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Assessing the Effect of Land Degradation on Farmer's Livelihood: A Case of Muhanga District, Rwanda

Humphrey SiehTarpeh

University of Lay Adventist of Kigali (UNILAK)

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***Corresponding Author:** Humphrey SiehTarpeh

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Abstract **Original Research Article**

This research focused on assessing the extent and nature of land degradation's impact on farmers' livelihoods in Muhanga District of the Southern Province, Rwanda. The specific objectives are to analyze the land degradation in Muhanga District of Southern Province, Rwanda, to assess the level of farmers' livelihood in Muhanga District of Southern Province, Rwanda and to establish whether there is a significant effect of land degradation on farmer's livelihood in Muhanga District, Southern Province of Rwanda. Therefore, the research will test the following hypotheses: H0: There is no significant effect of land degradation on livelihood of famers in Muhanga District of Southern Province, Rwanda and H1: There is a significant effect of land degradation on livelihood of famers in Muhanga District of Southern Province, Rwanda. The researcher used descriptive and correlational research design. The population of the study is 119,625 People in whole city of Muhanga, from whom a sample size of 391 is calculated using Cochran G. William formula. The data was collected using questionnaire and documentary. The data was analyseduwing means and standard deviation. The analysis of the coefficients in Table 4.21 shows that the variable "Land management practices" plays a significant role in affecting farmers' livelihoods. The standardized coefficient (Beta) of 0.371 is statistically significant ($p < 0.001$), indicating that land management practices is a prominent factor impacting farmers' livelihood. This suggests that Muhanga district has experienced a notable level of flood occurrences during the period of 2010-2022. The impact of land management practices on farmers' livelihood is substantial, highlighting the importance of understanding and addressing flood disasters in the region. The coefficient for "Deforestation" in Table 4.21 is highly significant with a Beta of 0.430 ($p < 0.001$). This indicates that deforestation due to land management practices has a significant impact on the livelihood status of farmers in Muhanga district. Farmers face substantial challenges in maintaining their livelihoods due to crop losses caused by land management practices... The findings indicate a moderate level of agreement among respondents regarding their awareness of soil erosion, its causes, and its significant contribution to land degradation. The acknowledgment of unsustainable agricultural practices and deforestation exacerbating soil erosion highlights the interconnected nature of these factors. This analysis forms a foundational understanding of the prevailing land degradation awareness in Muhanga District The regression analysis provides statistical evidence supporting the significant impact of certain aspects of land degradation on farmers' livelihood. Specifically, effective land management practices and addressing deforestation emerge as crucial factors positively influencing farmers' well-being. However, soil erosion and nutrient depletion, while acknowledged by respondents, may not exert a statistically significant impact based on the data. Based on the findings of the study on the effect of land degradation on farmers' livelihood in Muhanga District, Southern Province, Rwanda, the following recommendations are suggested: Encourage and support farmers in adopting sustainable agricultural practices that minimize soil erosion and nutrient depletion. This may include promoting agroforestry, contour plowing, cover cropping, and organic farming techniques. Agricultural extension services can play a crucial role in providing training and support. Implement reforestation programs to restore degraded lands and prevent further deforestation.

Keywords: *Land Degradation, Farmers, Livelihood, Impacts*

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1. INTRODUCTON

Globally, food production has been affected by land degradation (Kamau, 2018). Land degradation is the loss in productivity of land and its ability to provide services as a result of natural and anthropogenic factors. These factors affect soil quality and the ability of land to produce will have been affected and, hence, famine among smallholder farmers. Intentional and non-international human activity, as well as natural causes, all contribute to global soil degradation and land cover change.

Land degradation is a pressing global environmental issue that significantly affects agricultural productivity and poses a significant threat to farmer's livelihoods worldwide. It refers to the deterioration of land quality, resulting in reduced agricultural productivity, loss of biodiversity, and the depletion of natural resources. The consequences of land degradation are particularly severe for farmers, as their livelihoods heavily depend on the health and fertility of the land they cultivate.

Across the world over 20% of cultivated areas, 30% of forests and 10% of grasslands were suffering from degradation, affecting about 1.5 billion people, this degradation might be the result of numerous factors or combination of their including anthropogenic activities such as unsustainable land management practices and climatic variations (Bai et al., 2008). In Africa, land degradation stands at about 50% and this is associated with soil erosion, most of which occurred since the end of World War II, causing a 17% reduction in crop productivity. The extent of soil erosion shows that it's a worldwide environmental problem with some areas such as the horn of Africa and majority of sub – Saharan region being extremely prone to erosion due to prolonged dry periods and heavy erosive rainfall, falling on steep slopes with fragile soils, causing in considerable amounts of erosion. (Abdallah, 2016)

In Rwanda, according to Twagiramungu (2016), Land degradation specifically soil degradation is a major environmental problem in Rwanda, the degradation is particularly linked to hydrous erosion that affects a big portion of cultivated lands. It was assumed that the hydrous erosion reduces the capacity to feed 40 000 persons per year and causes annual losses of about 15 000 000 tons of soil. According to Sileshi (2016), the vulnerability to land degradation needs to be assessed continually to take appropriate resource conservation measures. Therefore, the aim of this study was to assess the impact of land degradation on agriculture productivity in Nyabihu district through the integration of GIS and RS. More specifically, the study is targeted to map the spatial and temporal changes in agriculture land use and land cover, to assess soil erosion and landslide as factors of land degradation, as well as other factors that affect agricultural productivity. It is against this background that the study assessed factors influencing land degradation, the level of land degradation, the impact of land degradation on crop production in Nyabihu district and the specific proposed land conservation measures.

The effect of land degradation on the natural environment is due to the depletion of forests (Birhanu, 2014). Land degradation also leads to the diminution of livestock in both quantity and quality so that the living standard of the rural people as a whole is affected by any change in the livestock sector. Land degradation also results in enhancing the unemployment rate and outmigration; where there is low agricultural and livestock production. Insufficient land for cultivation leads to a reduction of farm size that creates disguised unemployment.

1.2. STATEMENT PROBLEM

Land degradation is an urgent global concern that poses a significant threat to the livelihoods of farmers. This degradation, driven by factors such as deforestation, soil erosion, and improper land management practices, has far-reaching consequences for agricultural productivity and the overall well-being of farming communities (García-Ruiz, 2010; Oldeman et al., 1991). Therefore, this study seeks to investigate the effects of land degradation on farmers' livelihoods, with a specific focus on the following key dimensions:

Recent studies underline the critical significance of this issue. For instance, research by Montgomery (2019) highlights the link between land degradation and reduced crop yields, emphasizing the need to understand the impact on farmers' income and food security. Dixon et al. (2021) discuss the income disparities caused by farming disruptions due to land degradation, demonstrating the urgency of assessing the effects on farmers' livelihoods. Safriel et al. (2022) emphasize the broader socioeconomic implications of land degradation, underscoring the necessity of investigating its consequences for access to education, healthcare, and overall quality of life. Additionally, studies by Chen et al. (2022) and Gashaw et al. (2017) shed light on the adaptation strategies employed by farmers, thereby enhancing the understanding of mitigation and adaptation in the face of land degradation. This research specifically focused on assessing the extent and nature of land degradation's impact on farmers' livelihoods in Muhanga District of the Southern Province, Rwanda.

1.3. OBJECTIVES OF THE STUDY

General Objective

Assess the extent and nature of land degradation on farmer's livelihood in Muhanga District of Southern Province, Rwanda.

Specific Objectives

I. Analyze the land degradation in Muhanga District of Southern Province, Rwanda.
II. To assess the level of farmers' livelihood in Muhanga District of Southern Province, Rwanda.
III. To establish whether there is a significant effect of land degradation on farmer's livelihood in Muhanga District, Southern Province of Rwanda.

1.4. RESEARCH QUESTIONS

I. How is the land degradation in Muhanga District of Southern Province, Rwanda?
II. ii. What is the level of farmers' livelihood in Muhanga District of Southern Province, Rwanda?
III. iii. Is there a significant effect of land degradation on farmer's livelihood in Muhanga District, Southern Province of Rwanda?

2.0. REVIEW OF LITERATURE

This chapter review synthesizes existing research studies, analyses their findings, and identifies key themes and

trends. The review also discusses the socio-economic consequences of land degradation and examines potential solutions and policy interventions to mitigate its adverse effects on farmer's livelihood. This literature review aims to explore the effect of land degradation on the livelihood of farmers. Land degradation, caused by various factors such as deforestation, soil erosion, desertification, and chemical pollution, has significant implications for agricultural productivity and the well-being of farmers.

2.1. Universal Soil Loss Equation (USLE)

The Universal Soil Loss Equation (USLE) was developed in the early 1960s by researchers from the United States Department of Agriculture (USDA) and the Natural Resources Conservation Service (NRCS). While it doesn't have a single identifiable founder, it is a collaborative product of many scientists and researchers in the field of soil conservation and agriculture. The USLE has undergone extensive testing and revisions over the years, and some critics have raised concerns or suggested modifications to enhance its accuracy and effectiveness.

Some critics argue that the USLE's reliance on empirical data for its factors may lead to inaccuracies in estimating soil erosion. To address this, efforts have been made to refine the equation by incorporating more advanced modeling techniques and remote sensing data. Critics have pointed out that the USLE may not account for the geographic variability of soil and climate conditions (Zhang, 2021). Researchers have developed regional and local adaptations of the USLE to better suit different environments and conditions, such as the Revised Universal Soil Loss Equation (RUSLE) A study by Vericat et al. (2023) in the journal Land Use Policy explores the influence of climate change on soil erosion patterns and advocates for updated soil erosion models that incorporate changing climatic conditions. These recent references demonstrate the continued relevance of the USLE and its adaptations in understanding and addressing soil erosion in modern agriculture, environmental conservation, and policy development. Researchers are actively working to refine and expand the applications of the USLE to better account for evolving environmental conditions and challenges, including those related to climate change.

2.2. Individual Behavior Theories

2. Research on the well-established relationships between population development and land use has advanced significantly over the last three decades. It is feared that excessive population growth and spending will worsen resource depletion, cause environmental damage, and/or result in ecological collapse or other dangers. The lessons learned also demonstrate the importance of education in establishing a "spirit of responsibility" toward environmental issues and the best solutions for addressing them (Gatzweiler&Baumüller, 2014). population change's impact on the ecosystem, especially on land use in developing nations.

2.3. Conceptual Review on Land Degradation

Land degradation is a major threat to food security, particularly in the context of a rapidly growing global population living on finite land resources. Approaching 15% of the seven billion people alive today are classified as food insecure (FAO et al., 2017; FSIN, 2018). With the global population projected to hit nine billion by 2050 (Montpellier, 2013), the food insecurity challenge can be expected to become more severe, especially for sub-Sahara Africa, where an estimated quarter of the people are already hungry (Bremner, 2012). Current attempts to meet food and livelihood needs of sub-Saharan smallholder farms have often led to severe soil degradation

2.3.1. Soil Erosion

Erosion and sedimentation represent on-site and off-site problems. On-site, erosion can degrade the productivity of the soil necessary for crop and food production (Pimentel et al., 1976 and 1995; Meyer et al., 1984; Kimberlin and Moldenhauer, 1977). Soil erosion is a widespread environmental issue that can have significant negative impacts on agriculture, ecosystems, and overall land productivity. To control soil fertility decline, and to have sustainable agricultural development, soil erosion has to be arrested 52 or at least reduced to a tolerable level that is to a level below soil formation rate (Belay, 1992). Land degradation often leads to soil erosion, where topsoil is washed away by wind or water. This process depletes the nutrients and organic matter essential for plant growth. Desertification, a severe form of land degradation, occurs when arable land turns into desert-like conditions, rendering it unsuitable for cultivation or habitation (Turner et al., 2016). Soil erosion contributes to the loss of biodiversity as natural habitats are destroyed or fragmented. Many species are unable to survive or adapt to the degraded environment, leading to a decline in plant and animal populations. This can disrupt ecological balance and negatively impact ecosystem services such as pollination, nutrient cycling, and water regulation (Brevik et al., 2015). Soil erosion affects water resources by reducing the land's ability to retain water. Soil erosion and degradation can lead to decreased groundwater recharge and increased sedimentation in rivers and streams. This not only affects water availability for agricultural and domestic purposes but also disrupts aquatic ecosystems (Mantel, 1997).

2.3.2. Nutrient Depletion

The primary goal of increasing global agricultural productivity is to ensure food security for over 7.80 billion people in 2020 and>9.0 billion people in 2050 (Léridon, 2008). Ecosystem degradation is a major contributor to global food insecurity, reducing nutrient (nitrogen (N), phosphorus (P), and

potassium (K)) supply capacity in the global harvested area by 20 Tg (2.0 × 1012 g) per year (Mueller et al., 2013, Ray et al., 2013). Global inorganic N consumption has increased significantly over the last five decades, but only 47% of it is used by crops, while the rest causes environmental pollution and soil degradation (Elrys et al., 2019, Lassaletta et al., 2014). However, this is not the case in Sub-Saharan Africa (SSA), with low soil nutrient supply, crop nutrient uptake and high soil nutrient loss through leaching and soil erosion resulting in nutrient depletion (Mulualem et al., 2021). Cropping systems with high inorganic fertilizer application have a positive nutrient balance (surplus) that pollutes groundwater and surface waterways in industrialized and emerging countries (Lassaletta et al., 2014, Zhu et al., 2021).

2.3.4. Land Management Practices

All human life ultimately depends on land including the soil and water found there. From land, food is grown, protective shelters are raised on it, and through and across it the fresh water we drink is purified and delivered. Land provides humans with the means to live, and from the first steps tread upon it, has been a patient provider of vital resources. But, at the start of the 21st century, our lands are no longer able to keep up with the pressures placed on its limited resources. Increasing misuse and demands for its goods are resulting in rapidly intensifying desertification and land degradation globally – an issue of growing importance for all people and at all scales (ELD Initiative 2015, 9).

During the past decade, several studies and respective reports alerted the world's society regarding the phenomena of land degradation, i.e. the loss of soil productivity. Land degradation is a complex phenomenon that manifests in many ways. There have been numerous efforts using a variety of approaches to characterize land degradation over the last few decades. Estimates of the extent of land degradation vary, but approximately one third of the world's arable land is thought to have been affected by degradation and desertification to date (ELD Initiative, 2015).

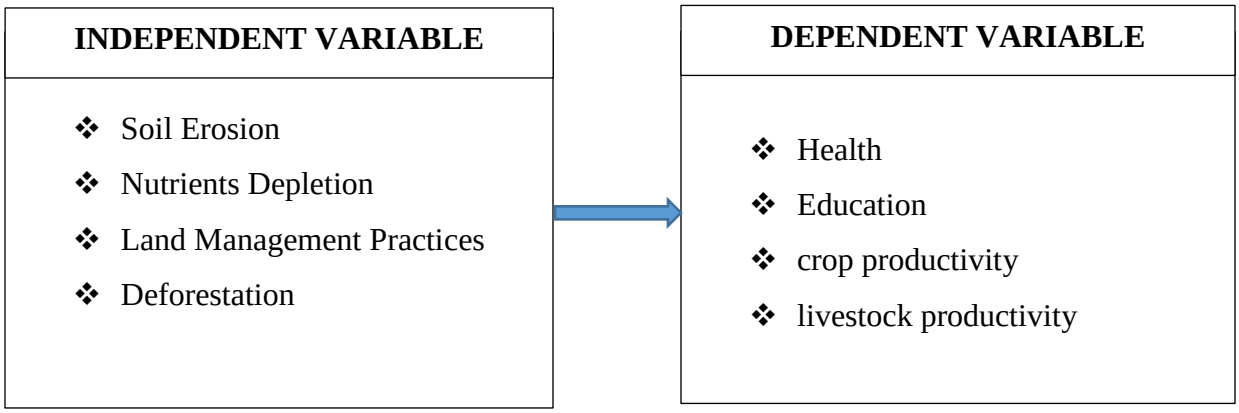
2.3.3 Livelihoods and Benefit Sharing

Local communities living around NNP live under subsistence agriculture and their soils are poorly productive and population has difficulty to access the market (Masozera, 2002). The poor soil leads to poor agriculture production and consequently a high food shortage (Halwart, 2008; Crawford 2012). Nyungwe is among high populated areas with 456 people/km2 (NISR, 2012). The National Institute of Statistics of Rwanda (NISR) has documented that about 48.4% of the community in the south western part of Rwanda where NNP is located live under poverty. (NISR, 2012) and consequently, these communities find themselves heavily reliant on the natural resources within their proximity seeking for multiples sources of income. The anthropogenic threats are often correlated with human population growth and poverty levels, with protected areas situated in regions characterized by rapidly growing, poverty-stricken human populations generally facing the highest levels of threats (Butchart et al., 2010; Challender& MacMillan, 2013; Craigie et al., 20 10).

2.4. CONCEPTUAL FRAMEWORK

A conceptual framework illustrates what the study expects to find through the research. It defines the relevant variables for the study and maps out how they relate to each other. The researcher assumes the relationship between variables. A conceptual framework is a detailed mental formulation of ideas that give direction to a study. It enables the interaction between dependent and independent variables to be portrayed (Kothari, 2004). In this study, the dependent variable is biodiversity conservation (killed animals, tree cutting and wildfire) while independent variable will be Community based conservation interventions

1.9. Conceptual Framework



1.11. Operational terms

3.0. MATERIALS AND METHOD

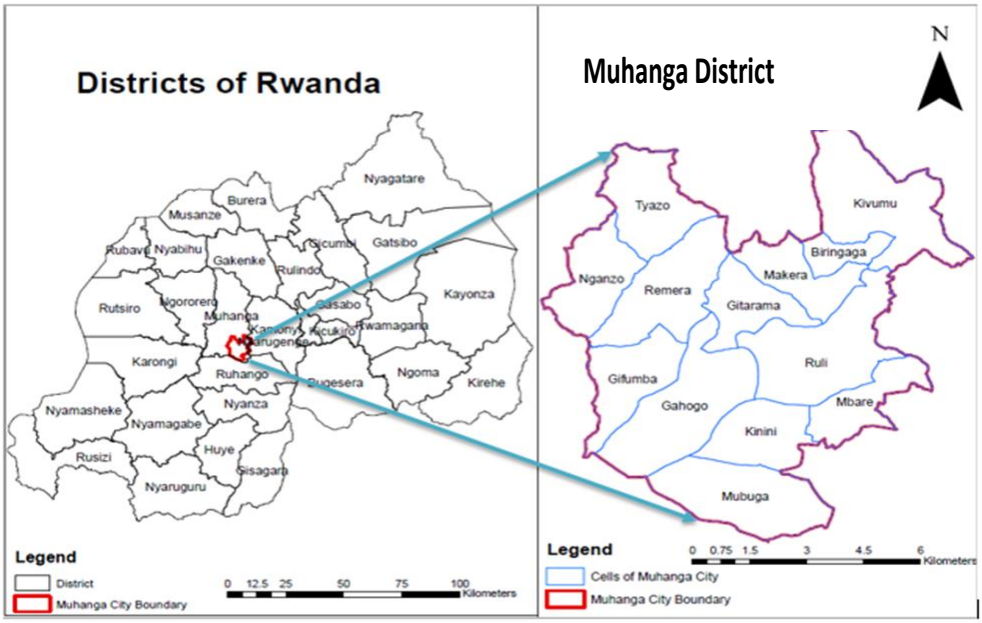
3.1. Research design

This research design had served as the general framework for the collection, measurement, and analysis of data (Akhtar &Islamia, 2016). It described the overall strategy you selected to integrate the various study components coherently and logically, ensuring you effectively addressed the research problem. A research design, according to Rodrigues (2022), is a master plan that outlines the techniques and steps to be taken in order to gather and analyze the necessary data. The research design aids the researcher in gathering pertinent information to accomplish the study's goals. This study will use a descriptive and correlation research designs because it allowed the researcher to gather information, summarize, present and interpret for the purpose of clarification.

3.2. Area of the study physical presentation

Muhanga District is one of the eight districts comprising the Southern Province. It is subdivided into twelve (12) sectors, sixty-three (63) cells and three hundred and thirty-one (331) villages (Imidugudu). The district covers an area of six hundred forty-seven-point seven square kilometers (647.7 km2) and, it is neighbouring the Districts of Gakenke in the North, Kamonyi in the East, Ruhango in the South and Ngororero in the West, Karongi District to the southwest and Ngororero District to the west.

The city also includes a key section of the Muhanga-Ruhango-Nyanza heritage corridor. Due to its geographical location, the city serves as the gateway to the west and south of the country. This central location is strategic and the availability of land (compared to Kigali) offers alternatives for businesses in need of space at proximate distance to the capital.



Population can be defined as" the totality of persons or objects with which a study is concerned. Thus, population is any group of people, organization about which one wants to draw conclusions (Fadhullah&Najwa 2022). Target population is defined as the entire aggregation of respondents that meet the designated set of criteria (Kothari, 2004). The population, also called the universe, is the set of people or entities to which findings are to be generalized and the population must be defined explicitly before a sample is taken (Garson, 2012).

Table 1: Population

Sector	**Population** household	**Proportionate sampling**	**Sample size**	**Systematic sampling technique**
Cyeza	30,209	25% of 391	**99**	Systematic sampling technique
Shyogwe	44,771	37% of 391	**146**	Systematic sampling technique
Nyamabuye	44,645	37%of 391	**147**	Systematic sampling technique
	119,625	**391**	**391**	

Before the sample can be selected, the researcher decided on how many respondents are needed to take part in the study. In other words, the researcher decided on the sample size to be used. That size was found using the formula developed by Cochran G. William and used by Taherdoost(2020) as shown below: $n = \frac{N \times No}{N+N0}$; Where$N0 = \frac{z_{\alpha}^2 . q . p}{e^2}$n0= required sample size = 95% confidence interval q= 1-p = 50% e= acceptable error = 0.05 (5%) Therefore, n0 = 50 x (100-50) x (1.96^2) / $(5)^2$ = 384. The sample size was 384 respondents. Finite population correction for proportions; sample size (n0) was adjusted using equation: The degree of variability for the targeted population is not known, thus the study assumes the maximum variability. Because a proportion of 0.5 indicates the maximum variability in a population, it is often used in determining a more conservative sample size(Guerrero et al., 2017). Finite population correction for proportions; sample size (n0) was adjusted using equation:

$$n = \frac{n_0}{1 + \frac{(n_0 - 1)}{N}}$$

Where; n= adjusted sample size; n0=original sample size (384); N= population size (119,625)

$$n = \frac{384}{1 + \frac{(384-1)}{119{,}625}}$$

n=359

Additional 10% non-respondents were included, thus a total of 391 respondents will administer the questionnaire.

3.3. Data Collection Instruments

During the study, the researcher used questionnaire, interview and documentary as data collection instruments.

3.3.1. Questionnaire

The questionnaire included closed-ended questions where respondents chose from the alternative answers. Questionnaire was chosen because of the following advantages: it saves time since many respondents can be dealt with at once, it allows easy analysis of data collected, it is easy to administer when the sample is literate.

In designing questionnaires, the researcher has used Likert scale to measures the respondents' views on Factors influencing the livelihood of farmers. Using Likert Scale, the respondent indicated whether he/she strongly agree (SA), agree (A), disagree (D), or strongly disagree

3.3. 2. Interview

Structured interview with one-on-one interview with single participants were used during collecting data.

3.3.3. Document Review

It is important to indicate the review of existing literature reviewed by different authors. The researcher visited UNILAK library, electronic sources, websites documents, Reports from NNP, where a great deal of literature by different authors about the subject matter was reviewed.

3.4. Data Quality Control

This part of the third chapter will present the data quality control through the validity and reliability.

3.4.1. Primary Data

The researcher obtained the primary data using the questionnaire and interview during this research. In designing questionnaires, the researcher used open and closed questionnaires to measures the respondents' views on land degradation and land use practices where the respondent answered the question according to his/her knowledge on farming activities.

There was a collection of quantitative information to better understand, explain, and interpret the effect of land degradation on farmer's livelihood. Hence, understanding trends in resource dynamics required historical information, which can be achieved using quantitative data to be collected through interview and questionnaire. Accordingly, detailed individual interviews and questionnaire was conducted in 3 Sectors (Nyamabuye, Cyeza and Shyogwe) that make up Muhanga District

Qualitative and quantitative analyses was used to achieve research Objectives by use of Descriptive analyses, Content Analytical Tool while Measurement of the "Effect" was done using the Regression Analysis

3.4.2. Secondary Data

To collect the secondary data, the researcher read documents such as textbooks, internet, magazines, power point presentations and especially reports concerning the subject matter of the study.

3.5. Data Processing

Raw data will be transformed into meaningful interpreted report using different techniques. In order to get quality information, there is generally need for standard checking so that the researcher could end up with realistic data, which clearly reflect the depicted situation.

Thus, stand checking will be done through editing, coding, and tabulation. This will be done in order to reduce detailed data to manageable proportions.

3.5.1. Data Analysis

In this study, the researcher processed and analyzed data using Excel and the Statistical Package for the Social Sciences (SPSS), which helped with the presentation of the results, analysis, and interpretation. The research topics was the main topic of the presentation. Numerical data was analyzed using quantitative methods, and the findings were displayed as tables and graphs to help with proper comprehension. The statistical package for social scientists (SPSS) was used to evaluate the data derived from closed-ended responses.

3.5.2. Limitation of the Study

In the current study, some of the respondents not be fluent with English as language; there was a need of research assistants to translate and administer questionnaires in Kinyarwanda to enable accurate response. Likewise, some of the information that was used in this study was sourced from secondary data such as published annual reports assessed in this current study.

3.6. Ethical Consideration

Greater accountability during the data collection were considered by much attention on ethical conduct (personal, professional, and during this research activity) In addition, there was two crucial components—"informed" and "consent"—that each call for careful thought in order to ensure that Participants/respondents are fully aware of what was requested of them, how the data was used, and what (if any) consequences there may be. The following information will be provided to the participants: Who the researcher(s) are, what the research's purpose is, and what participant data were gathered, how were the participant's data collected? What degree of dedication is expected of participants? How were these data reported and used? What are the potential risks of taking part in the research? is fundamentally important that the questionnaires and interview guides are robust, clear, and well written. If they are unclear, it was result in a non-reliable data, which may compromise the quality of data collected due to mistrust and not provide good protection for the participant or the researcher (Fleming &Zegwaard, 2018)

3.7. Risk of Harm, Anonymity and Confidentiality

The identity of participants was kept confidential or anonymous and the assurances extend beyond protecting their names to also include the avoidance of using self-identifying statements and information. Anonymity and confidentiality is an important step in protecting the participants from potential harm.

Participant anonymity and participant confidentiality are two terms commonly used synonymously when in fact they are different. the data was de-identified and the identity is kept confidential (e.g., interviews, where the participant identities are known to the researcher, therefore, only confidentiality, not anonymity, can be offered).

The research design needs to consider the potential of harm to the participants, the researcher, the wider community, and the institution. The harm can range from physical, resource loss (including time), emotional, and reputational. When considering the potential for harm, the approach should be, in descending order, to eliminate, isolate, and minimize the risk, with the participants being fully informed on what the risks are.

4.0. RESULTS AND DISCUSSIONS OF FINDINGS

Table 4.1. Age Level

Age of respondents	Frequency	Percentage
20-25	**26**	**6.6**
26-30	**65**	**16.6**
31-35	**52**	**13.2**
36-40	**77**	**19.6**
Above 41	**46**	**11.7**
Total	**391**	**100.0**

Table 4.1 shows that among the 391 respondents in the Muhanga District study, the majority were aged 36–40 (19.6%), followed by those aged 26–30 (16.6%) and 31–35 (13.2%), while the youngest group (20–25) represented only 6.6%. This age distribution suggests that middle-aged farmers are more actively engaged in agriculture and may be more directly affected by land degradation, whereas younger individuals appear less involved in farming activities.

Table 4.2. Distribution of respondents by gender

Respondents by gender	Frequency	Percentage
Male	211	53.9
Female	180	46.0
Total	391	100.0

Table 4.2 reveals that out of 391 respondents in the Muhanga District study, 53.9% were male and 46.0% were female. This gender distribution highlights a relatively balanced participation, allowing for insights into how land degradation may affect male and female farmers differently.

Table 4.3: Distribution of respondents by education level

Education level	Frequency	Percent
Primary	98	25.0
Secondary	173	44.2
University level	120	30.9
Total	391	100.0

Table 4.3 shows that among the 391 respondents, 25.0% had primary education, 44.2% had secondary education, and 30.9% had university-level education. This indicates that most participants have at least secondary education, reflecting a relatively well-educated farming population in the Muhanga District.

Table 4.4. Respondents' level of agreement on soil erosion

Soil erosion	Mean	Std. Dev.
I understand the causes and mechanisms of soil erosion in Muhanga District.	3.5643	1.06512
Soil erosion significantly contributes to land degradation in Muhanga District.	3.9812	.89732
Unsustainable agricultural practices, such as improper land cultivation and overgrazing, worsen soil erosion in the region.	3.6748	1.03412
The removal of trees and vegetation accelerates soil erosion in Muhanga District.	3.6384	1.02314
I am aware of soil conservation techniques that can mitigate soil erosion.	3.6411	1.00546
The implementation of soil conservation practices, such as terracing and agroforestry, is crucial to combat soil erosion and land degradation in Muhanga District.	3.6748	1.02316
Local communities, government, and non-governmental organizations should collaborate to promote soil conservation practices.	3.6384	1.02314
Education and training on soil conservation should be provided to farmers and landowners to foster sustainable land management practices.	3.8753	1.00546
Implementing soil conservation practices will have a positive and lasting impact on preventing land degradation in Muhanga District.	3.7642	.67543

Table 4.4 indicates that respondents in Muhanga District generally showed moderate to high agreement with statements about soil erosion, highlighting awareness of its causes and impacts. The highest agreement was on soil erosion's contribution to land degradation (mean = 3.9812), followed by recognition of unsustainable agricultural practices (mean = 3.6748) and understanding of erosion mechanisms (mean = 3.5643). further reveal that respondents recognized the critical role of vegetation and tree cover in preventing soil erosion, and strongly supported the use of soil conservation practices like terracing and agroforestry (mean = 3.6748). They also acknowledged the importance of education, awareness, and collaboration among stakeholders in promoting effective soil conservation, with high agreement on the positive long-term impact of these practices (mean = 3.7642), aligning with the insights of Smith et al. (2019) and Johnson & Brown (2021) on sustainable land management and community involvement.

Table 4.5. Nutrient depletion

Nutrient depletion	Mean	Std. Dev.
I have a clear understanding of how nutrient depletion affects soil quality and leads to land degradation.	3.8654	1.23174
Nutrient depletion significantly affects agricultural productivity and crop yields in the region.	3.9873	1.65432
I am aware of the main causes of nutrient depletion, such as unsustainable farming practices and poor soil management.	3.8756	.89765
I am familiar with sustainable farming practices that can help mitigate nutrient depletion and prevent land degradation.	3.5643	1.21332

I believe that adopting sustainable farming practices, such as crop rotation, agroforestry, and organic fertilizers, is crucial for preventing nutrient depletion and land degradation.	3.8764	1.01237
I recognize the importance of regular soil testing and analysis to identify nutrient deficiencies and guide appropriate soil nutrient management practices.	3.6748	1.02316
Collaboration among farmers, agricultural extension services, and local authorities is crucial to promote sustainable land management and address nutrient depletion.	3.8712	1.01222
Providing education and training to farmers about sustainable land management practices is vital for addressing nutrient depletion in Muhanga District.	4.1315	.99957
I believe that implementing sustainable farming practices will have a positive and lasting impact on preventing nutrient depletion and land degradation in Muhanga District.	4.0521	.87708

Table 4.5 shows that respondents in Muhanga District generally possess a strong understanding of nutrient depletion, recognizing its impact on soil quality (mean = 3.8654) and agricultural productivity (mean = 3.9873). While they are aware of its primary causes, such as poor soil management (mean = 3.8756), there is a noted gap in familiarity with sustainable farming practices to address these issues (mean = 3.5643), indicating the need for enhanced training and education.

Table: 4. 6: CORRELATIONS

CORRELATIONS		Farmers livelihood	Soil erosion	Nutrient depletion	Land management pracices	Deforestation
Farmers livelihood	Pearson Correlation	1	.819**	.818**	.843**	.847**
	Sig. (2-tailed)		.000	.000	.000	.000
	N	365	365	365	365	365
Soil erosion	Pearson Correlation	.819**	1	.969**	.911**	.893**
	Sig. (2-tailed)	.000		.000	.000	.000
	N	365	365	365	365	365
Nutrient depletion	Pearson Correlation	.818**	.969**	1	.913**	.903**
	Sig. (2-tailed)	.000	.000		.000	.000
	N	365	365	365	365	365
Land management practices	Pearson Correlation	.843**	.911**	.913**	1	.896**
	Sig. (2-tailed)	.000	.000	.000		.000
	N	365	365	365	365	365
Deforestation	Pearson Correlation	.847**	.893**	.903**	.896**	1
	Sig. (2-tailed)	.000	.000	.000	.000	
	N	365	365	365	365	365
**. Correlation is significant at the 0.01 level (2-tailed).						

Table 4.6. reveals strong, statistically significant positive correlations between land degradation factors—soil erosion, nutrient depletion, land management practices, and deforestation—and farmers' livelihoods in Muhanga District, with Pearson coefficients ranging from 0.818 to 0.847 ($p < 0.01$). The high intercorrelations among these factors ($r = 0.893$ to 0.969) highlight their interconnectedness, underscoring the need for integrated, holistic interventions to effectively address land degradation and enhance sustainable farming and rural livelihoods.

Table 4. 7: REGRESSION ANALYSIS

Model summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.869[a]	.755	.752	3.01485	.755	277.344	4	360	.000

Table 4.7: presents a regression analysis indicating a strong positive relationship (R = 0.869) between land degradation factors—soil erosion, nutrient depletion, land management practices, and deforestation—and farmers' livelihoods in Muhanga District. With an R-square of 0.755 and a significant F Change (277.344, $p < 0.001$), the model explains 75.5% of the variance in farmers' livelihoods, highlighting the substantial and interconnected impact of these degradation factors on rural well-being.

Table 4. 8: ANOVAa

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	10083.480	4	2520.870	277.344	.000[a]
	Residual	3272.153	386	8.477		
	Total	13355.633	364			

Table 4.8 presents the results of the Analysis of Variance (ANOVA) for the regression model examining the relationship between land degradation predictors—soil erosion, nutrient depletion, land management practices, and deforestation—and the dependent variable, farmers' livelihood, in Muhanga District. The ANOVA test yields a highly significant F-statistic ($F = 277.344$, $p < 0.001$), indicating that the regression model collectively explains a substantial proportion of the variance in farmers' livelihood. The regression sums of squares (10083.480) accounts for the explained variability due to the predictors, representing approximately 75.5% of the total sum of squares (13355.633). The remaining unexplained variability is captured by the residual sum of squares (3272.153).In conclusion, the ANOVA results affirm the statistical significance of the regression model, highlighting the substantial impact of the selected predictors on farmers' livelihood in Muhanga District. The percentages derived from the sum of squares values emphasize the considerable explanatory power of the model, reinforcing its utility in understanding the complex relationships between land degradation and agricultural sustainability in the study area.

Table 4.9: **Coefficients**

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	10.941	1.048		10.441	.000
	Soil erosion	.144	.116	.137	1.241	.215
	Nutrient depletion	-.043	.120	-.041	-.362	.717
	Land management practices	.513	.099	.371	5.181	.000
	Deforestation	.505	.078	.430	6.448	.000
a. Dependent Variable: Farmers livelihood						

The analysis of the coefficients in Table 4.9 shows that the variable "Land management practices" plays a significant role in affecting farmers' livelihoods. The standardized coefficient (Beta) of 0.371 is statistically significant ($p < 0.001$), indicating

that land management practices is a prominent factor impacting farmers' livelihood. This suggests that Muhanga district has experienced a notable level of flood occurrences during the period of 2010-2022. The impact of land management practices on farmers' livelihood is substantial, highlighting the importance of understanding and addressing flood disasters in the region.

The coefficient for "Deforestation" in Table 4.21 is highly significant with a Beta of 0.430 ($p < 0.001$). This indicates that deforestation due to land management practices has a significant impact on the livelihood status of farmers in Muhanga district. Farmers face substantial challenges in maintaining their livelihoods due to crop losses caused by land management practices. This implies that the status of livelihood in Muhanga district has been negatively affected by the impact of deforestation during the specified period.

5.0. SUMMARY OF KEYS FINDINGS

Summary of Major Findings

The findings of the research were presented based on the specific objectives of the research which are to assess the occurrences of flood disaster in Muhanga district from 2010-2022, to assess the livelihood of farmers of selected sectors of Muhanga district, and to determine whether there is a significant relationship between flood disaster and livelihood of farmers of selected sectors in Muhanga district

OBJECTIVE ONE:Analyze the Land Degradation in Muhanga District of Southern Province, Rwanda

The mean values from Table 4.4 illustrate the respondents' perceptions of various aspects related to soil erosion and its consequences in Muhanga District. The moderate level of agreement concerning the understanding of causes and mechanisms of soil erosion (Mean = 3.5643) suggests a baseline awareness among the respondents. Moreover, the acknowledgment of the significant contribution of soil erosion to land degradation (Mean = 3.9812) emphasizes the recognition of soil erosion as a key factor affecting the region. The mean values for statements related to unsustainable agricultural practices and deforestation (Means ranging from 3.6384 to 3.9812) indicate a collective acknowledgment of these factors exacerbating soil erosion. These findings collectively contribute to a nuanced understanding of land degradation awareness in Muhanga District, providing a foundation for targeted interventions and awareness campaigns.

OBJECTIVE TWO:To Assess the Level of Farmers' Livelihood in Muhanga District of Southern Province, Rwanda

Table 4.8 delves into the respondents' agreement on various dimensions of farmers' livelihood, revealing substantial implications for the well-being of the community. The mean values showcase a significant negative impact of land degradation across multiple facets. The decline in overall health and well-being (Mean = 4.4321) underscores the severity of the consequences. Similarly, the negative effects on the availability of clean water sources (Mean = 4.4214), hindrance to access quality education (Mean = 4.0821), and significant decreases in crop productivity (Mean = 4.6812) highlight the multifaceted challenges faced by farmers. Furthermore, the limited opportunities for livelihood diversification (Mean = 4.4173) and the negative impact on local economies (Mean = 4.3316) indicate broader socio-economic implications. The forced migration or displacement (Mean = 4.3753) suggests a severe consequence of land degradation on the community structure. The importance of increasing awareness about land degradation (Mean = 4.1454) emerges as a crucial aspect for fostering community-driven environmental conservation initiatives. Collectively, these findings contribute to a comprehensive assessment of the current state of farmers' livelihood in Muhanga District, emphasizing the urgent need for interventions to mitigate the adverse impacts of land degradation on the community's well-being.

OBJECTIVE THEEE:To Establish Whether There Is a Significant Effect of Land Degradation on Farmer's Livelihood in Muhanga District, Southern Province of Rwanda

The regression analysis in Table 4.12 establishes the statistical relationships between predictors (soil erosion, nutrient depletion, land management practices, and deforestation) and farmers' livelihood. Notably, the significant coefficients for land management practices (0.513) and deforestation (0.505) indicate a positive impact on farmers' livelihood. However, soil erosion (0.144) and nutrient depletion (-0.043) do not show a statistically significant effect. These findings support the conclusion that certain aspects of land degradation significantly influence farmers' livelihood in Muhanga District

5.1. CONCLUSION:

In conclusion, the comprehensive analysis of the data, as presented in Tables 4.1 to 4.12, provides valuable insights into the relationship between land degradation and farmers' livelihood in Muhanga District, Southern Province, Rwanda. The specific objectives of the study have been addressed and summarized as follows:

5.2. RECOMMANDATION:

Based on the findings of the study on the effect of land degradation on farmers' livelihood in Muhanga District, Southern Province, Rwanda, the following recommendations are suggested:

- **Promotion of Sustainable Agricultural Practices:**

Encourage and support farmers in adopting sustainable agricultural practices that minimize soil erosion and nutrient depletion. This may include promoting agroforestry, contour plowing, cover cropping, and organic farming techniques. Agricultural extension services can play a crucial role in providing training and support.

- **Reforestation and Conservation Initiatives:**

Implement reforestation programs to restore degraded lands and prevent further deforestation. Engage local communities in tree planting initiatives and sustainable forest management practices. Community-managed forests can serve as a valuable resource for biodiversity conservation and mitigating the impact of deforestation.

- **Integrated Land Management Strategies:**

Advocate for the implementation of integrated land management strategies that address multiple aspects of land degradation simultaneously. This could involve a combination of sustainable agriculture, afforestation, soil conservation practices, and community-led initiatives.

- **Capacity Building and Education:**

Provide continuous education and capacity-building programs for farmers and local communities. Focus on enhancing awareness of the causes and consequences of land degradation, as well as the implementation of sustainable land management practices. Collaboration with local schools and community organizations can be instrumental in reaching a wider audience.

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