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The effect of crop rotation on environmental protection in Kabale district, Uganda

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Abstract: *This study investigates the impact of crop rotation practices on environmental protection within Kabale district, Uganda. The research explores how rotating crops can contribute to achieving Sustainable Development Goals (SDGs) related to poverty reduction, food security, good health, clean water, climate action, and life on land. By analyzing the environmental benefits of crop rotation, the study aims to highlight its potential for promoting sustainable agricultural practices in the region.*

Keywords: Crop rotation, Environmental Protection

Background

Crop rotation, the practice of planting different crops in the same field over a sequence of seasons, boasts a rich history dating back to ancient civilizations. While its initial focus might have been on maintaining crop yields, its impact on environmental protection has become increasingly recognized. Here's a look at the historical development and environmental benefits of crop rotation.

Evidence suggests crop rotation practices were employed in Mesopotamia, Egypt, and China as early as 4000 BC. These early farmers likely observed the negative effects of continuous monoculture (planting the same crop repeatedly) and intuitively adopted crop rotation to maintain soil fertility. The scientific basis for crop rotation began to be understood in the 18th century. Agricultural pioneers like Charles Townshend in Britain popularized scientific crop rotation methods that addressed specific nutrient needs of different crops.
Today, crop rotation remains a cornerstone of sustainable agricultural practices. With growing concerns about environmental degradation, its role in protecting the environment has become even more crucial.

Kabale district in Uganda faces several environmental challenges, including soil erosion, nutrient depletion, and water pollution. These issues can be exacerbated by traditional farming practices that rely on continuous cultivation of the same crops. Crop rotation, however, offers a promising approach to address these concerns and promote environmental protection. Rotating crops disrupts pest and disease cycles that thrive on monoculture systems. This allows for the introduction of nitrogen-fixing legumes, which replenish soil fertility and reduce dependence on synthetic fertilizers. A more diverse cropping system creates a more varied landscape, providing habitat for beneficial insects, pollinators (bees, butterflies) and other wildlife. This fosters a healthy ecosystem that promotes natural pest control and enhances pollination, leading to improved crop yields.

Research Design

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.

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 (SLM 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 individuals who were actively participating and affected by crop rotation practices.

Sample Size

The sample size of the study was 347 respondents that was determined by the Slovene's formula but out of these, 280 received, responded and returned the questionnaire to the respondents.

Sampling Techniques

Simple random sampling was used to select 347 respondents to respond to the questionnaire and purposive sampling was used to select 25 key informants to respond to the interview guide.

Research instruments

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

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.

$$CVI = \frac{\text{no of items declared valid}}{\text{total no of items}} = \frac{6}{8} = 0.75$$

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 0.890. 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 crop rotation was 0.717 (number of items were 6), 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).

Findings

Crop Rotation and Environmental Protection in Kabale district, Uganda

Table 1: Responses to Crop Rotation items.

Opinion Statements	SA	A	NS	D	SD	M	Std. Dev
I use recommended types of crops on my land	139(49.6%)	141(50.4%)	0(0%)	0(0%)	0(0%)	4.50	0.501
I rotate crops to balance soil nutrient levels and prevent nutrient depletion	114(40.7%)	163(52.8%)	1(0.4%)	2(0.7%)	0(0%)	4.39	0.537
I grow crops which are rich in nutrients	31(11.1%)	117(41.8%)	23(8.2%)	109(38.9%)	0(0%)	3.25	1.092
I have noticed a reduction in soil borne diseases on my crops due to crop rotation practices	1(0.4%)	140(50%)	0(0%)	139(49.6%)	0(0%)	3.01	1.007
I rotate crops to reduce the risk of crop failure and ensure a stable income	133(47.5%)	146(52.1%)	0(0%)	1(0.4%)	0(0%)	4.47	0.521
I consult with agricultural experts and other farmers to develop an effective crop rotation plan	116(41.4%)	139(49.6%)	0(0%)	1(0.4%)	24(8.6%)	4.15	1.087

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

According to the findings in the data in Table 1, for the statement "I use recommended types of crops on my land," the majority of respondents 139 (49.6%) strongly agreed, while 141(50.4%) agreed. This indicates that the majority of farmers are following the recommended crop types for their land.

For the statement "I rotate crops to balance soil nutrient levels and prevent nutrient depletion,"163(52.8%) of respondents agreed, while 114(40.7%) strongly agreed,1(0.4%) was not sure and 2(0.7%) disagreed. This indicates that a significant number of farmers in Kabale District, Uganda, are aware of the importance of crop rotation and actively implement it in their farming practices to maintain soil health. Similarly, a minimal number of respondents, 2 individuals (0.7%), disagreed with the statement, indicating that they do not rotate crops for soil nutrient balance and nutrient depletion prevention.

For the statement "I grow crops which are rich in nutrients," only 31(11.1%) of respondents strongly agreed, while 117(41.8%) agreed, A significant proportion 109(38.9%) of respondents disagreed with the statement, implying that they might not prioritize nutrient content in the crops they cultivate or might not be actively selecting crops based on their nutrient profile and a small percentage of 23(8.2%) respondents were uncertain, indicating a lack of awareness or knowledge about the nutrient content of the crops they grow.

. This suggests that a majority of farmers are aware of the importance of nutrient-rich crops. The agreement indicates that farmers are taking proactive measures to manage their soils sustainably. By implementing crop rotation, they are adopting a soil conservation practice that can contribute to long-term agricultural productivity and reduce the need for excessive fertilizers and synthetic inputs.

For the statement "I have noticed a reduction in soil borne diseases on my crops due to crop rotation practices," only 1(0.4%) of respondents strongly agreed, while 140(50%) agreed and 139(49.6%) disagreed. This indicates that crop rotation practices have been effective in reducing soil-borne diseases. The disagreement from 49.6% of the respondents suggests that a significant proportion of farmers do not perceive a reduction in soil-borne diseases on their crops as a result of crop rotation practices. This indicates that they may not have observed tangible benefits or may not attribute disease reduction to crop rotation.

For the statement "I rotate crops to reduce the risk of crop failure and ensure a stable income,"133(47.5%) of respondents strongly agreed, while 146(52.1%) agreed and 1(0.4%) disagreed. This indicates that crop rotation is being used by a majority of farmers as a risk management strategy.

The statement "I consult with agricultural experts and other farmers to develop an effective crop rotation plan," 116(41.4%) of respondents strongly agreed, while 139(49.6%) agreed and a very small percentage of 1(0.4%) and 24(8.6% of respondents disagreed and strongly disagreed respectively with the idea of consulting with experts and peers for crop rotation planning. These respondents might prefer relying solely on their own knowledge and experience or have other reasons for not seeking outside advice. The high agreement, with 90.9% of respondents either strongly agreeing or agreeing, suggests that farmers in Kabale District, Uganda, recognize the importance of seeking advice and expertise from agricultural experts and fellow farmers. This indicates a willingness to learn and improve their crop rotation practices.

"I use recommended types of crops on my land" (M = 4.50, Std. Dev = 0.501): The participants, on average, show a high level of agreement (SA) in using recommended types of crops on their land. The responses are relatively consistent or clustered around the mean.

"I rotate crops to balance soil nutrient levels and prevent nutrient depletion" (M = 4.39, Std. Dev = 0.537): The participants, on average, show a positive attitude (A) towards rotating crops to balance soil nutrient levels and prevent nutrient depletion. The standard deviation suggests a moderate level of variation or diversity in the responses.

"I grow crops which are rich in nutrients" (M = 3.25, Std. Dev = 1.092): The mean suggests a neutral response (NS), indicating mixed opinions regarding growing crops rich in nutrients. The higher standard deviation indicates a wide range of responses, with some participants strongly agreeing and others strongly disagreeing.

"I have noticed a reduction in soil borne diseases on my crops due to crop rotation practices" (M = 3.01, Std. Dev = 1.007): The mean suggests a relatively lower level of agreement (NS) in noticing a reduction in soil-borne diseases due to crop rotation practices. The standard deviation indicates a diverse range of responses, with significant variability among participants.

"I rotate crops to reduce the risk of crop failure and ensure a stable income" (M = 4.47, Std. Dev = 0.521): The participants, on average, strongly agree (SA) that they rotate crops to reduce the risk of crop failure and ensure a stable income. The standard deviation suggests a moderate level of agreement among the participants.

"I consult with agricultural experts and other farmers to develop an effective crop rotation plan" (M = 4.15, Std. Dev = 1.087): The mean indicates a moderate level of agreement (A) in consulting with agricultural experts and other farmers to develop an effective crop rotation plan. The standard deviation suggests a wide range of responses, with considerable variation among participants.

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

Overall, the data suggests that many farmers are aware of the importance of crop rotation and the use of recommended crop types for their land. Consultation with agricultural experts and other farmers is also a common practice. However, more effort may be needed to encourage the use of nutrient-rich crops and to promote the benefits of crop rotation practices in reducing soil-borne diseases.

Table 2: Regression Analysis results on Crop Rotation and Environmental Protection showing the Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.614[a]	.377	.375	2.768

a. Predictors: (Constant), Crop rotation

Table 3: Regression results for the ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	1288.378	1	1288.378	168.140	.000[b]
	Residual	2130.189	278	7.663		
	Total	3418.568	279			

a. Dependent Variable: Environmental protection

b. Predictors: (Constant), Crop rotation

Table 4: Regression results between Crop Rotation and Environmental protection showing the Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	10.983	1.230		8.929	.000
	Crop rotation	.665	.051	.614	12.967	.000

a. Dependent Variable: Environmental protection

Table 2 shows a regression analysis where the dependent variable is "Environmental protection" and the independent variable is "Crop rotation". The model summary shows that the regression model accounts for 37.7% of the variance in the dependent variable, as indicated by the R-squared value.

The ANOVA table 3 shows that the regression model is significant, with a large F-value of 168.140 and a very small p-value of .000, indicating that the association between crop rotation and environmental protection is unlikely to be due to chance.

The coefficients table 4 shows that the intercept is 10.983, which is the predicted value of the dependent variable when the predictor variable is zero. The coefficient for "Crop rotation" is .665, which means that for every one-unit increase in crop rotation, there is an average increase of .665 units in environmental protection, after controlling for the effects of other variables in the model.

$Y=10.983+0.665X$

Where Y is Environmental protection and X and is crop rotation

The intercept term is 10.983. It represents the predicted value of the dependent variable (environmental protection) when the predictor variable (crop rotation) is zero. In this case, it suggests that even in the absence of crop rotation (X=0), there is a baseline level of environmental protection, which is approximately 10.983 units.

Coefficient for crop rotation: The coefficient for crop rotation is 0.665. This coefficient represents the average change in the dependent variable (environmental protection) for every one-unit increase in crop rotation, while holding other variables constant. In this case, for every one-unit increase in crop rotation (X), there is an average increase of 0.665 units in environmental protection (Y). This suggests a positive relationship between crop rotation and environmental protection.

In summary, the analysis suggests that crop rotation is a significant predictor of environmental protection, with higher levels of crop rotation associated with higher levels of environmental protection.

Therefore, the null hypothesis that stated that crop rotation has no significant influence on environmental protection is rejected. These findings are in agreement with the theory of change.

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

‘‘*Many farmers are implementing good agricultural practices such as using recommended crop types, rotating crops, and seeking advice from experts and other farmers. This is a positive sign for sustainable agriculture and can lead to healthier soil, better yields, and stable incomes.*

It is encouraging to see that a majority of farmers are aware of the importance of nutrient- rich crops, but the low percentage of respondents agree that there is room for improvement in this area. Encouraging farmers to grow

nutrient-rich crops can not only benefit their own health and income but also contribute to better nutrition and food security for the wider population. Overall, the many farmers are implementing good agricultural practices and seeking advice from experts and other farmers. However, there is always room for improvement, and efforts should continue to promote the importance of nutrient-rich crops and the benefits of sustainable farming practices such as crop rotation.''

Also, the District Natural Resources Officer who was one of the Key informants said this in relation to the effect of crop rotation on environmental protection in Kabale district:

''As a district natural resources officer, I am pleased to see that many farmers are implementing good agricultural practices such as using recommended crop types, rotating crops, and seeking advice from experts and other farmers. These practices are essential for sustainable agriculture and can lead to healthier soil, better yields, and stable incomes for farmers.

It is also encouraging to see that a majority of farmers are aware of the importance of nutrient-rich crops. However, there is still room for improvement in this area. Encouraging farmers to grow nutrient-rich crops can not only benefit their own health and income but also contribute to better nutrition and food security for the wider population.

As a key informant, I would encourage farmers to continue seeking advice and collaborating with experts and other farmers to optimize their practices. It is also important to continue promoting the benefits of sustainable farming practices such as crop rotation to reduce soil-borne diseases and ensure a stable income''.

One of the sub county chiefs said that:

''As a sub county chief,

'I am pleased to see that many farmers in our community are implementing good agricultural practices such as using recommended crop types, rotating crops, and seeking advice from experts and other farmers. These practices are crucial for sustainable agriculture and can lead to healthier soil, better yields, and stable incomes for farmers.

It is encouraging to see that a majority of farmers are aware of the importance of nutrient-rich crops, but it is clear that there is room for improvement in this area. Encouraging farmers to grow nutrient-rich crops can not only benefit their own health and income but also contribute to better nutrition and food security for the wider population.

As a key informant, I would encourage farmers to continue implementing good agricultural practices and seeking advice from experts and other farmers to optimize their practices. Additionally, efforts should be made to promote the importance of nutrient-rich crops and sustainable farming practices such as crop rotation to reduce soil-borne diseases and ensure a stable income''

Conclusion.

According to the findings, a sizable portion of farmers understand the value of crop rotation, choose crop varieties that are suggested for their soil, and engage with experts and other farmers to optimize their crop rotation programmes. The results also show that although while crop rotation practices are widely used, more efforts should concentrate on promoting nutrient-rich crops and increasing public awareness of the benefits of crop rotation. Overall, the findings suggest that promoting crop rotation and other sustainable farming practices can lead to improved environmental protection and sustainable agriculture in Kabale district of Uganda. Encouraging farmers to grow nutrient-rich crops and seek advice from experts and other farmers can not only benefit their own health and income but also contribute to better nutrition and food security for the wider population. The hypothesis Ho2: Crop rotation has no significant influence on Environmental Protection in Kabale district, Uganda was rejected and concluded that crop rotation has a significant effect on environmental protection.

Recommendations

The government should promote awareness and adoption of nutrient-rich crops. Despite a majority of farmers expressing awareness of the importance of nutrient-rich crops, the percentage of respondents who agreed was relatively low. Efforts should be made to educate farmers about the benefits of growing nutrient-rich crops, both for their own health and income and for improving nutrition and food security in the wider population. Training programs, workshops, and extension services can play a crucial role in promoting the adoption of nutrient-rich crops.

The Agricultural extension officers should enhance the understanding of crop rotation practices. The findings indicate that a significant number of farmers are already implementing crop rotation practices. However, to further encourage the adoption of this practice, it is essential to provide farmers with comprehensive information about the benefits of crop rotation, such as improved soil health, reduced soil-borne diseases, and stable income. Agricultural extension services, farmer field schools, and peer-to-peer knowledge sharing platforms can be utilized to educate farmers about effective crop rotation techniques.

The government and Non-Governmental Organizations Should Strengthen collaboration and knowledge-sharing platforms such as farmer field schools. The findings show that farmers are already consulting with agricultural experts and other farmers with in their farmer field schools to develop effective crop rotation plans. This collaborative approach should be encouraged and further strengthened. Creating platforms for farmers to share their experiences, knowledge, and best practices can foster innovation and continuous improvement in sustainable farming practices. Local agricultural organizations, community-based organizations, and farmer cooperatives can play a role in facilitating such knowledge-sharing initiatives.

The Government and relevant stakeholders should recognize the importance of sustainable farming practices, including crop rotation, and provide policy support. This can include incentives, subsidies, and favorable regulations that promote the adoption of recommended crop types, crop rotation, and the use of nutrient-rich crops. Policy frameworks that prioritize environmental protection and sustainable agriculture can create a conducive environment for farmers to adopt and sustain these practices.

Researchers should conduct further research and monitoring. Continuous research and monitoring are necessary to understand the long-term impacts and identify any challenges or barriers. Further studies can explore the specific mechanisms through which crop rotation contributes to environmental protection and quantify the benefits in terms of soil health, biodiversity, and ecosystem services. Such research can provide additional evidence and insights to support future interventions and policy decisions.

By implementing these recommendations, it is possible to further enhance sustainable agricultural practices, promote environmental protection, and contribute to the well-being of farmers, communities, and ecosystems in Kabale district and beyond.

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