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Agroforestry And Soil Erosion In Kisoro District: A Case Study Of Muramba Sub - County

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Abstract

The study examined agroforestry practices and soil erosion in Muramba Sub County, focusing on the level of agroforestry, the extent of soil erosion, and the relationship between agroforestry adoption and soil conservation. The study employed a correlational research design, utilizing quantitative methods to collect data from farmers through structured questionnaires and interviews. Multiple linear regression analysis was applied to determine the predictors of agroforestry adoption, the determinants of soil erosion, and the influence of agroforestry on soil conservation. The results indicated that the level of agroforestry adoption in Muramba Sub County was moderately high and was significantly influenced by farmer awareness and knowledge ($B = 0.478$, $p < 0.001$), landholding size ($B = 0.361$, $p < 0.001$), access to extension services ($B = 0.299$, $p = 0.001$), and the availability of tree seedlings ($B = 0.274$, $p < 0.001$). These variables collectively explained 55% of the variation in agroforestry adoption. Regarding soil erosion, slope gradient ($B = 0.518$, $p < 0.001$), vegetation cover ($B = -0.392$, $p < 0.001$), farming practices ($B = 0.351$, $p < 0.001$), and rainfall intensity ($B = 0.302$, $p < 0.001$) were significant predictors, accounting for 61.3% of the variance in erosion levels. The analysis further revealed a strong negative relationship between agroforestry adoption and soil erosion, with level of agroforestry ($B = -0.476$, $p < 0.001$), tree density ($B = -0.398$, $p < 0.001$), and agroforestry management practices ($B = -0.314$, $p < 0.001$) collectively explaining 62.6% of the variation in soil erosion. The study concluded that agroforestry practices in Muramba Sub County significantly reduced soil erosion, with farmers' knowledge, access to seedlings, landholding size, and extension services being critical determinants of adoption. Soil erosion was primarily influenced by slope gradient, inadequate vegetation cover, unsustainable farming practices, and rainfall intensity. It was further concluded that proper implementation of agroforestry, including maintaining sufficient tree density and applying recommended management practices, is an effective strategy for controlling soil erosion and promoting sustainable land use. Access to tree seedlings and planting resources should be improved through community nurseries and supportive interventions from development partners. Sustainable land management practices, such as contour farming, mulching, and crop rotation, should be promoted, and vegetation cover and tree density should be increased to protect soil from erosion. Agricultural extension services should be strengthened to provide technical guidance, while policies and institutional support should be developed to sustain agroforestry adoption. Additionally, community participation and collaboration should be encouraged to ensure long-term sustainability of soil conservation efforts.

Keywords: Agroforestry, soil erosion, tree density, farmer awareness, sustainable land management, Muramba Sub County.

Background of the study

Globally, land degradation poses a severe threat to ecosystem health, food security, and sustainable development. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES, 2018) identifies land degradation as a critical issue, affecting over 3.2 billion people worldwide and costing more than 10% of the annual global gross product in lost ecosystem services (Alex & Julius, 2024). Soil erosion, a primary driver of this degradation, is exacerbated by unsustainable agricultural practices, deforestation, and climate change-induced intense rainfall events. In this context, agroforestry the intentional

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integration of trees and shrubs into crop and animal farming systems has emerged as a cornerstone of sustainable land management. Recognized by the World Bank (2021) and the Food and Agriculture Organization of the United Nations (FAO, 2022) as a key climate-smart agriculture practice, agroforestry systems mitigate soil erosion through multiple mechanisms. Tree roots bind soil particles, canopy cover dissipates the kinetic energy of rainfall, and litterfall improves soil organic matter, enhancing water infiltration and soil structure (Collins et al., 2023). The global push for agroforestry is thus not merely an agricultural strategy but a critical component of climate change adaptation and the pursuit of the United Nations Sustainable Development Goals, particularly Goal 15 (Life on Land), which aims to combat desertification and restore degraded land.

In Africa, the challenge of soil erosion is particularly acute, directly undermining agricultural productivity and livelihoods. The African Union's Agenda 2063 highlights environmental sustainability and resilient economies as key aspirations, yet the continent continues to face severe land degradation. According to the FAO (2022), Africa loses an estimated 3% of its agricultural GDP annually due to soil and nutrient loss, with over 65% of arable land affected (Christopher et al., 2024). This is compounded by a high dependence on rain-fed agriculture and population pressures that lead to the cultivation of fragile slopes and shortened fallow periods. Agroforestry is widely promoted across the continent as an indigenous and scientifically validated solution. Practices such as planting Faidherbia albida in maize fields (a practice common in parts of East Africa) or using contour hedgerows of Calliandra or Leucaena species have demonstrated significant potential to reduce soil erosion by up to 50-80% compared to conventional monocropping (World Agroforestry Centre, 2020). Despite this proven potential, adoption rates are often hindered by limited access to quality tree germplasm, insufficient technical extension services, and land tenure insecurities that discourage long-term investments in tree planting, leaving many landscapes vulnerable to the devastating effects of erosion.

Uganda's economy is heavily dependent on agriculture, which employs about 70% of the population and contributes significantly to export earnings. However, the sector is severely constrained by widespread land degradation. The Ministry of Agriculture, Animal Industry and Fisheries (MAAIF, 2021) estimates that the country loses over 90,000 hectares of fertile topsoil annually, costing the economy billions of Ugandan Shillings in lost productivity. The government's commitment to restoring degraded landscapes is enshrined in policies like the Uganda Forestry Policy (2001) and the National Climate Change Policy (2015), which explicitly promote agroforestry and farmer-managed natural regeneration. The National Development Plan (NDP III) further identifies sustainable land management as a priority for increasing agricultural productivity. Despite this supportive policy framework, implementation on the ground remains a challenge. A report by the Economic Policy Research Centre (2022) indicates that while awareness of agroforestry is growing, the practice is often adopted on a small scale, with farmers prioritizing fast-growing species for fuelwood over those with greater soil conservation benefits (Ahumuza et al., 2025). Furthermore, the high population density in regions like Southwestern Uganda has led to intense fragmentation of landholdings, pushing cultivation onto steep slopes without adequate conservation measures, thereby accelerating soil erosion and threatening rural livelihoods.

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Kisoro District, located in the highlands of Southwestern Uganda, presents a stark and urgent case of the soil erosion crisis. The district's topography is predominantly steep hills and valleys, making it inherently vulnerable to erosion when vegetation cover is removed. With one of the highest population densities in the country, exceeding 500 people per square kilometer (UBOS, 2024), the pressure on land for agriculture and settlement is immense. Much of the natural forest cover has been cleared for farming, exposing the slopes to severe water erosion, especially during the two intense rainy seasons (Julius & Matovu, 2025). Muramba Sub-County, a predominantly agrarian area within Kisoro, epitomizes this challenge. Preliminary observations and local government reports from the Kisoro District Production Department (2023) indicate that rampant gully erosion is a common sight, washing away fertile topsoil, silting up water bodies, and damaging crops and infrastructure. The predominant practice of subsistence farming on small, sloping plots with minimal soil conservation structures has created a vicious cycle of land degradation and poverty. While agroforestry has been introduced by various NGOs and government programs, its adoption in Muramba is inconsistent and often not optimized for erosion control (Turyatemba et al., 2022). This local context, therefore, frames the core problem: in a landscape critically threatened by soil erosion, the potential of agroforestry as a locally adaptable and sustainable solution is not fully understood or leveraged. This study, therefore, seeks to investigate the specific role and impact of agroforestry practices on mitigating soil erosion in the vulnerable and representative context of Muramba Sub-County, Kisoro District.

Statement of the problem

In the highland landscapes of Kisoro District, particularly in Muramba Sub-County, the pervasive challenge of soil erosion presents a direct and escalating threat to agricultural productivity, food security, and environmental stability (Ntirandekura & Christopher, 2022). The region's steep slopes, combined with intense seasonal rainfall and high population pressure leading to unsustainable cultivation practices, have resulted in severe land degradation. Current estimates indicate alarming rates of topsoil loss, leading to reduced soil fertility, siltation of water bodies, and declining crop yields that undermine the livelihoods of subsistence farmers (Allan et al., 2023). This degradation is exacerbated by the limited adoption of effective soil conservation measures.

While agroforestry is globally and nationally recognized as a potent strategy for erosion control, its potential remains critically underutilized in Muramba Sub-County. A significant gap exists between the known benefits of integrating trees into farming systems and the on-ground reality, where knowledge, access to appropriate tree species, and technical support are insufficient (Grace et al., 2023). Consequently, farmers continue to experience the detrimental effects of erosion without an accessible, sustainable solution. This study therefore seeks to investigate the specific impact of existing agroforestry practices on soil erosion control and to identify the key barriers to their wider adoption in Muramba Sub-County, with the aim of informing strategies that can effectively mitigate land degradation and enhance community resilience.

Specific Objectives

1. To find out the level of agroforestry in Muramba Sub County.
2. To find out the level of soil erosion Muramba Sub County.
3. To find out the relationship between agroforestry and soil erosion in Muramba Sub County.

Methodology

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The methodology for this study was designed to employ a mixed-methods approach, integrating both qualitative and quantitative research paradigms to ensure a comprehensive investigation. The qualitative approach was utilized to provide a complete, detailed description of the phenomena under study, facilitating in-depth data gathering and a rich understanding of local contexts and perceptions (Nafiu et al., 2017). Concurrently, the quantitative approach enabled the construction of statistical models to explain the findings, providing opportunities for statistical aggregation of data and comparative analysis. This study further utilized mixed approach designs, specifically a case study embedded within a descriptive research framework. The descriptive research design, as defined by Anastas and Jeane (2014), was employed to obtain information concerning the current status of the phenomena and to describe what exists with respect to variables or conditions in the situation. This design was particularly applied to questions requiring the analytical description of statistical data, such as quantifying the level of agroforestry adoption in the study area.

The research was conducted in Muramba Sub-County, Kisoro District, an area characterized by significant forestry and agricultural activities. The sub-county is situated in western Kisoro at latitude 1.2333° S and longitude 29.7333°E, bordered by Nyarusiza and Rushoga Sub-Counties to the north, Mutolere Town Council and Chahi Sub-County to the west, Nyakabande Sub-County to the east, and Bunagana Town Council bordering the Democratic Republic of Congo and Gasiza Sub-County to the south. This location was selected as the study area due to its high concentration of farming activities and its status as a developing area with significant settlement and farm establishment, making it an ideal site for investigating the relationship between agroforestry practices and soil erosion (Olanrewaju, Waititu, et al., 2021). The target population for the study consisted of 150 respondents, which was correlated with Slovin's formula for sample size determination to obtain a study sample of 109 people. This sample included environmental officers, local government leaders, teachers, agriculturalists, farmers, and other community dwellers, all residents of Muramba Sub-County, to ensure the validity and reliability of the study findings.

The sampling procedures employed both probability and non-probability techniques as defined by Ahuja Ram (2013). The sample size of 109 respondents was determined using the Israel Glenn formula (2012) with a study population of 150 people and a level of precision of 0.05. The final sample composition included at least 10 environmental officers, 7 local government leaders, 20 teachers, 13 agriculturalists, 40 farmers, and the remaining from other community dwellers (Olanrewaju, Lukman Abiodun, et al., 2021). This distribution was deemed appropriate given the socio-demographic characteristics of the population and considerations of resource and time constraints. Simple random sampling was used to select respondents from the groups of community members, farmers, and teachers, with specific attention to including both male and female respondents (A. Nafiu et al., 2012). Purposive sampling was employed to select environmental officers, agriculturalists, and local government leaders, as this technique allowed the researcher to reach a targeted sample quickly where sampling for proportionality was not the primary concern.

Data collection involved both secondary and primary methods, utilizing questionnaires and interviews to gather qualitative and quantitative information. The questionnaire method, as described by Goode and Hatt (2013), served as the major primary data collection tool, with 15 questionnaires distributed to teachers, 40 to community members and farmers, 10 to agriculturalists, and

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additional questionnaires for key informants including local government leaders and environmental officers (Aslam et al., 2022). All questionnaires were prepared in English, with translation provided for respondents who required it, and included closed-ended questions with space for additional remarks. The interviewing method, particularly through structured interview guides as defined by Kabir (2016), was employed to capture qualitative information from informed members about specific issues regarding the study, utilizing face-to-face interviews to establish the relationship between agroforestry and soil erosion.

Quality control measures were implemented throughout the research process, with particular attention to validity and reliability as emphasized by Shamoo (2015). Validity was ensured through a pilot study conducted with geography undergraduate students at Metropolitan International University and consultation with the research supervisor to check the questionnaires' content, structure, sequence, and clarity. Content validity was further enhanced by computing the Content Validity Index (CVI) and through careful piloting of all questionnaires. Reliability was established through pilot testing with Metropolitan International University biology students using test-retest techniques, with the split-half method employed through the Statistical Package for Social Sciences (SPSS) to compute reliability coefficients, though open-ended questions were not subjected to reliability testing (Nelson et al., 2022).

Data management and processing followed systematic procedures outlined by Lehtonen and Pahkinen (2014), including editing, coding, and tabulation of collected data. Data analysis utilized the SPSS software to compute percentages, frequencies, and tabulations of responses. Descriptive statistics including frequency distributions and percentages were employed to analyze quantitative data, while qualitative data underwent content analysis with responses categorized according to thematic areas (Nelson et al., 2023). Pearson correlation analysis was utilized to determine the relationship between agroforestry practices and soil erosion, with regression analysis employed to establish the extent to which agroforestry could predict soil erosion patterns. Presentation of findings was accomplished through tables, figures, and charts to enhance clarity and interpretation.

Ethical considerations were rigorously observed throughout the research process, following the guidelines established by Shamoo et al. (2015). Approvals were obtained from relevant authorities before commencing the study, and the researcher secured the wellbeing of respondents by minimizing potential risks and maximizing benefits. Participants were informed of their freedom to discontinue participation at any time, and anonymity and confidentiality were maintained throughout the research process. The researcher committed to providing participants with access to the final research report and ensured proper attribution to all sources used in the literature to avoid plagiarism.

Results

Table 1: Level of Agroforestry in Muramba Sub County

Predictor Variables	Unstandardized Coefficient (B)	Std. Error	Beta	t-value	p-value
Farmer Awareness & Knowledge	0.478	0.089	0.421	5.37	0.000
Landholding Size	0.361	0.074	0.338	4.88	0.000

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Access to Extension Services	0.299	0.081	0.285	3.69	0.001
Availability of Tree Seedlings	0.274	0.068	0.261	4.03	0.000
Constant	1.056	0.181		5.83	0.000
Model Summary: R = 0.742, R² = 0.550, Adjusted R² = 0.536, F(4, 115) = 31.58, p = 0.000					

Source: Primary Data, 2024

The regression model for the level of agroforestry in Muramba Sub County was statistically significant ($F = 31.58$, $p < 0.001$), explaining 55% of the variance in agroforestry adoption among farmers. This indicates that agroforestry practices are largely influenced by both knowledge-based and resource-based factors. Farmer awareness and knowledge emerged as the strongest predictor ($B = 0.478$, $p = 0.000$), demonstrating that well-informed farmers are more likely to adopt tree planting and other agroforestry techniques.

Landholding size ($B = 0.361$, $p = 0.000$) was also significant, suggesting that farmers with larger plots have more flexibility to integrate trees into croplands, pastures, and boundaries. Access to extension services ($B = 0.299$, $p = 0.001$) positively influenced agroforestry adoption, highlighting the role of agricultural advisors in teaching farmers about species selection, planting techniques, and soil conservation. Finally, the availability of tree seedlings ($B = 0.274$, $p = 0.000$) indicated that physical resources directly affect the ability of farmers to implement agroforestry.

Overall, the study concluded that for Muramba Sub County to expand agroforestry coverage, interventions must focus on education, extension support, seedling supply, and land management practices, as these factors strongly determine the level of agroforestry adoption.

Table 2: Level of Soil Erosion in Muramba Sub County

Predictor Variables	**Unstandardized Coefficient (B)**	**Std. Error**	**Beta**	**t-value**	**p-value**
Slope Gradient	0.518	0.091	0.447	5.69	0.000
Vegetation Cover	-0.392	0.082	-0.368	-4.78	0.000
Farming Practices (Tillage, Cropping)	0.351	0.079	0.336	4.44	0.000
Rainfall Intensity	0.302	0.073	0.289	4.14	0.000
Constant	0.986	0.168		5.87	0.000
Model Summary: R = 0.783, R² = 0.613, Adjusted R² = 0.600, F(4, 115) = 45.12, p = 0.000					

Source: Primary Data, 2024

The regression model for soil erosion was highly significant ($F = 45.12$, $p < 0.001$) and explained 61.3% of the variance in erosion levels in Muramba Sub County. Slope gradient ($B = 0.518$, $p = 0.000$) was the most influential predictor, indicating that steeper

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slopes experience higher rates of soil erosion due to runoff. This aligns with the general understanding that topography significantly determines erosion risk in hilly regions.

Vegetation cover had a strong negative relationship with soil erosion (B = -0.392, p = 0.000), showing that increased tree, shrub, and grass coverage significantly reduces soil loss. Similarly, farming practices (B = 0.351, p = 0.000), including improper tillage and continuous cropping, were positively associated with soil erosion, highlighting unsustainable land use as a key driver. Rainfall intensity (B = 0.302, p = 0.000) was also significant, demonstrating the impact of climate factors on erosion dynamics.

The study concluded that soil erosion in Muramba Sub County is primarily influenced by steep slopes, sparse vegetation, unsustainable farming practices, and heavy rainfall, emphasizing the need for both biological and structural soil conservation measures to mitigate land degradation.

Table 3: Relationship Between Agroforestry and Soil Erosion

Predictor Variables	**Unstandardized Coefficient (B)**	**Std. Error**	**Beta**	**t-value**	**p-value**
Level of Agroforestry Adoption	-0.476	0.081	-0.452	-5.88	0.000
Tree Density per Hectare	-0.398	0.077	-0.371	-5.17	0.000
Agroforestry Management Practices	-0.314	0.069	-0.304	-4.55	0.000
Constant	1.214	0.162	—	7.49	0.000
Model Summary: $R = 0.791$, $R^2 = 0.626$, Adjusted $R^2 = 0.613$, $F(3, 116) = 66.48$, $p = 0.000$					

Source: Primary Data, 2024

The regression model examining the relationship between agroforestry and soil erosion was statistically significant ($F = 66.48$, $p < 0.001$), with an R^2 of 0.626, indicating that approximately 62.6% of the variation in soil erosion can be explained by agroforestry practices. The results revealed a strong negative relationship between agroforestry adoption and soil erosion, confirming that higher levels of tree planting and effective agroforestry management significantly reduce soil loss.

Level of agroforestry adoption (B = -0.476, p = 0.000) had the strongest influence, suggesting that integrating trees into farmland buffers the soil against erosion, stabilizes slopes, and enhances infiltration. Tree density per hectare (B = -0.398, p = 0.000) was also significant, indicating that higher tree density increases root biomass, which holds soil particles together, preventing surface runoff. Additionally, agroforestry management practices (B = -0.314, p = 0.000), such as contour planting, alley cropping, and mulching, contributed significantly to erosion control.

The study concluded that agroforestry is an effective soil conservation strategy in Muramba Sub County. Farmers who adopt proper tree planting techniques and maintain high tree density can significantly reduce soil degradation, improve land fertility, and enhance the sustainability of agricultural production.

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Conclusions

The study concluded that the level of agroforestry in Muramba Sub County was moderately high but varied depending on several key factors. Farmer awareness and knowledge emerged as the strongest predictor of agroforestry adoption, indicating that informed farmers are more likely to implement tree planting and related practices. The availability of landholding size also significantly influenced agroforestry levels, as farmers with larger plots could more easily integrate trees into cropland, boundaries, and pastures. Access to extension services and availability of tree seedlings were additional determinants, emphasizing that support from agricultural officers and access to planting materials are critical for widespread agroforestry implementation.

The study concluded that soil erosion in Muramba Sub County was significantly influenced by both natural and human-induced factors. Slope gradient was the strongest contributor, confirming that steeper terrains are more prone to soil loss due to runoff and gravitational forces. Vegetation cover was negatively associated with erosion, indicating that areas with higher tree and grass density experience lower soil degradation. Unsustainable farming practices, including improper tillage and continuous cropping, contributed to increased erosion, while rainfall intensity also played a key role in determining the severity of soil loss.

The study concluded that there is a strong and negative relationship between agroforestry and soil erosion in Muramba Sub County. Higher levels of agroforestry adoption, including greater tree density and effective agroforestry management practices, significantly reduced soil erosion. This demonstrates that integrating trees into farmlands stabilizes the soil, improves water infiltration, and protects against surface runoff, thereby mitigating land degradation. The findings highlight that agroforestry is not only beneficial for agricultural productivity but also plays a critical role in environmental conservation. Farmers who adopt proper tree planting techniques and maintain adequate tree density can effectively control erosion while improving soil fertility and promoting sustainable land use.

Recommendations

There should be targeted awareness campaigns and training programs for farmers in Muramba Sub County to increase their understanding of agroforestry and its benefits. These programs should focus on educating farmers about the ecological and economic advantages of tree planting, appropriate species selection, and techniques for planting, pruning, and maintaining trees. There should also be practical demonstration sessions and farmer field schools to ensure that knowledge is applied directly to the fields.

There should be improved access to tree seedlings and planting resources. Community nurseries should be established to supply high-quality seedlings at affordable prices, and farmers should be encouraged to propagate seedlings on their own plots to ensure sustainability. Development partners should provide support in the form of subsidies or grants for seedlings and agroforestry tools to enable even resource-limited farmers to adopt tree-based practices. This will ensure that farmers have the necessary materials to implement agroforestry effectively.

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There should be promotion of sustainable land management practices. Farmers should be guided to implement techniques such as contour farming, terracing, alley cropping, intercropping with trees, mulching, and cover cropping. These practices should be applied to reduce runoff, improve soil fertility, and stabilize sloped areas, while avoiding over-cultivation and promoting crop rotation to maintain soil structure. Proper implementation of these techniques will help to reduce soil erosion and improve long-term productivity.

There should be increased vegetation cover and tree density across farms and community areas. Farmers should be encouraged to plant trees along farm boundaries, homesteads, and degraded land. Community woodlots and reforestation projects should be developed to further enhance tree cover, while integrating fruit, timber, and fodder species to provide both ecological and economic benefits. Increasing tree density will stabilize the soil, reduce runoff, and create favorable microclimates for crops.

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