop Production. *Science* (4), Vol 219: pp458-465.
- [57] IFPRI (International Food Policy Research Institute), 2005. Poverty and Land Degradation in Ethiopia: How to Reverse the Spiral? International Food Policy Research Institute (IFPRI). Pp1-9.
- [58] Tilahun A, Takele B and Endrias G, 2001. Reversing the Degradation of Arable Land in the Ethiopian Highlands. *Managing Africa's soils* No. 23. International center for research in agro forestry. Pp1-20.
- [59] Fit sum H, Pender J and Nega G, 1999. Land Degradation in the Highlands of Tigray and Strategies for Sustainable Land Management: Socio economics and Policy Research Working Paper 25. International Livestock Research Institute.
- [60] UNCCD, 2017. Golbal land out look: secretiat of the United Nations Convaention of Combat Desertification, firstEdit. Bonn, Germany www.unccd.int
- [61] Eswaran, H., Lal, R., Reich, PF., 2017. Land degradation: an overview. *Responses to Land degradation* 10: 20-35.
- [62] Sonneveld BGJS, Keyzer MA, Ndiaye D (2016) Quantifying the impact of land degradation on crop production: the case of Senegal. *Solid Earth* 7(1): 93.
- [63] Issaka S, Ashraf MA (2017) Impact of soil erosion and degradation on water quality: a review. *Geol Ecol Landsc* 1(1): 1–11.
- [64] Scherr, S. 1999. Soil degradation: a threat to developing-country food security by 2020? *Food, Agriculture and the Environment Discussion Paper 27*. Washington DC: International Food Policy Research Institute.
- [65] ELD Initiative & UNEP (2015) The economics of land degradation in Africa: benefits of action outweigh the costs. Available from <http://www.eld-initiative.org>
- [66] Kirui OK (2016) Impact of land degradation on household poverty: evidence from a panel data simultaneous equation model (No. 310-2016-5325).
- [67] Heger MP, Zens G, Bangalore M (2020) Land and poverty: the role of soil fertility and vegetation quality in poverty reduction. *Environ Dev Econ* 25(4): 315–333.
- [68] Long, H., Qu, Y., 2018. land use police land transition and land managemet: a mutual feeddackprespective. *land use police* 74: 111-120.
- [69] Bedasa, N. A. and Hussein, J. W. (2018) 'Challenges in Managing Land-Related Conflicts in East Hararghe Zone of Oromia Regional State, Ethiopia', *Society & Natural Resources*, 31(3), pp. 351–366. <https://doi.org/10.1080/08941920.2017.1400626>
- [70] Nigussie, Z., Tsunekau., A., Haregeweyn., N., Adgo., E., Cochraned., L., Flonguete., A., Abele., S., 201 8. Applying Ostrom's institutional analysis and development framework to soil and water conservation activities in north-western Ethiopia. *Land use policy* 71: 1-10.
- [71] Brown, S. and Lugo, A. E., 1994. Rehabilitation of tropical lands: a key to sustaining development. *Restoration ecology*, 2(2), pp. 97-111.
- [72] Gessesse, B., 2010. Review of land degradation and land management in Ethiopia up to 2008/09. In *Forum For Environment Addis Ababa, Ethiopia*.
- [73] Nyenje, P. M., Foppen, J. W., Uhlenbrook, S., Kulabako, R. and Muwanga, A., 2010. Eutrophication and nutrient release in urban areas of sub-Saharan Africa—a review. *Science of the total environment*, 408(3), pp. 447-455.
- [74] McLeman R (2017) Migration and land degradation. Global Land Outlook working paper. UNCCD.