

Research Article

The Status of Land Degradation Induced by Soil Erosion and Management Options in Duna District, Hadiya Zone, Central Ethiopia

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Abstract

Land resource degradation is a significant environmental issue that adversely impacts economic development and the livelihoods of farming communities. Therefore, the study aimed to explore land degradation by soil erosion and its management options in study area. To evaluate the causes and status of land degradation and for explore management practices against land degradation in the research area. To meet the established objectives, relevant data was gathered from samples area which was chosen using a stratified sampling method based on their agro-ecological conditions. The study's findings show that the livelihoods of all sampled household heads rely on mixed farming activities, with 90.3% of respondents engaged in both crop production and livestock rearing. The study indicates that crop and livestock productivity among household heads has been declining over time due to land degradation. In addition to land degradation, land shortage and limited access to farm inputs are significant challenges for crop production, leading to the expansion of farmland into grazing areas to compensate for crop losses caused by land degradation. The extent of land degradation in the study area continues to increase over time, as indicated by findings from the four selected kebeles are highly degraded; High population pressure, the area's topography, and frequent changes in farming and land use are the primary factors exacerbating land degradation in the study area, leading to a decline in the quality of farmland productivity. In response to the impacts of land degradation on their livelihoods, the community has implemented various strategies. Common approaches in the study area include cultivating cereal crops, engaging in daily labor, practicing handicrafts, planting perennial crops like buckthorn for sale, participating in irrigation activities, and clearing vegetation and forests to expand farmland.

Keywords

Land Degradation, Soil Erosion, Management

1. Introduction

Land is one of the few natural capitals directly involved in livelihood and welfare of the rural poor especially low- and middle-income countries. However, a range of interconnected socio-demographic and natural factors such as population

pressure, continuous expansion of agricultural activities, migration, and resettlement in natural reserves, climate change and associated risks influence land resources [7]. In poor nations with high population density, people often live

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in marginal areas and engage in cultivation of marginal lands which has more negative than positives to the society and environment [8]. The rapid degradation of one natural resource may have a positive feedback on the other resource and most feed off each other with devastating effect on soil, vegetation cover, continuous nutrient mining as well as migration of wildlife [6].

Ethiopia is one of the poorest nations, facing significant soil loss due to land degradation [18]. This situation leads to decreased vegetation cover, pushing farmers to adopt unsustainable land use practices [14]. Most of Ethiopia's populations are farmers living in rural areas, with their livelihoods almost entirely reliant on agriculture. Land is a crucial and limited natural resource that forms the foundation of agricultural production systems [17]. Therefore, effective land management is essential for generating wealth in many communities [2]. Currently, efforts to increase agricultural yield to feed increasing population involves expansion of land under cultivation [16]. The Ethiopian highlands, which make up 44% of the country's total land area, are significantly at risk from soil and biological degradation [10]. Approximately 27 million hectares, or about 50% of the highlands, are already severely degraded. Within this area, millions of hectares are experiencing significant erosion. If the current trend of soil degradation persists, per capita income in the highlands could decrease by 30% over the next 20 years. Additionally, around 54% of the remaining highlands are highly vulnerable to erosion [11].

According to [1], the Hararghae highlands in Eastern Ethiopia, as well as the Tigray, Wollo, and Semen Shoa highlands in the north, along with the Gamo-Gofa highlands and the Bilate River basin—which begins on the eastern slopes of the Gurage highlands and extends through the eastern Hadiya and Kembatta highlands—are among the most severely eroded and degraded areas in Ethiopia [5]. The country faces significant soil erosion, with estimated annual soil loss ranging from 16 tons per hectare per year to 179 tons per hectare per year [12]. Since 80% of Ethiopia's population is involved in agricultural activities [10], the rapid expansion of agricultural practices to support the growing population is contributing to increased land degradation in the country. The cultivation of marginal lands and deforestation exacerbate land degradation through soil erosion [3]. Water-induced soil erosion and nutrient loss are significant contributors to land degradation and pose major challenges to agricultural productivity [4]. Intensive cultivation of the land and grazing by livestock contribute to soil erosion by water or wind [20]. In the face of climate variability, the amount and intensity of precipitation is changing and this aggravates soil erosion and the extent of soil loss due to water and wind erosion [14].

As most of the rural population relies on agriculture for their livelihoods, land degradation, particularly in the form of soil erosion, is a significant issue linked to agricultural systems [3]. Previous studies explored farmers' awareness and sources of information about land degradation as well as

conservation practice against land degradation in the research area [15].

In order to tackle degradation challenge the government along with multiple partners embarked on a range of conservation measure but the threat to current agricultural production and future sustainability remains [13]. However, the extent of land degradation, particularly soil erosion, and the management practices implemented to address it are not well studied in the area. Therefore, this research aims to fill this information gap by gathering firsthand data on the status, causes, and impacts of land degradation, as well as the management strategies in the study area. The result of this study was useful to decision makers and various stakeholders to plan future intervention measures against land degradation in the research area.

The the overall objective of this research was to assess the extent of land degradation induced by soil erosion and management options in Duna district of Hadiya Zone, Central Ethiopia.

- a) To evaluate the causes and extent of land degradation in Duna district
- b) To explore management practices against land degradation in the research area

2. Materials and Methods

Description of the Research Area

This research was conducted in the Duna district, located in the Hadiya Zone of Central Ethiopia. It lies 274 km south of Addis Ababa, the country's capital, and 42 km from Hosanna, the capital town of Hadiya Zone (Duna district transport office). The study area encompasses approximately 39,782.59 hectares. Duna district is bordered to the south by Doyogena district, to the west and north by the Kembata-Tembaro Zone, and to the east by Soro district [9].

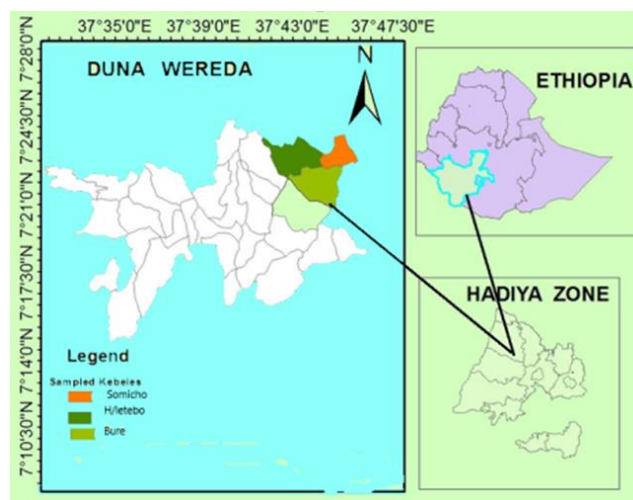


Figure 1. Map of the study area.

Design

A cross-sectional study design incorporating both qualitative and quantitative methods will be used to achieve the study's objectives. Due to limited time and resources, a cross-sectional design is preferable for gathering detailed information about existing land degradation problems in the study area. This design involves collecting data from sample households at a specific point in time to examine the current situation regarding the issue.

Sampling Techniques

First Duna district was selected for this study due to its familiarity to the researcher and ease of access to data collection. In Duna district, there are 32 kebeles. For this study, three kebeles that are experiencing significant degradation due to deforestation, soil erosion, and nutrient depletion have been selected. The sample households from three *kebele* were selected from the available list using systematic simple random sampling.

Sampling Size

To select a sample, it is essential to follow a systematic approach. An appropriate sample ensures high precision, accuracy, and confidence at minimal cost. To determine the optimal sample size, several factors must be considered: a) Objective of the study b) Research design c) Cost constraints and plans for statistical analysis. The sample size for this study is determined using the simplified formula provided by Yemane [19].

$$n = \frac{N}{1 + N(e)^2}$$

$$n = \frac{490}{1 + 490(0.05)^2}$$

$$n = \frac{490}{2.225} = 220$$

Where n= sample size

N=target population

e= error terminology (5%)

Data Source

The data required for this study was collected from both primary and secondary sources. Primary data was gathered from land users, development agents, district land administration and environmental protection experts, kebele leaders, and religious leaders. To enhance the reliability of the primary data, secondary sources were also utilized. This included published and unpublished documents from district offices, aerial photographs, topographic maps, and population data obtained from various governmental institutions. In addition, frequent field observations using a Global Positioning System (GPS) were conducted to gather primary information for verifying ground truth related to image classification and assessing soil loss vulnerability against office document references.

3. Primary Data Collection Instruments

Household Survey

In the survey, data was collected on household demographic characteristics, socio-economic factors, issues related to land degradation, and its impact on the communities management practices used was obtained by gathering information from target groups.

Informant Interview

Key informant interviews are crucial for obtaining information relevant to assessing land degradation problems.

Focus group discussion

In this study, both qualitative and quantitative analysis methods were utilized. Qualitative information recorded in notebooks from focus group discussions, conversations during key informant interviews, and personal observations was organized, structured coherently, and analyzed in descriptive text form.

Field Observation

Direct personal observation involved visits to both cultivated and uncultivated land, examining the topography, vegetation cover, settlement patterns, and the overall aspects of the land degradation problems in the study area.

Method of Data Analysis

In this study, both qualitative and quantitative data analysis methods were employed. Qualitative information recorded in notebooks from focus group discussions, key informant interviews, and personal observations was organized, coherently structured, and analyzed in descriptive text form. For quantitative data analysis, the Statistical Package for Social Sciences (SPSS) version 26 was utilized. This involved coding and entering the collected data into the computer for analysis and tabulation of results. The analysis was conducted using descriptive statistical methods, including frequency distributions, percentages, and bar graphs

4. Results and Discussion

Land degradation on soil erosion, extent, and its magnitude

Land degradation for farmers refers to the decline in the productive quality of the land, particularly due to soil erosion or the land's inability to produce crops without fertilizer. This degradation is significant and acknowledged by farmers in each target kebele. Approximately 212 (96.4%) of the sampled household heads reported experiencing land degradation issues on their farmland. Among these respondents, 92 (100%) from Bure Bulishana, 55 (100%) from Somicho, and 65 (89.1%) from Ha Latebo acknowledged that there is a land degradation problem on their farmland. Only 10.9% of the household heads in Ha Latebo reported that there is no land degradation on their farmland. This indicates that land degradation is a significant issue affecting crop production in each target kebele, ultimately impacting the livelihoods of the farming communities.

A total of 43 respondents (19.5%) indicated that soil erosion has been a problem on their farmland over the last five years. Additionally, farmers who reported that land degradation due to soil erosion has occurred on their farmland over the past ten years include 46 (50%) in Bure Bulishana, 26 (47.3%) in Somicho, and 43 (58.9%) in Ha Latebo kebele, respectively. Farmers reporting that land degradation due to soil erosion has occurred over the last fifteen years include 13 (14.1%) in Bure Bulishana, 12 (21.8%) in Somicho, and 15 (20.5%) in Ha Latebo kebele. Additionally, about 9 (9.8%), 7 (12.7%), and 6 (8.2%) respondents noted that soil erosion has been a problem over the past twenty years in Bure Bulishana, Somicho, and Ha Latebo, respectively. They cited several reasons for this degradation, including population pressure, the area's topographic nature, inappropriate land management practices, and frequent farming. This indicates that soil erosion has a long history as a land degradation issue in the study area.

Perceived Indicators of Land Degradation Due to Soil Erosion

There are several indicators of land degradation related to soil erosion, including reduced land productivity, drying up of water bodies such as springs, decreased yields from cultivated fields, and the inability to produce cereal crops without fertilizer. In the study area, respondents were asked about these issues. Accordingly, 88 (95.6%) in Bure Bulishana, 51 (94.5%) in Somicho, and 70 (95.9%) in Ha Latebo identified crop reduction from year to year as the main indicator of land degradation due to soil erosion in each target kebele. Furthermore, the same respondents noted that the reduction of land productivity, which affects sufficient crop production, is a significant indicator of land degradation. Regarding livestock reduction as an indicator, 88 (95.6%) in Bure Bulishana, 51 (94.5%) in Somicho, and 70 (95.9%) in Ha Latebo also reported this concern in each kebele.

Degree of land degradation due to soil erosion

Land degradation due to soil erosion is accelerating, primarily as a result of over-cultivation. According to the table below, all 92 respondents (100%) from Bure Bulishana, 52 respondents (94.5%) from Somicho, and 67 respondents (91.7%) from Ha Latebo reported that soil erosion is increasing over time. Meanwhile, a small number of respondents—3 (5.5%) from Somicho and 6 (8.2%) from Ha Latebo—indicated that land degradation due to soil erosion is decreasing.

Causes of the Increase in Land Degradation Due to Soil Erosion

In Bure Bulishana, 83 respondents (90.2%), in Somicho, 48 respondents (87.3%), and in Ha Latebo, 63 respondents (86.3%) indicated that high population pressure is the primary cause of increased land degradation due to soil erosion. Additionally, participants in focus group discussions noted that both high population pressure and deforestation significantly contribute to the severity of land degradation. The growing population puts pressure on farmland distribution,

forcing households to expand into marginal areas and to cultivate land at the expense of vegetation and forests. Thus, population pressure is identified as the main driving factor behind the escalating land degradation from soil erosion in all target kebeles.

Severity of land degradation caused by soil erosion

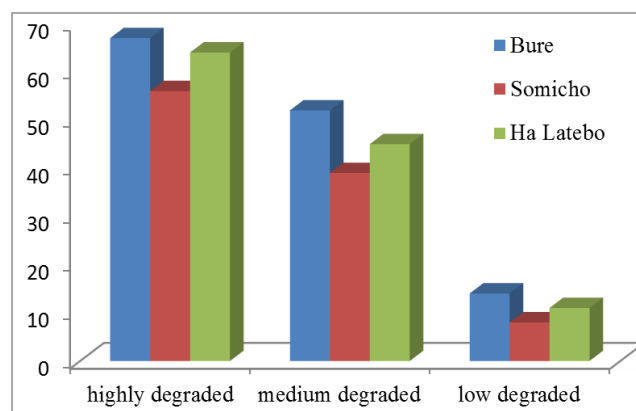


Figure 2. Magnitude resulting from soil erosion.

Effects of land degradation on livelihoods

The effects of land degradation on crop and livestock productivity, water resources, and natural forests are key indicators of its severity in the study area. Participants in focus group discussions and key informant interviews noted that the community's livelihood relies heavily on agriculture and livestock. Consequently, land degradation adversely impacts these activities, forcing people to sell their farm animals and labor. Additionally, they mentioned that the repercussions of land degradation on agricultural and livestock productivity, as well as its effects on water and firewood resources, often result in fewer daily meals and reduced meal quality. This situation can also lead to children dropping out of school and increased migration.

Impacts of land degradation on crop productivity

The availability and fertility of land are crucial factors for the livelihoods of farming communities in the study area, as the amount of productive land directly influences the quantity of crops available for household consumption. The primary crops grown in the area include barley, wheat, teff, potatoes, maize, chickpeas, and lentils, with perennial crops like buckthorn also present. Crop types vary from kebele to kebele due to climatic differences; for instance, dagusa, chickpeas, and vetch are prevalent in Ha Latebo and Somicho, while peppercorn is common in Ha Latebo. However, the productivity of these crops is declining due to land degradation. According to the table below, 195 respondents (88.6%) indicated that land degradation negatively impacts their crop yields. In addition to land degradation, challenges such as limited access to farm inputs, land shortages, and snow (beredo) also hinder crop productivity in the area. Participants in focus group discussions and key informant inter-

views noted that while land degradation affects all types of crops, the extent of its impact varies by crop. For example, teff and beans are particularly vulnerable, as teff is primarily grown in the summer, which exacerbates erosion rates and ultimately reduces its productivity.

Currently, the cultivation of beans is no longer feasible due to declining soil fertility. Participants in the focus group discussions and key informant interviews noted that the current level of crop production is insufficient to sustain their families' livelihoods. Consequently, farmers are compelled to use fertilizers to boost crop yields. They indicated that the use of chemical fertilizers has become widespread over the past decade, and there is now no crop variety being cultivated without fertilizers. Additionally, the cost of chemical fertilizers continues to rise each year, surpassing their financial capabilities. This trend has a detrimental impact on their net income from production.

Impacts of land degradation on livestock

Livestock production plays a crucial role in the economy and is regarded as an asset. It is vital for addressing food shortages during crop failures, and land cultivation is often carried out using animals such as oxen. In the study area, livestock production is the second most important economic activity for households, following crop production. Households own various types of livestock, including oxen, cows, calves, sheep, and donkeys. The number of livestock is a key factor influencing crop production, as it provides the necessary power for land cultivation. However, the productivity of livestock has been declining over time due to land degradation.

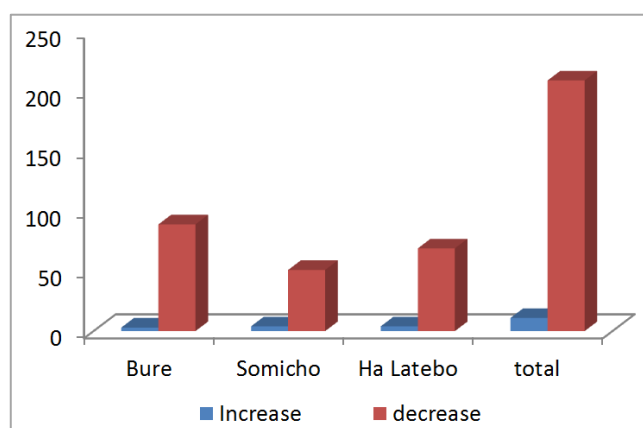


Figure 3. Impacts of land degradation on livestock.

As shown in the graph, the productivity and size of grazing land is declining over time as a result of land degradation. This is the main reason for decreasing of livestock productivity in the study area. Based on personal observation during data collection area enclosure is the main land management practices to rehabilitate the degraded area and this is the main reason for declining of grazing land.

Impacts of land degradation on water resource

In Ethiopia, land degradation affects not only crop and livestock productivity but also the water resources essential for human well-being. Various activities, both positive and negative, have been undertaken in the watersheds of lakes, reservoirs, rivers, and streams due to a growing human population. Extensive deforestation, overgrazing, and poor crop and soil management practices over time have led to significant sediment accumulation in river channels, lakes, and reservoirs. Consequently, 87 respondents (94.6%) from Bure Bulishana, 51 (92.7%) from Somicho, and 70 (95.9%) from Ha Latebo kebeles indicated that land degradation impacts water resources. Conversely, the remaining respondents—5 (5.4%) in Bure Bulishana, 4 (7.3%) in Somicho, and 3 (4.1%) in Ha Latebo—believed that land degradation does not affect water resources.

Effects of land degradation on firewood resource

The severe extent of land degradation has significantly harmed valuable natural resources, particularly forests that serve as energy sources. Land degradation negatively affects forest resources because the degradation of agricultural land often leads to the deforestation of natural forests to make up for the loss of productive cropland.

Strategies Employed by the Community to Address Land Degradation

Mitigate the adverse effects of land degradation on the livelihoods of rural households, various strategies must be implemented. These strategies can be either beneficial or harmful. Negative approaches include cutting down trees for charcoal production or clearing forests to expand farmland. This is supported by the results of the LULCC analysis conducted in the watershed. In contrast, positive strategies in the study area include engaging in daily labor, selling farm animals, crafting, and utilizing irrigation. Notably, a significant majority of respondents, 216 (99.0%), indicated that there are viable options available to counter the impacts of land degradation on their livelihoods.

Strategies Used by the Community to Mitigate the Effects of Land Degradation

Land degradation adversely affects the livelihoods of farming communities, leading to reduced income. To address these challenges, various strategies are employed. In the study area, the community utilizes several approaches to combat the issue. Approximately 85 respondents (92.4%) in Bure Bulishana, 47 (85.5%) in Somicho, and 62 (84.9%) in Ha Latebo engage in daily labor as a way to tackle the problem. Those who sell farm animals as a strategy comprise 82 (89.2%) in Bure Bulishana, 47 (85.5%) in Somicho, and 59 (80.8%) in Ha Latebo. Additionally, about 78 (84.8%) in Bure Bulishana, 43 (78.2%) in Somicho, and 60 (82.2%) in Ha Latebo practice handicraft as an option, while 75 (81.5%) in Bure Bulishana, 40 (72.7%) in Somicho, and 54 (74%) in Ha Latebo engage in trade. Participants in focus group discussions and key informant interviews noted that the application of these strategies varies from one kebele to another.

5. Conclusion

Land resource degradation is the major environmental problem negatively affecting economic development in general and livelihood of the farming community in particular in Ethiopia. So the study tried to investigate land degradation by soil erosion and its management options in Duna district, Hadiya Zone, Central Ethiopia. Questionnaires were distributed to 220 randomly selected household heads. As the result of this study indicates that like the other parts of the country land degradation is the serious problem which negatively affects the livelihood of the farming community. As the finding of the study indicates crop and livestock productivity of the household heads are declining over time because of land degradation. In addition to land degradation, land shortage, less access to farm inputs are the main challenges for crop production and expansion of farmland on grazing land to compensate the loss of crop as a result of land degradation and area enclosure for restoration practices are the main challenges for livestock production. The magnitude of land degradation in the study area increases from time to time. As the finding indicates from the four selected kebeles Bure Bulishana and Somicho are highly degraded, Ha Latebo kebele is medium degraded. The Large size of farmland is damaged as a result of land degradation in each target kebeles. As the finding indicates high population pressure, topographic nature of the area, frequent farming and land use land cover change are the main factors aggravating the problem of land degradation in the study area and the quality of farmland productivity become decline. The main effects that the community face as a result of land degradation on livelihood includes reduced in a daily number of meals, reduced in quality of food, withdrawal of children from school and health problem. Regarding the strategies applied by the community to overcome the effect of land degradation on livelihood, there have been types of options undertaken in the study area by the farming community. The common strategies applied in the study area includes farm animal sale to buy cereal crops, daily labor, handcraft, planting perennial crops like buckthorn and selling it, irrigation activity and deforestation of vegetation and forest to expand farmlands.

6. Recommendations

The finding the study indicates that there is a serious land degradation problem and it seriously affects the livelihood of the farming community in the study area. So, based on the finding of the study, the following points will be important for the future in order to reduce the problem and to make the environment suitable in particular in the study area and generally in the country.

- 1) There should be a technological advancement in order to increase agricultural productivity and to disseminate information regarding land management practices.

- 2) Area enclosure is the main technique for rehabilitation of degraded lands. So there should be active participation of local community to make it sustainable.
- 3) Training should be given to the farmers regarding the use of compost and its preparation in order to increase crop productivity on their farmland.
- 4) Focus should be given on searching of alternative soil and water conservation rather than focusing on terracing.
- 5) It is better to create awareness about the negative effects of land degradation on livelihood. Knowing the negative effect of land degradation on livelihood enables the farmer to manage their farmland effectively.
- 6) Irrigation activity is the main option applied by the community to overcome the effect of land degradation on livelihood. It is better to provide modern instruments like pumps to the farmer to make irrigation more effective.
- 7) It is better to give emphasis on modern crop seeds to increase crop productivity.
- 8) The livelihood of the farming community in the study area directly depends on the land resource for both crop and livestock productivity but the sustainability of their livelihood is affected by land degradation. So, focus should be given on introduction of non-farm incomes source rather than depending on the land resource.

Abbreviations

CSA	Central Statistical Agency
DDTO	Duna District Transport Office
FAO	Food and Agricultural Organization
HZCE	Hadiya Zone Central Ethiopia
LULCCADF	Land Use and Land Cover Changes and Associated Driving Forces
LULCC	Land use Land Cover Change
SPSS	Statistical Package Social Science
SECALD	Strategies Employed by the Community to Address Land Degradation

Conflicts of Interest

The authors declare no conflicts of interest.

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