

**The effect of agroforestry on Environmental Protection in Kabale district, Uganda**

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**Abstract**

This study examined the effect of Agroforestry on Environmental Protection in Kabale district, Uganda. The study anchored on the theory of change and the Systems theory. The study was based on these sustainable Development Goals: SDG 1 (No poverty), SDG 2 (Zero Hunger), SDG 3 (Good Health and Well-being), SDG 6 (Clean Water and Sanitation), SDG 13 (Climate Action), and SDG 15 (Life on Land). The study employed a cross-sectional survey design and implemented a comprehensive mixed-method approach with pragmatism philosophy to examine the phenomenon. Simple random sampling was used to select 347 respondents from the target population of 2639 respondents who were engaging in agroforestry practices from Rubaya, Butanda, Kamuganguzi and Kitumba Sub counties in Kabale district, Uganda. Purposive sampling was employed to select 25 key informants who were interviewed. To capture a broad range of perspectives, self-administered copies of the questionnaire were distributed to 347 participants who were residents actively engaged in agroforestry practices. Out of 347 copies of the Questionnaire that were administered to the respondents, 280 questionnaires were filled and returned back. Quantitative and qualitative analysis techniques were applied to the collected data. Findings indicate a positive relationship between agroforestry and environmental protection. It was concluded that this research provides valuable insights into the impact of agroforestry Practices on environmental protection in Kabale district, Uganda. Recommendations include promoting awareness and education, strengthening collaboration among stakeholders, developing and implementing supportive policies, establishing monitoring and evaluation systems, sustaining support from NGOs, enhancing collaboration and knowledge-sharing platforms, advocating for policy support, and encouraging community-based initiatives for soil conservation. The study suggests improvements in policy implementation, intergovernmental coordination, resource allocation, stakeholder collaboration, and policy implementation mechanisms to enhance environmental protection efforts.

**Keywords: Agroforestry, Environmental Protection, Uganda**

**Introduction**

Amidst the global pursuit of sustainable solutions, agroforestry emerges as a beacon of hope, intertwining the realms of agriculture and forestry to foster a resilient environment. Its impact on environmental protection resonates profoundly with the United Nations' Sustainable Development Goals (SDGs), offering a holistic approach that addresses multiple facets of sustainable development. "This study Agroforestry and environmental protection

was closely related to several Sustainable Development Goals (SDGs) outlined by the United Nations in 2015. Here are some of the relevant SDGs and how they relate to the study:

**SDG 1: No Poverty:** Sustainable Land management such as agroforestry trees provide alternative sources of income and when people have improved livelihoods, it reduces pressure on the land.

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**SDG 2: Zero Hunger:** Sustainable land management practices, such as agroforestry, can contribute to increasing agricultural productivity and ensuring food security. By improving soil health, diversifying crop production, and reducing environmental degradation, these practices can help achieve the goal of ending hunger and promoting sustainable agriculture.

**SDG 3: Good Health and Well-being:** Sustainable land management practices have a direct impact on human health. By reducing the use of chemical inputs, improving water quality, and preserving ecosystems, these practices contribute to a healthier environment, reducing the risk of diseases and promoting overall well-being.

**SDG 7: Affordable and Clean Energy:** Agroforestry and other sustainable land management practices can contribute to the production of biomass energy. By integrating trees and crops, farmers can generate renewable energy sources, such as wood for cooking and heating, reducing the reliance on fossil fuels and promoting clean energy alternatives.

**SDG 13: Climate Action:** Sustainable land management practices, including agroforestry, play a significant role in mitigating climate change. Trees in agroforestry systems act as carbon sinks, sequestering carbon dioxide from the atmosphere and helping reduce greenhouse gas emissions. These practices contribute to climate change adaptation and resilience by enhancing ecosystem functions and reducing vulnerability to extreme weather events.

The study's findings on the effect of Agroforestry on environmental protection are crucial for achieving these SDGs by addressing pressing global challenges such as hunger, poverty, climate change, and ecosystem degradation. By promoting sustainable practices such as

agroforestry, the study contributes to the broader agenda of sustainable development and the realization of these goals (United Nations Environment Programme,2019).

Environmental protection, on the other hand, focuses on safeguarding the natural environment and its resources. It entails policies, regulations, and actions aimed at preventing or reducing pollution, mitigating environmental impacts, and conserving natural habitats. The objective of environmental protection is to ensure the preservation and sustainable use of natural resources for the benefit of current and future generations. (United Nations Environment Programme,2021)

Environmental protection measures include the enforcement of environmental laws and regulations, the promotion of renewable energy sources, waste management strategies, and pollution control measures. By addressing issues such as air and water pollution, deforestation, and habitat destruction, environmental protection contributes to the overall sustainability of land resources and ecosystems. (Lal, R,2015)

Environmental protection and sustainable land management are now acknowledged as essential elements of global sustainable development. The first international symposium on sustainable land use was held in 1990 in New Delhi and featured the first presentation of the concept of sustainable land management (SLM). This symposium was put on by the Indian Council of Agricultural Research (ICAR), the United States Department of Agriculture (USDA), and the United States Rodale Institute. Since then, numerous academic institutions and research groups have conducted in-depth studies across the globe that cover every facet of sustainable land use.

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The emergence of modern environmental protection can be traced back to the mid-20th century, when concerns about pollution and natural resource depletion began to gain global attention. The United Nations Conference on the Human Environment held in Stockholm in 1972 was

a landmark event in this regard, as it brought together representatives from around the world to discuss environmental issues and set the stage for international cooperation on environmental protection (United Nations Environment Programme, n.d.).

### **Theoretical Perspective**

There are many theories that have been advanced by various authors in attempt to link agroforestry practices to environmental protection and these include:

#### **The Theory of Change**

The theory of change was made popular by Weiss (1995), who clearly and efficiently defined it as a theory explaining how actions are believed to lead to a series of results that contribute to the ultimate intended impacts. Any degree of intervention, like a company or an occasion, is capable of having one. It might also be created for a strategy, plan, program, or policy. A theory of change simply explains in great detail how and why a desired change is anticipated to occur in a certain situation. The theory of change offers a guide for comprehending the cause-and-effect connections necessary to bring about a desired change. It directs the development, implementation, and evaluation of interventions and assists stakeholders in articulating their presumptions, methods, and desired results.

#### **The Systems Theory**

In the middle of the 20th century, Ludwig von Bertalanffy and Ross Ashby created the systems theory. It sees systems as a collection of components or elements that work together to create a complex whole. The theory emphasizes the necessity to take into account the complete system while researching phenomena like sustainable land management and environmental preservation because changes in one element of the system might have an impact on other parts.

Systems theory focuses on the interconnection and interdependence of many aspects as it investigates the linkages and interactions between diverse parts of a system. This theory aids in comprehending the intricate interactions between natural ecosystems, human activities, and socio-economic issues in the context of sustainable land management and environmental protection. It emphasizes the necessity of taking the whole system into account when determining how land management practices affect the environment and vice versa.

### **METHODS**

#### **Research Design**

Research designs, which encompass quantitative, qualitative, and mixed methodologies, play a crucial role in explicitly outlining the processes of a research study.

For this particular study, a cross-sectional research design was adopted. The cross-sectional design involves gathering data at a single point in time to assess the relationship between variables or phenomena. In this case, both quantitative and qualitative data collection methods were utilized to obtain a comprehensive understanding of the research topic.

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By employing a cross-sectional design, the researcher was able to capture a snapshot of the subject of study, considering various factors and capturing different perspectives. The combination of quantitative and qualitative data collection methods allowed for a more nuanced and comprehensive analysis of the research problem

A quantitative approach of analysis, according to Creswell (2014), creates analysis of an idea by making assumptions and then using data collection to either confirm or deny the assumptions. The qualitative approach determines the significance of a given phenomenon from the point of view of the participants and analyzes it over time, in contrast to the quantitative approach which determines the significance of a given phenomenon from the point of view of the participants and analyzes it over time. A mixed method approach was required since the participants' behavior was monitored as they engaged in activities to acquire the data.

Using a quantitative technique, the researcher was able to quickly measure and assess data and establish the relationship between an independent variable (agroforestry practices) and the dependent variable. The perspectives and opinions of community members on SLM activities and their role in environmental protection were gathered using a qualitative approach. In addition, a qualitative approach was used to gather deeper, more detailed information in the form of exhaustive written descriptions.

#### **Target Population**

The target population of the study was 2639 people. This population included residents who were engaged in or affected by agroforestry practices and since all the residents reached were actively participating in all these practices with support from Self Help Africa, African International Christian Ministry, Caritas, Nature Uganda, NAADS and the local government of Kabale district. It was easier for the researcher to collect data.

#### **Sample size**

This study employed mixed method sampling design. In this study, 280 residents who were engaging in agroforestry responded to the questionnaires in the first phase of the study while in the second phase, 25 respondents were purposively selected and interviewed with the purpose of gathering in depth qualitative data. These were identified by both the researcher and research assistants.

#### **Sample Size for Quantitative Data**

The study used the Sloven's sample size formula to determine the study sample size. Accordingly, a sample size of 347 was determined for the study. An additional 25 respondents (key informants) were purposely sampled for the study. The key informants were selected based on the researcher's belief that they were knowledgeable enough to provide valuable data for the study.

From the accessible population, a sample size of 347 respondents were determined using the Sloven's formula as follows:

$$n = N/(1+Ne^2)$$

Where: n=means of sample size, N=the population size and e= the error of sampling or the confidence interval at 95% therefore e=0.05%. It represents also the level of precision.

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Using the same formula  $n = N / (1 + Ne^2)$

Sample size determination for Rubaya, Butanda, Kitumba and Kamuganguzi Sub counties for the residents practicing agroforestry was given by:

$$n = \frac{N}{1 + Ne^2}$$

$$n = \frac{2639}{1 + 2639(0.05)^2}$$

$$n = 347$$

**Table 1: Sample size and composition for Rubaya, Butanda, Kitumba and Kamuganguzi Sub Counties in Kabale district.**

| Location              | Categories                         | Target population | Sample size | Sampling techniques    |
|-----------------------|------------------------------------|-------------------|-------------|------------------------|
| Rubaya Subcounty      | Residents practicing agroforestry  | 890               | 117         | Simple Random Sampling |
| Butanda Subcounty     | Residents practicing agroforestry  | 560               | 74          | Simple Random Sampling |
| Kitumba Subcounty     | Residents practicing agroforestry  | 600               | 79          | Simple Random Sampling |
| Kamuganguzi Subcounty | Residents practicing agroforestry. | 589               | 77          | Simple Random Sampling |
| <b>Total</b>          |                                    | <b>2639</b>       | <b>347</b>  |                        |

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### Sample Size for Qualitative Data

The sample size for qualitative data was obtained through purposive sampling. Twenty-five (25) key informants from the four sub counties were identified and subsequently interviewed. All the participants were sought out because they had specific information and knowledge about agroforestry practices and environmental protection.

**Table 2: Key informants sample size framework for in- depth interviews for qualitative research method.**

| Categories                                | Target Population | Sample size | Sample Methods     |
|-------------------------------------------|-------------------|-------------|--------------------|
| District Natural Resources Officer        | 1                 | 1           | Purposive Sampling |
| District Environment Officer              | 1                 | 1           | Purposive Sampling |
| Subcounty Chiefs                          | 4                 | 4           | Purposive Sampling |
| Parish Chiefs                             | 5                 | 5           | Purposive Sampling |
| Subcounty Agricultural Extension Officers | 8                 | 4           | Purposive Sampling |
| Local Council Chairpersons                | 9                 | 9           | Purposive Sampling |
| NGO Representative                        | 3                 | 1           | Purposive Sampling |
| <b>Total</b>                              | <b>31</b>         | <b>25</b>   |                    |

### Selection of Villages

The villages for this study were chosen using the purposive sampling method, guided by three specific criteria. Firstly, the selection was based on the regional and physical environmental characteristics of each village. Secondly, the primary focus was on the community landscape. Lastly, villages with well-organized farmer groups collaborating with organizations like AICM, Self-Help Africa and Nature Uganda were included. Despite some limitations, purposive sampling proved valuable when the research question demanded a specific sample of participants with particular characteristics. Villages demonstrating sustainable Land Management Practices were purposely selected for this study.

### Selection of Participants

Each village was chosen with its study participants based on pre-existing locally run farmer's groups. These groups included both men and women including adults and Youth who had taken part in agricultural research projects carried out by AICM, Self Help Africa, Nature Uganda, and National Agricultural Advisory services (NAADS). They had a range of social,

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economic, and educational backgrounds. The attendees typically included local officials, particularly LC1 Chairpersons. So, was argued that the chosen individuals were a representative of the neighborhood.

### **Research Instruments**

Creswell (2012) states that a research instrument is an assessing, monitoring, and recording data device.

#### **Questionnaire**

The Questionnaire utilized in this research had two main parts: (1) a demographic section that asked about the respondents' gender, age, occupation, education level, marital status, and (2) a section on the independent, dependent variables and intervening variables, which used a 5-point Likert scale to obtain clear responses from the participants. The questionnaire allowed for standardization of the data that was collected. The same set of questions were administered to multiple participants, ensuring consistency in the data collected. This standardization enabled easier comparison and analysis of responses.

Structured questions were utilized for effective analysis and to make the surveys simpler for respondents to complete. The questionnaires were distributed and conducted independently to provide respondents enough time and space to complete them. These were finished whenever it was most convenient for the respondents. The likelihood of getting reliable information increased as a result. Using this method, more confidentiality was ensured. Sensitive information was disclosed without fear. Questionnaires were gathered afterward.

A 5 Point Likert scale rating of 5=strongly agree, 4=agree, 3= not sure, 2=disagree and 1=strongly disagree was used for the dependent, independent and intervening variable questions as recommended by (Amin, 2005)

#### **Interview Guide**

The researcher used in-person interviews to speak with respondents about how they regarded both dependent, independent and intervening factors. In order to collaborate on survey analysis findings and explore more in-depth relationships suggested by the quantitative analysis that were supported by the data, the researcher interviewed participants while being guided by an interview guide that contained semi-structured questions for important information. The researcher was able to better understand the study's goals and obtain additional information not available through self-administered questionnaires with the aid of face-to-face interview data. An interview guide was used because it provides a structured framework for conducting interviews. It outlines the key topics, questions, and prompts to guide the interviewer throughout the interview process. This structure ensures consistency across interviews and helps maintain focus on the research objectives. The researcher was able to explain, elaborate, and persuade the respondents of the value of the research by using interview guides. (Mugenda and Mugenda 2003).

### **Validity and Reliability of Research Instruments.**

This section describes the pilot test study and explores the accuracy and consistency of the measurement tools used.

#### **Validity**

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Amin (2005) defines validity as "the extent to which a test measures what it claims to measure." In other words, validity is the degree to which a test accurately measures the construct or concept it is intended to measure. Amin emphasizes that a test can only be considered valid if it has been shown to accurately measure the construct of interest through appropriate methods of validation, such as content validity, criterion-related validity, or construct validity.

Content validity refers to the extent to which a test adequately covers the domain of knowledge or skills it is intended to measure. Criterion-related validity refers to the degree to which a test correlates with other measures or outcomes that are known to be related to the construct being measured. Construct validity refers to the degree to which a test accurately measures the underlying theoretical construct it is intended to measure, as demonstrated by patterns of correlation with other tests or measures, convergent and divergent validity, or factor analysis.

In this study however, emphasis was put on content and construct validity. The content validity of the instrument was determined using the following formula before the real field survey.

$$CVI = \frac{\text{no of items declared valid}}{\text{total no of items}}$$

CVI stands for content Validity index and in this study the point of validity=0.7 and above.

Construct validity is a measure of the degree to which data obtained meaningfully and accurately reflects and represents a theoretical scope. To achieve this, a study used a panel of experts/judges of five members. Two panelists recommended the removal of dependent variable questions citing content irrelevancy but others were in agreement with an instrument. All of them made comments and suggestions regarding the clarity of the questions. Going by the formula, the CVI for this research was 0.88. Thus, the study passed the test content validity calculated as the number of items regarded relevant by the experts (49) divided by the total number of items (55). The recommendations from the panel of experts were used to refine and enhance validity of the instruments. Their suggestions aided the researcher to remove ambiguous terms and aided missing items to make it possible for the study to produce clear and specific questions and improve the quality and validity of the questions.

### Reliability

The reliability of the research instruments was established using Cronbach Alpha Coefficient test. This was computed using SPSS. The Cronbach Alpha statistics in this study for agroforestry was 0.834 (number of items were 9) and environmental protection was 0.716 (with 7 items). Since the average Cronbach alpha for the study was above 0.7 for all, the research instrument was regarded as highly reliable and consistent (Amin, 2005).

**Table 3: Summary of Cronbach Alpha Reliability Coefficients for study variables**

| Aggregated Variable      | No. of items | Cronbach's Alpha (%) |
|--------------------------|--------------|----------------------|
| Agroforestry             | 9            | 0.834                |
| Environmental Protection | 6            | 0.717                |

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### Data Processing and Analysis.

Qualitative data was analyzed using Content analysis: This involved systematically examining the content of qualitative data, such as transcripts of interviews to identify themes and patterns. For the purpose of qualitative data analysis, field notes were typed up and interview responses were sorted and coded to enable statistical analysis. Data was carefully analyzed to see if the data speaks to the research questions. Quantitative data was analyzed using Statistical Package for Social Sciences (SPSS) Version 22. To analyze quantitative data, tables of descriptive statistics were employed.

The correlation coefficient approach was used to analyze the relationship between the variables with the assistance of statistical tools. Inferential statistics to test the research hypothesis were used. This involved using statistical tests such as the regression analysis to determine whether there were significant differences or relationships between variables. Also, narrative analysis was used to analyze qualitative data.

### Ethical Considerations.

The researcher requested for consent and cooperation from the respondents before beginning data collection in order to obtain the necessary data for the study.

The confidentiality of the information they supplied was guaranteed, as the fact that the results of the study were utilized for academic purposes.

The researcher made an effort to communicate truthfully in all scientific contexts. The researcher did not create false information or display it incorrectly.

When necessary, the researcher asked for advice. The researcher made an effort to provide credit to any information sources that they referenced or used during the research process.

In order to avoid thoughtless mistakes and carelessness, the researcher thoroughly and critically reviewed the work and data provided by respondents.

### Presentation of the Findings

**Objective: To examine the effect of Agroforestry and Environmental Protection in Kabale District, Uganda**

**Table 4: Responses to Agroforestry items**

| Statements                                                          | SA         | A          | NS      | D       | SD    | M    | Std. Dev |
|---------------------------------------------------------------------|------------|------------|---------|---------|-------|------|----------|
| I grow agroforestry trees such as Calliandra & Grevillea on my land | 139(49.6%) | 141(50.4%) | 0(0%)   | 0(0%)   | 0(0%) | 4.50 | 0.501    |
| I plant agroforestry trees with crops on my land                    | 114(40.7%) | 163(58.2%) | 1(0.4%) | 2(0.7%) | 0(0%) | 4.39 | 0.537    |

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|                                                                                                                |            |            |          |            |          |      |       |
|----------------------------------------------------------------------------------------------------------------|------------|------------|----------|------------|----------|------|-------|
| Agroforestry has improved the quality of the soil on my land                                                   | 31(11.1%)  | 117(41.8%) | 23(8.2%) | 109(38.9%) | 0(0%)    | 3.25 | 1.092 |
| I prepare nursery beds for agroforestry trees                                                                  | 1(0.4%)    | 140(50%)   | 0(0%)    | 139(49.6%) | 0(0%)    | 3.01 | 1.007 |
| Agroforestry practices have helped me reduce my reliance on external inputs such as fertilizers and pesticides | 133(47.5%) | 146(52.1%) | 0(0%)    | 1(0.4%)    | 0(0%)    | 4.47 | 0.521 |
| I face challenges in accessing credit and financing to implement agroforestry practices                        | 116(41.4%) | 139(49.6%) | 0(0%)    | 1(0.4%)    | 24(8.6%) | 4.15 | 1.087 |
| I have received training on agroforestry practices and techniques                                              | 50(53.6%)  | 130(46.4%) | 0(0%)    | 0(0%)      | 0(0%)    | 4.54 | 0.500 |
| I believe that agroforestry can help address land degradation and desertification                              | 148(52.9%) | 118(42.1%) | 14(5%)   | 0(0%)      | 0(0%)    | 4.48 | 0.592 |
| Agroforestry practices have helped me to diversify my income sources on the farm                               | 22(7.9%)   | 133(47.5%) | 0(0%)    | 125(44.6%) | 0(0%)    | 3.19 | 1.098 |

**Source: Primary Data, 2023**

**Key:** n=280, SA=strongly agree, A=agree, NS=not sure, D=disagree, SD=Strongly disagree, M=Mean, Std. Dev=standard deviation.

The findings in table 14 above indicate that majority of the farmers around 139 (49.6%) strongly agreed and 141(50.4%) agreed that they grow agroforestry trees such as Calliandra & Grevillea on their land and 114(40.7%) farmers strongly agreed that they plant agroforestry with other crops, 163(58.2%) agreed that they plant agroforestry with other crops, 1(0.4%) of the farmers were not sure and 2(0.7%) of the respondents disagreed that they don't plant agroforestry trees with crops. This indicates a high level of adoption of agroforestry practices among the farmers surveyed.

The statement "Agroforestry has improved the quality of the soil on my land" received mixed responses, with only 31(11.1%) strongly agreeing and 117(41.8%) somewhat agreeing, 109(38.9%) disagreeing and 23(8.2%) not sure. This suggests that while some farmers have experienced improvements in soil quality, others may not have seen significant changes or may not be aware of the impact of agroforestry on soil health.

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The statement "I face challenges in accessing credit and financing to implement agroforestry practices" received a relatively high level of agreement with 116 (41.4%), 139 (49.6%) agreed with the statement, 1 (0.4%) disagreed and 24 (8.6%) strongly disagreed. The high level of agreement suggests that a significant number of respondents in Kabale District, Uganda, face challenges in accessing credit and financing for implementing agroforestry practices. This implies that there may be limited financial resources available to support farmers in adopting and implementing agroforestry systems.

On the other hand, the percentage of disagreement and strong disagreement combined is relatively low (9%), indicating that the majority of respondents do indeed acknowledge the challenges related to credit and financing in the context of agroforestry. This suggests that a significant proportion of respondents acknowledge the difficulties related to credit and financing when it comes to agroforestry initiatives.

On a positive note, a high proportion of farmers 133 (47.5%) strongly agreed that agroforestry practices have helped them reduce their reliance on external inputs such as fertilizers and pesticides while 146 (52.1%) agreed, 1 (0.4%) disagreed. This suggests that agroforestry can provide a sustainable alternative to conventional agriculture that relies heavily on chemical inputs.

Finally, the majority of farmers surveyed 148 (52.9%) strongly agreed, 118 (42.1%) agreed and 14 (5%) were not sure that agroforestry can help address land degradation and desertification. This highlights the potential of agroforestry as a nature-based solution to some of the environmental challenges facing agriculture. However, it's essential to address the concerns and uncertainties of the 5% who were not sure to provide them with information and understanding about the benefits of agroforestry.

Finally, 22 (7.9%) strongly agreed, 133 (47.5%) agreed and 125 (44.6%) of respondents disagreed that Agroforestry practices had not helped them to diversify their income sources on the farm. The majority of respondents (55.4%) either agreed or strongly agreed that agroforestry practices had helped them diversify their income sources on the farm. This indicates that a significant proportion of farmers in Kabale District, Uganda, perceive agroforestry as a viable means to expand their income beyond traditional farming activities and the positive perception suggests that agroforestry practices have the potential to contribute to income diversification. Farmers have successfully incorporated income-generating activities such as selling seeds and seedlings of agroforestry trees, timber, non-timber forest products, or other tree-based products into their farm operations.

Overall, the data indicates that while there are some respondents who do not perceive significant income diversification benefits from agroforestry practices, a notable majority does acknowledge the positive effects of these practices on diversifying their income sources on the farm.

"I grow agroforestry trees such as Calliandra and Grevillea on my land" ( $M = 4.50$ , Std. Dev = 0.501): The participants, on average, show a high level of agreement (SA) in growing agroforestry trees on their land. The responses are relatively consistent or clustered around the mean.

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"I plant agroforestry trees with crops on my land" ( $M = 4.39$ , Std. Dev = 0.537): The participants, on average, show a positive attitude (A) towards planting agroforestry trees alongside crops. The standard deviation suggests a moderate level of variation or diversity in the responses.

"Agroforestry has improved the quality of the soil on my land" ( $M = 3.25$ , Std. Dev = 1.092): The participants' responses for this statement are more varied. The mean suggests a neutral response (NS), indicating mixed opinions regarding the improvement of soil quality through agroforestry practices. The higher standard deviation indicates a wide range of responses, with some participants strongly agreeing and others strongly disagreeing.

"I prepare nursery beds for agroforestry trees" ( $M = 3.01$ , Std. Dev = 1.007): The mean suggests a relatively lower level of agreement (NS) in preparing nursery beds for agroforestry trees. The standard deviation indicates a diverse range of responses, with significant variability among participants.

"Agroforestry practices have helped me reduce my reliance on external inputs" ( $M = 4.47$ , Std. Dev = 0.521): The participants, on average, strongly agree (SA) that agroforestry practices have helped them reduce reliance on external inputs. The standard deviation suggests a moderate level of agreement among the participants.

"I face challenges in accessing credit and financing for agroforestry practices" ( $M = 4.15$ , Std. Dev = 1.087): The mean indicates a moderate level of agreement (A) in facing challenges related to accessing credit and financing for agroforestry practices. The standard deviation suggests a wide range of responses, with considerable variation among participants.

"I have received training on agroforestry practices and techniques" ( $M = 4.54$ , Std. Dev = 0.500): The participants, on average, strongly agree (SA) that they have received training on agroforestry practices and techniques. The responses are relatively consistent or clustered around the mean.

"I believe that agroforestry can help address land degradation and desertification" ( $M = 4.48$ , Std. Dev = 0.592): The participants, on average, strongly agree (SA) that agroforestry can help address land degradation and desertification. The standard deviation suggests a moderate level of agreement among the participants.

"Agroforestry practices have helped me to diversify my income sources on the farm" ( $M = 3.19$ , Std. Dev = 1.098): The mean suggests a relatively lower level of agreement (NS) in terms of agroforestry practices helping participants diversify their income sources. The higher standard deviation indicates a wide range of responses, with significant variability among participants.

Overall, the mean values provide an indication of the participants' average responses to each statement, while the standard deviations reflect the variability or dispersion

Overall, the data suggests that while agroforestry practices have been adopted by a significant proportion of farmers, there are still challenges to be addressed in terms of access to credit and financing, awareness of the benefits of agroforestry, and the need for continued research and education to support the scaling up of these practices.

**Table 5: Regression Analysis results on Agroforestry and Environmental Protection showing the**

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**Model Summary**

| Model | R                 | R Square | Adjusted R Square | Std. Error of the Estimate |
|-------|-------------------|----------|-------------------|----------------------------|
| 1     | .639 <sup>a</sup> | .408     | .406              | 2.698                      |

a. Predictors: (Constant), Agroforestry

**Table 6: Regression Analysis results on Agroforestry and Environmental Protection showing ANOVA<sup>a</sup>**

| Model |            | Sum of Squares | Df  | Mean Square | F       | Sig.              |
|-------|------------|----------------|-----|-------------|---------|-------------------|
| 1     | Regression | 1395.355       | 1   | 1395.355    | 191.729 | .000 <sup>b</sup> |
|       | Residual   | 2023.212       | 278 | 7.278       |         |                   |
|       | Total      | 3418.568       | 279 |             |         |                   |

a. Dependent Variable: Environmental protection

b. Predictors: (Constant), Agroforestry

**Table 7: Regression Analysis results on Agroforestry and Environmental Protection showing Coefficients<sup>a</sup>**

| Model | Unstandardized Coefficients |            | Standardized Coefficients | T | Sig. |
|-------|-----------------------------|------------|---------------------------|---|------|
|       | B                           | Std. Error | Beta                      |   |      |

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|   |              |        |       |      |       |      |
|---|--------------|--------|-------|------|-------|------|
| 1 | (Constant)   | 10.100 | 1.216 |      | 8.306 | .000 |
|   | Agroforestry | .464   | .034  | .639 |       | .000 |

The regression analysis was used to determine the effect of agroforestry on environmental protection.

The model summary table 5 shows that the correlation coefficient between the independent variable and dependent variable is 0.639, indicating a moderate positive correlation. The R-squared value of 0.408 suggests that 40.8% of the variance in the dependent variable is explained by the independent variable. The adjusted R-squared value of 0.406 indicates that the model is not overfitted.

The ANOVA table 6 shows that the regression model is significant ( $p < .001$ ), meaning that the regression model explains a significant amount of the variance in the dependent variable. The coefficient table 7 shows that the intercept value is 10.1, which is the predicted value of the dependent variable when the independent variable is zero. The slope coefficient for the independent variable, "Agroforestry," is 0.464, indicating that a one-unit increase in the independent variable is associated with a 0.464 unit increase in the dependent variable.

In summary, the analysis suggests that the variable "Agroforestry" has a significant positive effect on the dependent variable "Environmental protection." The model is statistically significant and explains 40.8% of the variance in the dependent variable. The implication of the analysis is that the variable "Agroforestry" has a significant positive effect on the dependent variable "Environmental protection. This is in line with the theory of change that looks at the actions deemed to bring results which in turn results to change.

**The model equation is therefore,  $Y = 10.100 + 0.464X_1$**

where Y represents the predicted value of Environmental protection,  $X_1$  represents the value of Agroforestry, 10.100 represents the intercept, and 0.464 represents the slope of the regression line.

This equation can be used to predict the value of Environmental protection based on the value of Agroforestry. The intercept of 10.100 represents the expected value of Environmental protection when Agroforestry is zero. The slope of 0.464 indicates that for each one-unit increase in Agroforestry, Environmental protection is predicted to increase by 0.464 units, holding all other variables constant.

The regression model presented suggests that there is a positive relationship between agroforestry and environmental protection. The coefficient for  $X_1$  (Agroforestry) is positive, indicating that as agroforestry increases, so does environmental protection. This finding is consistent with the literature on the positive effects of agroforestry on the environment. Thus, the null hypothesis that was stating that there is no effect of agroforestry on environmental protection is rejected.

This analysis acknowledges the potential interconnectedness between Agroforestry and Environmental protection within the broader system of environmental management and conservation which is in agreement with the systems theory. In systems theory, one of the key concepts is the interconnectedness between different components of a system. In this context, the

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regression analysis explores the relationship between Agroforestry (independent variable) and Environmental Protection (dependent variable). Also, the Systems theory often involves the identification of dependent and independent variables in a system to understand their relationships and seeks to understand how changes in one component (Agroforestry) may influence or impact another component (Environmental Protection) within the system.

These findings are supported by the views from the key informants when asked about the effect of agroforestry on environmental protection in Kabale district of Uganda. Most of the views from the participants seem to reach a general consensus that agroforestry leads to environmental protection. Interviewees gave different views about the effect of agroforestry and environmental protection in Kabale district. For example, one interviewee, who is a chairperson LC1 of one of the villages explained as follows;

*"As a chairperson and farmer who has adopted agroforestry practices, I have seen firsthand how planting agroforestry trees alongside crops can improve soil quality and reduce the need for chemical inputs. However, I have also faced challenges in accessing credit and financing to invest in these practices, which can be a barrier for many farmers. Nevertheless, I believe that agroforestry has the potential to address some of the environmental challenges we face in agriculture, such as land degradation and desertification."*

Another participant, who is a subcounty chief working in the area where the study was conducted explained that;

*"There is a high level of adoption of agroforestry practices among farmers in our subcounty, with many planting trees such as Calliandra and Grevillea alongside crops such as beans, Irish potatoes and sweet potatoes. However, there are still challenges that need to be addressed, such as access to credit and financing although some NGOS such as African International Christian Ministry have been supporting farmers with agroforestry seedlings and seeds, their contracts have ended when farmers still wanted them, which has limited farmers' ability to invest in agroforestry practices, some farmers are still hesitant to plant these trees on their land, others cut trees for their neighbours to stake their beans but generally planting agroforestry trees has improved the fertility of the farmers soils and they no longer depend on agro inputs from shops".*

An Environmental Officer that was interviewed for this study, had this to say:

*"As the District Environment Officer, I am pleased to see that agroforestry practices have been adopted by a significant proportion of farmers in Kabale district. This is an important step towards achieving our environmental protection goals, as agroforestry can help to address land degradation and desertification while reducing reliance on chemical inputs.*

*However, there is still work to be done to increase awareness of the benefits of agroforestry and ensure that farmers have access to credit and financing to implement these practices. Through continued research, education, and collaboration with local stakeholders, we can support the scaling up of agroforestry in Kabale district and promote sustainable agriculture that benefits both farmers and the environment."*

Another chairperson LC1 that was interviewed for this study, had this to say:

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*"As the Chairperson LC1, I am encouraged by the high level of adoption of agroforestry practices among farmers in our district. It is important that we continue to support and promote these practices as they have the potential to improve soil quality, reduce reliance on chemical inputs and address land degradation and desertification.*

*However, it is clear that farmers face challenges in accessing credit and financing to implement these practices, which could limit their ability to fully benefit from agroforestry. We need to work together with local stakeholders to find solutions to this issue and ensure that farmers have the necessary resources to invest in agroforestry. In addition, agroforestry faces challenges and limitations in its widespread adoption such as limited farmer knowledge and awareness and insufficient policy support"*

An NGO representative from African International Christian Ministry (AICM) who was interviewed had this to say:

*We have supported the farmers with agroforestry seeds and seedlings of Calliandra and Grevillea, offered them some training on how to prepare nursery and seedbeds for these agroforestry and sensitized community members on the benefits of agroforestry trees and there is high adoption of agroforestry practices in the community, the farmers soil quality has improved, farmers no longer rely on pesticides and fertilizers from shops and they are now using the trees to stake their beans. Moreso, we supported the farmers in Rubaya and Butanda Sub counties to formulate the soil and water conservation bylaw that encourages them to plant agroforestry trees to boost their soil fertility and improve on food production.*

Another Key informant who was the chairperson LC1 of Kariko cell in Kitumba Subcounty Stated that *"we used to get seeds and seedlings of agroforestry trees from NAADS programme and some training on how to plant agroforestry trees but now days we no longer and most people who used to plant agroforestry no longer but for us who have continued to plant these seedlings by buying them from the nursery operators, our soils are fertile and stable they can't easily be eroded by soil erosion"*.

### **Discussion of Findings**

The objective of the study was meant to examine the effect of Agroforestry on environmental protection in Kabale district of Uganda. To achieve this objective, the researcher collected responses from 280 respondents that were actively engaging in the agroforestry Practices. The questions were in 5-Point Likert scale requiring the respondents to choose from strongly agree to strongly disagree.

The findings presented from the descriptive analysis, indicated that a substantial proportion of farmers have adopted agroforestry practices, such as planting trees on their land and intercropping with crops. This demonstrates a positive trend towards sustainable agriculture, as agroforestry practices have been shown to improve soil health, increase biodiversity, and reduce the environmental impact of farming. The findings indicate that farmers have embraced agroforestry practices, which involve planting trees on their land and intercropping with crops. Agroforestry is a sustainable land management practice that directly relates to SDG 15 (Life on land). This goal focuses on the protection, restoration of biodiversity on land and sustainable use of terrestrial ecosystems.

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However, the mixed responses to the statement regarding the impact of agroforestry on soil quality suggest that there is a need for more education and awareness-raising about the benefits of these practices. Farmers who have not experienced improvements in soil quality may need guidance on the appropriate agroforestry practices to implement on their land to maximize the benefits.

The high level of agreement with the statement about challenges in accessing credit and financing suggests that financial barriers are hindering the wider adoption of agroforestry practices. This highlights the need for policymakers and financial institutions to explore innovative ways to support farmers in investing in agroforestry.

The positive response to the statement about reducing reliance on external inputs indicates that agroforestry can provide a sustainable alternative to conventional agriculture, which relies heavily on chemical inputs. This is a positive development, as excessive use of agrochemicals has been associated with negative environmental and health impacts. The findings align with Abeinomugisha (2019) where he stated that agroforestry results to increased crop yields and leads to reduced reliance on agro inputs and input costs. Also, the positive response to reducing reliance on external inputs and the findings about increased crop yields and reduced reliance on agro inputs in agroforestry practices align with SDG1(No poverty) and SDG 2: Zero Hunger. Agroforestry contributes to sustainable agriculture, increased crop yields, reduced reliance on agro inputs, and cost savings for farmers, all of which are central to the objectives of SDG 2.

Finally, the majority of farmers surveyed believe that agroforestry can help address land degradation and desertification, highlighting the potential of these practices as a nature-based solution to environmental challenges. This is directly linked to SDG 6's objective of protecting and restoring water-related ecosystems, as soil erosion can lead to sedimentation in water bodies, affecting water quality and aquatic habitats.

Simple linear regression analysis findings also revealed that agroforestry has a significant positive effect on environmental protection in Kabale district of Uganda, as indicated by a moderate positive correlation (0.639) and a statistically significant regression model ( $p < .001$ ). These findings implied that in the presence of agroforestry, there was a high possibility of environmental protection and vice versa. These findings are consistent with the views of key informants who agreed that agroforestry leads to environmental protection. However, the informants also mentioned challenges faced by farmers in accessing credit and financing to invest in agroforestry practices. Therefore, increasing awareness of the benefits of agroforestry and finding solutions to address the challenges faced by farmers can promote sustainable agriculture that benefits both farmers and the environment. The hypothesis  $H_01$ : agroforestry has no effect on environmental protection in Kabale district of Uganda was rejected and concluded that agroforestry has a significant effect on environmental protection.

Findings were consistent with Nair, P.K.R. (2020) who stated that Agroforestry can provide multiple environmental benefits and should be considered as an important land-use system for sustainable agriculture in Europe. The potential of agroforestry for environmental protection, includes improved soil quality, reduced erosion, enhanced biodiversity, and carbon sequestration. His findings suggest that agroforestry can play an important role in environmental protection and sustainable agriculture. Nair's findings highlight the environmental benefits of agroforestry, including improved soil quality, reduced

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erosion, enhanced biodiversity, and carbon sequestration. These benefits align with the objectives of SDG 13, which focuses on taking urgent action to combat climate change and its impacts. Research studies have demonstrated the positive environmental impact of agroforestry. For instance, a study by Jose et al. (2019) found that agroforestry systems reduced soil erosion by 56% compared to conventional agriculture.

In contrast, the study carried out by Luedeling et al. (2014) provides evidence that agroforestry systems can significantly improve soil quality and reduce soil erosion in regions prone to these issues. This is consistent with the findings of Nair, P.K.R. (2020), who stated that agroforestry can provide multiple environmental benefits which also in line with the research findings.

Ong (2018) carried out a study in Uganda and found out that agroforestry had been widely adopted by smallholder farmers as a means to improve their livelihoods and contribute to sustainable land use management.), agroforestry practices in Uganda have helped farmers to increase their farm productivity, improve soil fertility, and reduce the risks associated with climate variability. In addition, agroforestry has contributed to the conservation of natural resources, such as water and soil, and has helped to mitigate the effects of climate change. His study concurred that agroforestry had a significant impact on environmental protection.

Also, findings are in agreement with (Kamanga et al., 2018) who stated that despite its benefits, agroforestry faces challenges and limitations in its widespread adoption. These include limited farmer knowledge and awareness, insufficient policy support, and potential trade-offs between agricultural productivity and environmental goals.

### **Conclusions**

The results demonstrate the widespread use of agroforestry techniques and point to their beneficial effects on biodiversity and soil health. Findings also show that farmers have adopted agroforestry practices, which entail intercropping crops with trees on their land. Farmers who have not noticed improvements in soil quality may require advice on the best agroforestry techniques to use on their land in order to maximize the benefits. Additionally, the majority of respondents had trouble obtaining finance and financing, suggesting that financial obstacles are preventing the widespread adoption of agroforestry practices. This emphasizes the requirement for policymakers and financial institutions to investigate cutting-edge strategies to aid farmers in investing in agroforestry's 15 (Life on land) is directly related to the sustainable land management practice known as agroforestry. This objective is focused on the preservation, restoration, and sustainable use of terrestrial ecosystems. To ensure that all farmers get profits from agroforestry, more education is necessary. The hypothesis Ho1: agroforestry has no effect on environmental protection in Kabale district, Uganda was rejected and concluded that agroforestry has a significant effect on environmental protection.

### **Recommendations**

The government, private sector and research institutions such as National Agricultural Research Organization (NARO) should conduct further research. Further research and data collection specifically focused on the effect of agroforestry

practices on environmental protection in Rubaya, Butanda, Kitumba, and Kamuganguzi Sub counties in Kabale district is needed. This will provide local context and insights into the effectiveness of these practices in the study area.

The department of Agriculture and Natural Resources at the district and Subcounty levels should promote awareness and education through field visits and talks over the local radios. Given the mixed responses regarding the impact of agroforestry on soil quality, it is important to provide farmers with information and education about the benefits of agroforestry practices. This can help address any misconceptions and increase awareness about the positive effects on soil health.

Efforts should be made by the government, NGOs and financial institutions to facilitate access to credit and financing options specifically tailored for agroforestry initiatives. Collaboration with local stakeholders, including NGOs and financial institutions, can help develop innovative financing mechanisms. The farmers need to be supported with funds in their saving groups under their farmer field schools to enable them afford agroforestry practices and to help them get money to buy agroforestry seeds and seedlings to plant on their land.

The government and the private sector should Strengthen Extension services to provide technical assistance, training, and ongoing support to farmers interested in adopting agroforestry. This can enhance their understanding of agroforestry techniques and help address any implementation challenges. Continued research and education are crucial for the scaling up of agroforestry practices this can be achieved through the agriculture extension officers and NGOs field officers working on certain community projects.

Collaboration between government agencies, NGOs, research institutions, and local communities is essential to support the adoption and expansion of agroforestry practices. This collaboration can facilitate knowledge sharing, provide resources, and create a supportive environment for farmers to engage in agroforestry. Through conducting meetings and workshops these stakeholders can share on how to promote the adoption of these practices.

Policymakers should be encouraged to develop and implement policies that promote agroforestry as a nature-based solution to environmental challenges. Supportive policies can include incentives for farmers, regulations to protect agroforestry systems from destruction by animals and theft, and integration of agroforestry into agricultural and environmental strategies. To assess the effectiveness of agroforestry in environmental protection, it is important for the governmental bodies, private sector organizations, and research institutions to establish monitoring and evaluation systems. Long-term studies can track the impact of agroforestry on soil quality, biodiversity, carbon sequestration, and other environmental indicators. This information can inform decision-making, support policy development, and guide future interventions and more so the existing Village Natural Resources Management committees (VNRMCs) should be supported by the government and private sector to effectively monitor and report on agroforestry systems.

Sustain and expand support from NGOs: NGOs, such as the African International Christian Ministry and Nature Uganda mentioned in the findings, have played a role in supporting farmers with agroforestry seeds, seedlings and training. Efforts should be made to sustain and expand such support, ensuring continuity and long-term engagement to further promote the adoption of agroforestry practices.

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By implementing these recommendations, stakeholders can contribute to the broader adoption of agroforestry practices, enhance environmental protection, and support sustainable agricultural practices in Kabale district and beyond.

#### **Contribution of the Study to Knowledge**

The study reveals a significant policy gap in sub-counties like Kitumba and Kamuganguzi, where community bylaws dedicated to soil and water conservation are lacking. The absence of specific regulations limits the ability to enforce sustainable land management practices including the planting of agroforestry and hinders efforts to protect soil health and water resources. This contributes to the body of knowledge by recognizing the need for comprehensive policies that cover various aspects of environmental conservation, including soil and water management.

The study provides empirical evidence regarding the relationship between sustainable land management practices and environmental protection. By conducting quantitative analysis and regression modeling, the study demonstrates the positive association between factors such as agroforestry with environmental protection. These findings contribute to the existing body of knowledge by adding empirical support to the understanding of the relationship between sustainable land management practices and environmental outcomes.

The study is conducted in a specific context, which allows for a deeper understanding of the relationship between agroforestry practices and environmental protection within that context. The findings shed light on the specific challenges and opportunities related to sustainable land management practices in the study area. This contextual understanding is valuable for researchers, policymakers, and practitioners working in similar contexts, as it provides insights into the specific factors influencing environmental protection in that particular region.

The study combines both qualitative and quantitative data to provide a comprehensive understanding of the research topic. The qualitative data gathered through interviews with key stakeholders complement the quantitative findings and add depth and context to the analysis. This integration of different types of data enhances the richness of the study and contributes to a more holistic understanding of the relationship between sustainable land management practices and environmental protection.

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