International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

The Factors Affecting the Adoption of Ecological-Based Adaptation (EbA) Practices Among Smallholder Farmers Adjacent to Lake Nakivale Isingiro District, Southwestern Uganda

Joseph Mwesigye[1], Rebecca Kalibwani[2], Doreen Atwongyeire[3]

[1,2,3]Faculty of Agriculture, Environmental Sciences and Technology, Bishop Stuart University P.O Box 9, Mbarara

Abstract

This study aimed to establish factors affecting the adoption of Ecological-Based Adaptation (EbA) practices among smallholder farmers Adjacent to Lake Nakivale Isingiro District, southwestern Uganda. The study employed a cross-sectional study design. A sample size of 322 was selected both randomly and purposively from a total population of 1085. Both questionnaires and interview guides were used to collect data from farmers and key informants (extension service providers and political leaders). The data collected was analyzed using Ms Excel version 2016 and Statistical Package for Social Scientists (SPSS) for descriptive and inferential statistics. The study findings revealed that access to credit, education, and institutional support is essential for farmers towards adoption of EbA practices like agroforestry and crop diversification. The study also highlights challenges faced by Lake Nakivale communities, including; low incomes and severe food insecurity, necessitating urgent interventions to improve food security and adapt to environmental changes. The study recommends the need for local governments and development partners to educate both farmers and policymakers about the benefits of Ecological-Based Adaptation (EbA) practices.

Keywords: factors, adoption, EbA practices, small holder farmers

Introduction

Ecological-Based Adaptation (EbA) practices are a set of strategies and approaches designed to help communities and ecosystems adapt to the challenges posed by climate change while also promoting environmental sustainability. In agricultural systems, EbA refers to the integration of agricultural management techniques that leverage biodiversity, ecological mechanisms, or ecosystem services (whether at the plot, farm, or landscape scale) to enhance the resilience of crops or livestock against climate fluctuations. Practices centered on ecosystem-based adaptation can enhance crop yields while concurrently addressing climate challenges (Kissi et al., 2023). Ecological-Based Adaptation (EbA) practices are a set of strategies and approaches designed to help communities and ecosystems adapt to the challenges posed by climate change while also promoting environmental sustainability. In agricultural systems, EbA refers to the integration of agricultural management techniques that leverage biodiversity, ecological mechanisms, or ecosystem services (whether at the plot, farm, or landscape scale) to enhance

the resilience of crops or livestock against climate fluctuations. According to (Kissi et al., 2023; Kurniawati, 2017) various agricultural methods revolve around the stewardship of ecosystem services and biodiversity. Some examples of EbA techniques encompass employing agroforestry to mitigate soil degradation, erosion, and shield land from the effects of floods, extreme temperatures, and other climatic influences on both livestock and crops (Kissi et al., 2023).

According to (Barman et al., 2022), employing strategies such as crop diversification, intercropping, and crop rotation within agricultural fields, along with soil conservation methods to combat erosion and preserve soil fertility amidst heavy rainfall, and water-saving techniques like direct seeded rice cultivation are highlighted. As a critical and irreplaceable resource, soil offers vital sustenance to ecosystem services, human existence, and societal well-being. As observed by Barman et al., (2022), diversification of crops through the intercropping system has a significant advantage in land use efficiency, monetary returns and crop productivity as compared to mono-cropping. It has also been evidenced by the same authors that intercropping results in more efficient use of solar energy and harnessing benefits of positive interactions of crop association.

Uganda, predominantly reliant on agriculture, is home to a vast majority of small-scale farmers who often lack the means and capabilities to access advanced adaptation options such as technological advancements and improved seed varieties (Devis, 2023; Zizinga et al., 2022). Hence, EbA practices have emerged as crucial and cost-effective adaptation strategies at the farm level. These farmers primarily depend on community-led sources for agricultural information and extension services, followed by support from public and private institutions (Zizinga et al., 2021).

The social connections among farmers play a pivotal role in facilitating climate change adaptation through the sharing of adaptation experiences (Scott & Richardson, 2021), particularly significant in contexts like Uganda where formal institutional access is limited (Aturihaihi et al., 2023). Despite the acknowledged importance of governmental institutions and social networks, there is a notable absence of efforts to explore the correlation between farmers' social capital, institutional access, and the adoption of individual and multiple EbA practices. Recognizing this gap, it was necessary to conduct a study to comprehend existing EbA practices among farmers and the determinants influencing their adaptation decisions among smallholder farmers Adjacent to Lake Nakivale Isingiro District, southwestern Uganda.

Study objective

To establish the factors affecting the adoption of EbA practices among smallholder farmers living adjacent to Lake Nakivale in southwestern Uganda

Rationale

The farming communities residing adjacent to Lake Nakivale in Isingiro district face significant challenges, including climate change impacts, resource depletion, and economic constraints (Bintoora, 2013). Despite the potential benefits of ecosystem-based adaptation (EbA) practices, such as sustainable water and soil management and agroforestry, which enhance agricultural productivity, reduce vulnerability to climate change, increase income and food security, and promote the sustainable use of natural resources, adoption rates remain low among farmers in the area (UNHCR Uganda, 2020). This gap between the expected livelihood improvement through EbA adoption and the current reality underscores a critical research gap. Understanding the reasons for this discrepancy was crucial for developing targeted interventions and policies to bridge the divide and address the challenges these

vulnerable communities face. Thus a study was done to assess the factors influencing the adoption of EbA practices among smallholder farmers Adjacent to Lake Nakivale Isingiro District, southwestern Uganda

Methods

Data collection

The study employed a cross-sectional study design. A sample size of 322 was selected both randomly and purposively from a total population of 1085. Both questionnaires and interview guides were used to collect data from farmers and key informants (extension service providers and political leaders). The questionnaire included concise and targeted details regarding household demographics (such as age, sex, and educational level), economic status (income, land holdings), institutional attributes (availability of credit, involvement in extension programs, participation in climate resilience workshops, and affiliation with community organizations). In addition, quantitative data gathered from farmers included their familiarity with Ecological-based adaptation techniques, information channels utilized, methods of knowledge dissemination within and across villages, prevalent agricultural practices, rationales behind their adoption, and the effectiveness of selected practices in enhancing productivity and climate resilience. Initially the questions were formulated in English, and later translated into local languages to ensure clarity and comprehension among respondents. This method allowed a selected number of farmers to answer questions related to the study phenomenon in the language they understood better.

However, the researcher and the research assistants also made farm visits of the selected smallholder farmers for identification and presence of EbA practices such as the presence of agroforestry on bared land, mulching, home gardens, soil and water conservation structures, to compliment and validate the information obtained during the face-to-face interviews. The field survey also helped in taking information on how farmers implement EbA practices on their farms.

Ethical considerations

The research sought clearance from Bishop Stuart University Research Ethics Committee (BSU-REC) which was granted (BSU-REC-2024-330). Before embarking on data collection, informed consent was obtained from each respondent. At the onset of data collection, the researcher obtained permission from the Refugee Desk officer (RDO) to conduct the study in the area The researcher ensured that every respondent was explained to, about his or her rights and assured confidentiality and anonymity. The likely risks and potential benefits were also explained to them. It was also made clear to the respondents that their participation was voluntary. Other people's works have been acknowledged through citations and references.

Findings

Table 1: Socio-economic characteristics of farmers

Socio-economic characteristics of farmers		Frequency (F)	Percentage (%)
Gender of Respondent	Male	175	54.3%
	Female	147	45.7%
Age of Respondents	>18	24	7.5%
	19-28	74	23.0%
	29-38	107	33.2%
	39 and Above	117	36.3%

Marital Status of Respondent	Married	223	69.3%
	Single	80	24.8%
	Divorced	11	3.4%
	Widowed	8	2.5%
Number of household members	1-3	30	9.3%
	4-6	127	39.4%
	7-9	107	33.2%
	10 and above	58	18.0%
Level of Education	No Education	22	6.8%
	Primary	83	25.8%
	Secondary	104	32.3%
	Tertiary	113	35.1%
Main source of income	Farming	252	78.3%
	Civil Service	22	6.8%
	Business	44	13.7%
	Transport	4	1.2%
Type of crops grown	Maize	69	21.4%
	Beans	136	42.2%
	Bananas	99	30.7%
	Others	18	5.6%
Types of Animals Reared	Cattle	65	20.2%
	Goat and Sheep	83	25.8%
	Poultry	112	34.8%
	Others	62	19.3%
How did you acquire land	Inheritance	75	23.3%
	Purchase	208	64.6%
	Renting	39	12.1%

The gender distribution was important for analyzing the perspectives and experiences captured in the study. It helps identify any potential gender-specific patterns or disparities in the responses. The results indicated the majority of respondents 54.3% were Male while 45.7% were Female. This showed that the study had more male farmers than female counterparts. The study results imply that males have more access to agricultural extension services or maybe more involved in decision-making related to farming practices. This could affect the adoption practices if women, who may have less access to resources or decision-making power, are less likely to learn about or invest in this technology compared to men. The male-headed households were the majority because they are mainly the people responsible for managing farm activities.

Understanding the age distribution of respondents is crucial for analyzing how different age groups perceive and engage with ecological-based adaptation (EbA) practices and livelihoods. According the findings, 7.5% were below 18 years, 23% between 19-28 years, 33.2% were between 29-38 years. The majority of respondents were aged 39 and above, considered to be within the economically active age

group capable of undertaking ecological-based adaptation practices. This indicated that they had mostly been active in agricultural production

The study results revealed that majority of the respondents constituting to 69.25% were married, followed by 24.84% that were single, 3.416% were divorced and 2.484% widowed. The study results implied that marital status affects decision-making dynamics within the household. For example, if one spouse is more supportive of adopting ecological-based practices while the other is not, this could influence whether or not the practice is adopted on the farm.

The researcher was also interested to know the number of household members which can help gain insights into the varied contexts in which ecological-based adaptation (EbA) practices are implemented and the study revealed that majority 127(39.4%) had between 4-6, followed by 107(33.2%) with 7-9, followed by 58(18.0%) with 10 and above while the least 30(9.3%) with between 1-3 household members.

Education determines a smallholder farmers' ability to obtain, interpret and apply information to their day-to-day farming activities. Wood et al. (2014) study findings argued that farmers' education level is directly related to their economic development and directly determines a farming household's access to information services and corresponding responds to that information. Regarding level of education, majority of the respondents 104(32.3%) had completed secondary level, followed by 113(35.1%) who completed tertiary level, 83(25.8%) completed primary level while 22(6.8%) had never attended school. Considering the level of education is important because it helps farmers learn about new technologies from extension services and agriculture-focused NGOs. Farmers with higher levels of education might be more interested in seeking information about innovative techniques like EbA practices. They can better understand the benefits and apply these practices effectively on their farms.

The study sought to establish main occupation of household members in order to determine the source of income and According to the findings, majority 78.3% said that they get income from farming (cattle rearing, growing beans, growing maize and Matooke), 14.9% revealed business (Shops, house for rent, bars) and 6.8% revealed civil service and 1.2% revealed Transport as a source of employment as shown in table 2 above.

Land acquisition was also a crucial factor influencing agricultural practices and land management among smallholder farmers. Understanding the methods through which farmers obtain their land can provide insights into their capacity for sustainable practices, particularly in relation to Ecosystem-based Adaptation (EbA) practices and their impact on livelihoods. According to study results, majority of respondents 64.6 % revealed that the land they use was purchased, 28.3% revealed that the land they use was inherited from their parents and relatives while few 12.1% respondents revealed that the land they use is always rented.

The study also aimed to ascertain the types of crops grown by the respondents, and the findings revealed that majority 42.24% said that they grow beans, followed by 30.75% who grow Bananas, 21.43% revealed Maize while 5.59% revealed Others (Cassava, Sweet Potatoes, Groundnuts, Millet, Irish Potatoes among others)

About the types of animals reared by the respondents, findings revealed a variety of livestock farming practices among the people surveyed. It indicated the highest percentage of respondents, 112 (34.8%), are engaged in poultry farming, followed by a total of 83 respondents (25.8%) are involved in rearing goats and sheep, 65 respondents (20.2%) reported rearing cattle while 62 respondents (19.3%) mentioned rearing other types of animals, which could include a variety of species such as pigs, rabbits. This balanced mix of livestock rearing highlights the adaptive strategies employed by these farmers. The diversity in

livestock types indicates that farmers are already using varied methods to enhance their resilience economic challenge.

The researcher was eager to know the size of land and the responses are revealed in the following table:

Table 2: Descriptive Statistics on the size of land

Category	n	Minimum	Maximum	Mean	Std. Deviation
Farm size in acres	322	1.13	21.0	2.154	4.2365
Valid N (listwise)	322				

The size of the farm was considered for its influence on Ecological-Based adaptation practices on livelihoods, besides it is an important factor of production. Average land size under farming was 2.154 acres with a minimum holder having an acre and the largest being 21 acres. The average farm size of 2.154 hectares reinforces the fact that the majority of famers operated within smaller land holdings due to population pressure in the study area. The study results showed that bigger farms usually have more access to resources like labor and money. They also grow a wider variety of crops and produce more. Because of this, larger farms are more likely to use advanced technologies, such as ecological-based adaptation practices. They can spread the initial costs over a larger area, which can make it cheaper overall. In contrast, smaller farms have fewer resources and find it harder to adopt new technologies due to higher costs per unit.

4.4 Factors affecting the adoption of EbA practices among smallholder farmers

First and foremost, respondents were asked to mention whether there is any challenge preventing farmers from adopting ecological-based adaptation practices and their responses were captured and presented in the following below:

Table 3: Are there any challenges preventing you from adopting ecological-based adaptation practices

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	300	93.2	93.2	93.2
	No	22	6.8	6.8	100.0
	Total	322	100.0	100.0	

The study findings in the table revealed that the majority of the respondents 300(93.2%) had challenges that are preventing them from adopting ecological-based adaptation practices unlike the least number constituting to 22(6.8%) who disagreed with the statement.

Respondents were again asked to mention the sources of information farmers rely on learning about EbA practices, responses were captured and presented in graph below:

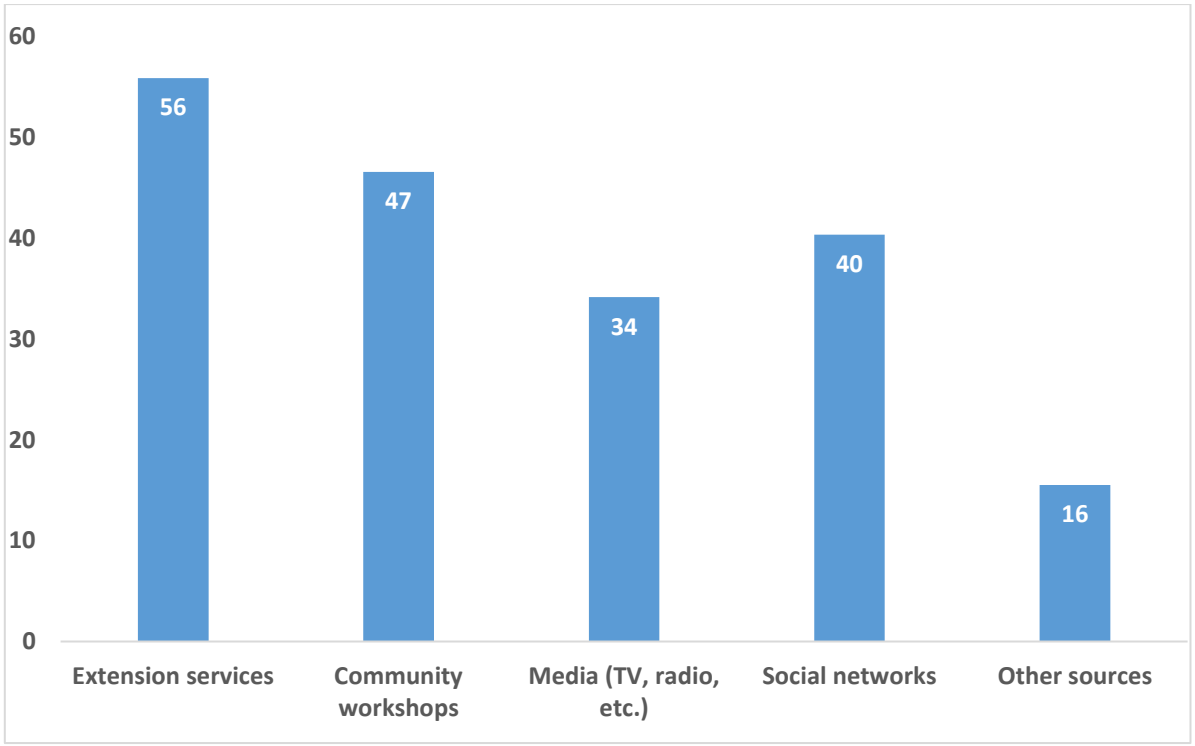

Figure 2: A graph showing sources of information farmers rely on learning about EbA practices

From the study findings, it was revealed that 56% rely on extension services provided by agricultural experts and government agencies and these services offer technical advice, training, and support for implementing EbA practices. Followed by 47% who revealed community workshops and they showed that these workshops are often organized by local NGOs, community groups, or agricultural cooperatives and provide hands-on training and knowledge sharing among farmers, 34% use media sources such as TV, radio, and newspapers to learn about EbA practices, 40% rely on social networks, including farmer groups, friends, and family, to exchange information and experiences related to EbA practices while 16% mentioned other sources of information, including online resources (websites, forums), agricultural fairs, and academic institutions and the study found out that these sources provide additional insights and up-to-date information on the latest developments in ecological-based farming.

In an Interview with the Principal Agricultural Officer, Isingiro District, he said that,

"Smallholder farmers access information on Ecological-Based Adaptation (EbA) practices through a variety of channels like extension services provided by agricultural experts and government agencies and these services are vital as they offer technical advice, training, and support that are crucial for implementing EbA practices effectively" (Key Informant Interview, April, 2024).

The Principal District Agricultural Officer further noted that,

"I would like to emphasize the importance of continuous support and the need for improving these information channels. By enhancing the reach and quality of extension services, increasing the frequency and accessibility of community workshops, and leveraging media and online platforms more effectively, we can ensure that all farmers have the necessary tools and knowledge to adopt sustainable agricultural practices and improve their livelihoods" (Key Informant Interview, April, 2024.

More still, the study also revealed findings on improving awareness and knowledge about Ecological-based adaptation (EbA) Practices and the results are revealed in the following figure.

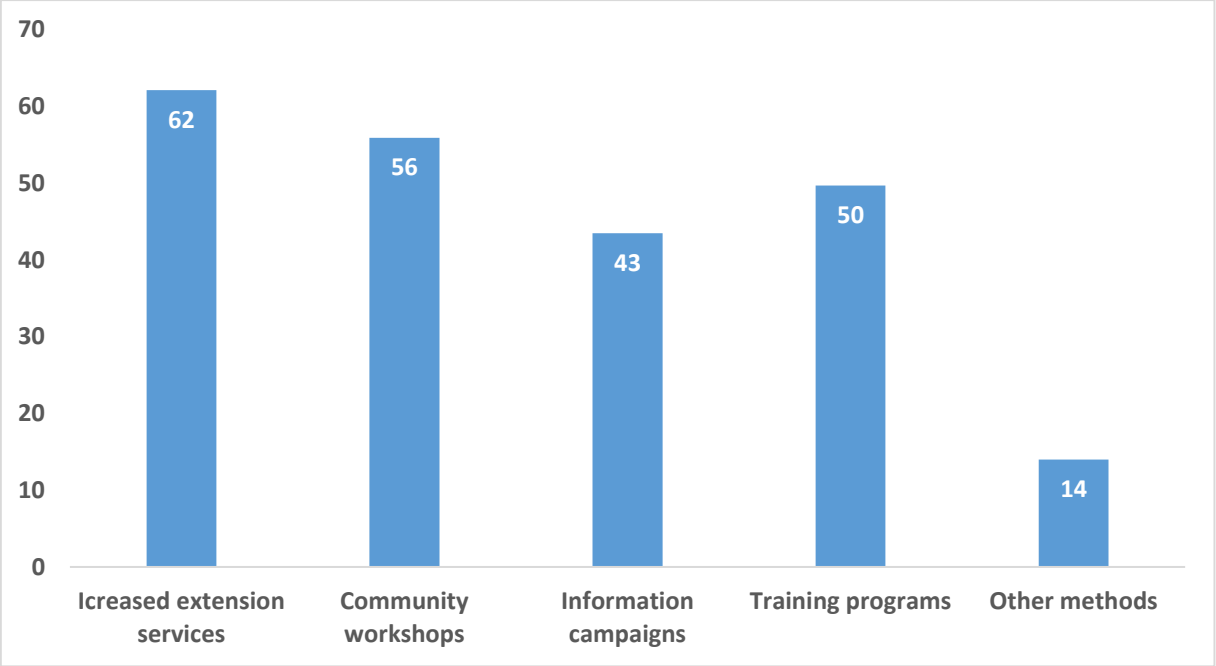

Figure 3: A graph showing how awareness and knowledge about EbA practices can be improved in the community

From the graph above, it was revealed that 62% believe that increasing extension services would significantly improve awareness and knowledge of EbA practices, 56% suggest organizing more community workshops, 43.5% recommend conducting information campaigns, 49.7% emphasize the need for more structured training programs while 14.0% mentioned other ways to improve awareness and knowledge. Suggestions include setting up demonstration farms where farmers can see EbA practices in action, creating farmer field schools for continuous learning, and involving local leaders and influencers in promoting sustainable farming practices

Respondents were asked to mention whether there is any support systems or organizations assisting in the adoption of EbA practices, responses were captured and presented in figure below:

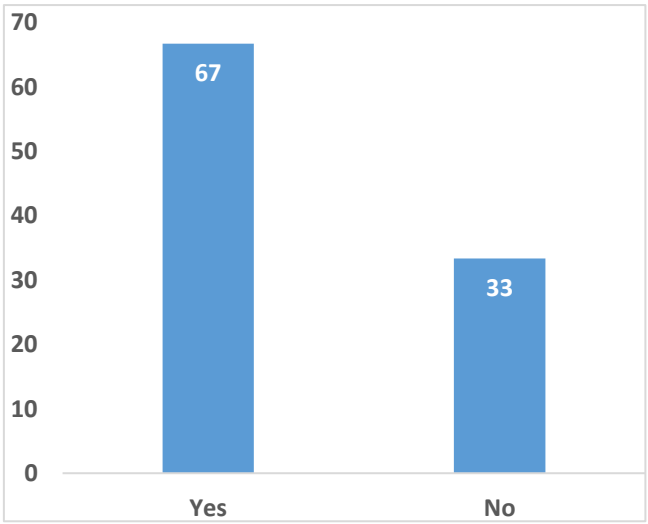

Figure 4: A graph showing if any support systems or organizations is assisting in the adoption of EbA practices

From the graph above, it was found out that 67% indicated that support systems or organizations are assisting them in adopting EbA practices while 33 indicated that they do not receive assistance from any support systems or organizations. More still, respondents were asked what type of support would encourage you to adopt more EbA practices and the results are revealed in the table below.

Table 4: Type of support would encourage you to adopt more EbA practices

Financial support	210	28
Technical assistance	190	25
Access to resources (seeds, tools, etc.	180	24
Training programs	170	23
Other forms of support	50	7

From table above, majority 28% indicated that financial support would be the most encouraging form of assistance and the study revealed that this includes grants, low-interest loans, or subsidies to help cover the costs associated with implementing EbA practices, 25% expressed a need for technical assistance and this involves receiving expert guidance on how to effectively implement and manage EbA practices, ensuring they are properly executed and sustainable, 24% stated that having better access to resources such as seeds, tools, and equipment would significantly encourage them to adopt more EbA practices, 23% emphasized the importance of training programs while 7% mentioned other forms of support that would be beneficial.

Table 5: Correlation matrix between EbA practice adoption and associated factors

	EbA practice adoption	
Factors	Chi-Square	p-value
Gender	5.790	0.023
Age	2.317	0.314
Level of education	15.215	0.005
Household size	12.048	0.001
Farming experience	5.480	0.025
Knowledge on the practices	0.519	0.471
Membership to a group	4.985	0.036
Land size	4.120	0.042
Household income	0.029	0.864
Access to extension services	5.978	0.011
Access to climate information	2.088	0.554
Access to credit services	5.878	0.015
Access to market	1.768	0.184
Institutional support	1.770	0.183
Perceived climate variability	6.588	0.010

Results in Table 5 showed the correlation matrix between EbA practice adoption and associated factors and the relationship was measured at 5% level of probability. At bivariate level, gender (x^2 = 5.790,

p=0.023), level of education (x^2 = 15.215, p=0.005), household size (x^2 = 12.048, p=0.001), farming experience (x^2 = 5.480, p=0.025), membership to a group (x^2 = 4.985, p=0.036), land size (x^2 = 4.120, p=0.042), access to extension services (x^2 = 5.978, p=0.011), access to credit services (x^2 = 5.878, p=0.015), and perceived climate variability (x^2 = 6.588, p=0.010) presented as significant factors affecting the adoption of EbA practices among smallholder farmers. Other factors like age, knowledge of the practices, household income, access to market and lack of access to market showed no association with the adoption of EbA practices.

Table 6: Results of the logistic regression model of EbA practice adoption in relation to different factors

Variable	Value	AOR (95% CI)	p-value
Gender	Male	1.962 (1.169 - 3.294)	0.034
	Female	1	
Level of education	None	0.856 (0.312 - 2.351)	0.763
	Primary	0.882 (0.422 - 1.845)	0.738
	Secondary	2.569 (1.239 - 5.327)	0.017
	Tertiary	1.441 (0.656 - 3.164)	0.363
	University	1	
Household size	1 - 3	0.947 (.289 - 3.097)	0.928
	4 – 6	1.603 (0.390 - 2.933)	0.023
	7 – 9	1.419 (.462 - 4.362)	0.541
	10 and above	1	
Farming experience	In years	2.764 (.863 - 2.153)	0.013
Membership to a group	Non-member	0.588 (0.367 - .940)	0.027
	Member	1	
Land size	In acres	1.384 (0.169 - 2.871)	0.022
Access to extension services	Yes	0.509 (.241 - 1.079)	0.078
	No	1	
Access to credit services	Yes	2.985 (1.507 - 4.782)	0.001
	No	1	
Perceived climate variability	Negative	0.360 (0.021 - 0.154)	0.034
	Positive	1	

Dependent variable: adoption of EbA practices (1-using the practices, 0- not using the practices)

- OR → Odds Ratio
- CI → Confidence Interval

Results of the logistic regression model of the factors affecting the adoption of EbA practices among smallholder farmers were presented in table 4.8. The Adjusted Odds Ratio (AOR) indicates how each

variable influenced the likelihood of adopting EbA practices, controlling for other factors. Adoption of EbA practices was used as the outcome category in the equation. Nine factors were hypothesized and only eight (8) factors remained statistically significant at multivariate level including; gender, level of education, household size, farming experience, membership to a group, land size, access to credit services, and perceived climate variability.

Gender increased the log odds of the probability of adopting of EbA practices. The results indicate that male farmers were 1.962 times more likely to adopt these practices compared to female farmers (AOR: 1.962, 95% CI: 1.169 - 3.294, p = 0.034). This finding highlights a gender disparity in the adoption of sustainable agricultural practices. Several underlying reasons could explain this disparity, such as differences in access to resources, decision-making power, and participation in agricultural training and extension services. Interventions aiming to promote EbA practices should consider gender-specific approaches to ensure equitable access and participation.

Level of education was another crucial factor influencing the adoption of EbA practices. Farmers with secondary education were significantly more likely to adopt EbA practices compared to those with university education (AOR: 2.569, 95% CI: 1.239 - 5.327, p = 0.017). Interestingly, primary education, tertiary education, and lack of formal education did not show significant effects on adoption, indicating that secondary education was the critical threshold for enabling farmers to understand and implement EbA practices effectively. This finding underscores the importance of secondary education in rural areas to enhance the adoption of sustainable agricultural practices.

Household size increased the log odds of the probability of adopting of EbA practices. Households with 4-6 members were significantly more likely to adopt these practices compared to households with 10 or more members (AOR: 1.603, 95% CI: 0.390 - 2.933, p = 0.023). Medium-sized households may have an optimal balance of labor availability and resource allocation that facilitates the adoption of new practices. Conversely, very small or very large households face labor constraints or resource dilution, respectively, hindering their ability to adopt EbA practices.

Farming experience significantly increased the likelihood of adopting EbA practices (AOR: 2.764, 95% CI: 0.863 - 2.153, p = 0.013). Experienced farmers, having faced various climatic and agricultural challenges over the years, may be more adept at recognizing the benefits of EbA practices and integrating them into their farming systems. This finding suggests that extension services and training programs should leverage the knowledge and experience of seasoned farmers to promote EbA practices.

Being a member to a group increased the log odds of the probability of adopting of EbA practices. Non-group members were significantly less likely to adopt these practices (AOR: 0.588, 95% CI: 0.367 - 0.940, p = 0.027). Group membership often provides farmers with access to shared resources, information, and support networks that facilitate the adoption of new agricultural practices. Farmer groups and cooperatives can thus be effective platforms for disseminating information and encouraging the adoption of EbA practices.

Land size positively influenced the adoption of EbA practices (AOR: 1.384, 95% CI: 0.169 - 2.871, p = 0.022). Farmers with larger landholdings were more likely to adopt these practices, possibly due to greater financial capacity, better access to resources, and more flexibility to experiment with new practices. This finding highlights the need to support smallholder farmers with limited land resources to adopt EbA practices, perhaps through subsidies or shared community resources.

Access to credit services was a strong enabler for the adoption of EbA practices (AOR: 2.985, 95% CI: 1.507 - 4.782, p = 0.001). Farmers with access to credit were nearly three times more likely to adopt these

practices compared to those without access. Credit services provide the necessary financial resources for farmers to invest in new practices and technologies. Enhancing access to credit, particularly for smallholder farmers, can significantly boost the adoption of sustainable agricultural practices.

The perception of climate variability significantly impacted on the adoption of EbA practices. Farmers who perceived climate variability negatively were less likely to adopt these practices (AOR: 0.360, 95% CI: 0.021 - 0.154, p = 0.034). Negative perceptions of climate variability is always associated with skepticism or lack of awareness about the effectiveness of EbA practices in mitigating climate risks. This finding underscores the importance of awareness campaigns and education on the benefits of EbA practices in addressing climate variability.

In an interview with the Senior Environment Officer of Isingiro District, he talked about what helps and hinders small farmers in adopting Ecosystem-based Adaptation (EbA) practices. He had this to say:

"Male farmers and those with secondary education are more likely to use these sustainable methods because they have better access to resources and information. ...experienced farmers are key to adopting these practices as they have the right amount of labor and knowledge. Being part of the group and having access to credit help to provide support and money needed for new farming methods. However, Iam worried about farmers who don't believe in climate change, as they are less likely to adopt EbA practices. There is a need for strong awareness campaigns and education to show the benefits of EbA in tackling climate risks".

The factor of education and many other factors were found to be interactively affecting adoption of EbA practices by farmers. The more the farmers were exposed to knowledge and skills about ecological based adaptation practices, the easier it was for them to positively respond to the practices about Ecological - based Adaptation.

Acknowledgement

We give tribute to the staff and management of the Faculty of agriculture, environment and science technology, Bishop Stuart University for all the support extended to the completion of this this study.

Discussion

The findings from the study suggest that there are significant challenges hindering the adoption of ecological-based adaptation (EbA) practices among smallholder farmers in the area, ranging from environmental factors like unpredictable climate to socio-economic issues such as access to credit services and institutional support. The study found out that male farmers were significantly more likely to adopt EbA practices compared to female farmers, with an adjusted odds' ratio (AOR) of 1.962 (95% CI: 1.169 - 3.294, p = 0.034). Men typically had better access to resources such as land, credit, and information, which enhanced their capacity to adopt innovative practices. For example, male-dominated decision-making processes in households limiting women's participation in adopting new agricultural technologies. In contrast, women often faced more significant barriers, including limited access to land ownership and financial services. For instance, women's limited control over land tenure often resulted in reduced investment in long-term sustainable practices like agroforestry or soil conservation. This finding is consistent with other studies, such as those by (Quisumbing & Doss, 2021), which highlight the pervasive gender gaps in agriculture, where women have less access to land, credit, and extension services. Cultural norms and gender roles restrict women's access to critical resources needed for adopting new agricultural technologies.

More still, the study found that farmers with secondary education were more likely to adopt EbA practices compared to those with university education (AOR: 2.569, 95% CI: 1.239 - 5.327, p = 0.017). This counterintuitive result may be due to secondary-educated farmers being more involved in farming activities and more receptive to practical, on-the-ground solutions compared to university-educated individuals who might pursue non-agricultural careers. Similar patterns to education were observed in Tanzania, where (Sari, 2014) which found out that farmers with basic education levels were more likely to adopt climate-smart agriculture practices due to their active involvement in farming and practical knowledge gained through experience.

Size of the household also played a crucial role in EbA practices adoption. Households with 4-6 members were more likely to adopt EbA practices compared to those with 10 or more members (AOR: 1.603, 95% CI: 0.390 - 2.933, p = 0.023). Moderate-sized households had an optimal balance of labor availability and resource allocation, facilitating the adoption of labor-intensive practices like agroforestry or organic farming. Conversely, larger households struggle with resource constraints, reducing their capacity to implement new practices. Additionally, farmers with extensive farming experience were more inclined to adopt EbA practices (AOR: 2.764, 95% CI: 0.863 - 2.153, p = 0.013). Experienced farmers likely have a better understanding of the benefits of these practices and the skills to implement them. In Uganda, Rubongoya, (2019) found that experienced farmers were more adept at recognizing the benefits of sustainable practices and had the necessary skills to implement them effectively.

Membership in community groups significantly boosts the likelihood of adopting EbA practices (AOR: 0.588, 95% CI: 0.367 - 0.940, p = 0.027). Groups provide platforms for sharing knowledge, resources, and collective action, making it easier for farmers to learn and implement new practices. This finding aligns with studies from Burkina Faso and Mali, where group membership facilitated the adoption of conservation agriculture through shared resources and peer support (Andrieu et al., 2021). Land size also positively influenced adoption (AOR: 1.384, 95% CI: 0.169 - 2.871, p = 0.022). Farmers with larger landholdings can afford to experiment with new practices and bear potential risks, which smaller landholders might avoid. In Tanzania, larger farms were more likely to implement agroforestry practices, as reported by (Navajas & Mkali, 2019), due to greater financial capacity and resource availability.

Access to credit services was a critical enabler for adopting EbA practices, with farmers having access to credit being nearly three times more likely to adopt these practices (AOR: 2.985, 95% CI: 1.507 - 4.782, p = 0.001). Credit provides the financial means to invest in necessary inputs, technologies, and labor. In Viet Nam, for instance, access to microfinance significantly improved farmers' ability to implement climate-smart agricultural practices, as evidenced by (Khoi & Gan, 2017). Ensuring that smallholder farmers have access to affordable credit is crucial for the widespread adoption of EbA practices.

Farmers' perception of climate variability significantly impacted their likelihood of adopting EbA practices. Those who perceived climate variability negatively were less likely to adopt these practices (AOR: 0.360, 95% CI: 0.021 - 0.154, p = 0.034). Negative perceptions lead to risk aversion and a reluctance to invest in new practices. Similar findings were reported in the Philippines and Timor-Leste, where farmers with a negative outlook on climate change were less inclined to adopt adaptation strategies due to fear of potential failures and perceived high risks (ADB, 2021). Educating farmers about the benefits and potential success of EbA practices is therefore, essential to alter these perceptions and encourage adoption of these practices.

Conclusion

Adoption of EbA practices among smallholder farmers is influenced by a combination of socio-economic and environmental factors including gender, education, household size, farming experience, group membership, land size, access to credit, and perceptions of climate variability all play significant roles. Several adaptation barriers were found to confront the effective adoption of EbA by smallholder farmers in the district, including limited access to appropriate extension services.

Recommendations

The findings above highlight the need for targeted interventions to address the barriers and leverage the enablers for adopting EbA practices. Gender-specific strategies, educational programs tailored to different education levels, support for moderate-sized households, and strengthening farming experience through training can enhance adoption rates. Encouraging group memberships, facilitating access to credit, and positively influencing perceptions of climate variability are also crucial.

References

1. ADB. (2021). Climate Risk Country Profile: Timor-Leste Philippines. *Asian Development Bank*. www.worldbank.org
2. Andrieu, N., Dumas, P., Hemmerlé, E., Caforio, F., Falconnier, G. N., Blanchard, M., & Vayssières, J. (2021). Ex ante mapping of favorable zones for uptake of climate-smart agricultural practices: A case study in West Africa. *Environmental Development*, *37*. https://doi.org/10.1016/j.envdev.2020.100566
3. Aturihaihi, C., Opio, F., Tumwesigye, W., & Beyihayo, G. A. (2023). Smallholder Farmers' Coping Strategies to Perceived Climate Change and Variability in Isingiro District, South Western Uganda. *African Journal of Climate Change and Resource Sustainability*, *2*(1), 51–67. https://doi.org/10.37284/ajccrs.2.1.1203
4. Barman, A., Saha, P., Patel, S., & Bera, A. (2022). Crop Diversification an Effective Strategy for Sustainable Agriculture Development. *Sustainable Crop Production - Recent Advances*, *April*. https://doi.org/10.5772/intechopen.102635
5. Bintoora, K. K. A. (2013). The cost of poor land use practices in Lake Nakivale Wetland in Isingiro District, Uganda. *African Journal of Environmental Science and Technology*, *7*(6), 448–456. https://doi.org/10.5897/ajest2013.1490
6. Devis, A. (2023). Effects Of Urbanization On Wetland Waste Management In Uganda , A Case Of Lubigi Wetland In. *Metropolitan Journal of Environmental and Health Research*, *2*(9), 460–468.
7. Khoi, P. D., & Gan, C. (2017). Rural credit market and microfinance in Vietnam. In *Microfinance In Asia* (Issue May 2017). https://doi.org/10.1142/9789813147959_0002
8. Kissi, A. E., Villamor, G. B., & Abbey, G. A. (2023). Ecosystem-Based Adaptation Practices of Smallholder Farmers in the Oti Basin, Togo: Probing Their Effectiveness and Co-Benefits. *Ecologies*, *4*(3), 535–551. https://doi.org/10.3390/ecologies4030035
9. Kurniawati, putri. (2017). No Titleالابتزاز الإلكتروني.. جرائم تتغذى على طفرة «التواصل ال. *Universitas Nusantara PGRI Kediri*, *01*, 1–7.
10. Navajas, H., & Mkali, F. (2019). *Terminal Evaluation of UNEP Adaptation Fund Project: Implementation of Concrete Adaptation Measures to Reduce Vulnerability of Livelihoods and Economy on Coastal Communities of Tanzania*. *December*.

https://wedocs.unep.org/xmlui/handle/20.500.11822/31110

11. Quisumbing, A. R., & Doss, C. R. (2021). Gender in agriculture and food systems. In *Handbook of Agricultural Economics* (1st ed., Vol. 5). Elsevier B.V. https://doi.org/10.1016/bs.hesagr.2021.10.009
12. Rubongoya, R. (2019). *Evaluating the Utilisation of Climate-Smart Agricultural Technologies By Smallholder Farmers : a Case in Kyenjojo District , Uganda*.
13. Sari, S. P. (2014). Education ad agriculture in Tanzania ر. *Pontificia Universidad Catolica Del Peru*, *8*(33), 44.
14. Scott, C. K., & Richardson, R. B. (2021). Farmer social connectedness and market access: A case study of personal networks among emerging farmers. *Journal of Agriculture, Food Systems, and Community Development*, *10*(2), 431–453. https://doi.org/10.5304/jafscd.2021.102.024
15. UNHCR Uganda. (2020). Nakivale Settlement Profile: Isingiro district, Uganda. *Unhcr*, *HS/029/20E*(July), 94.
16. Zizinga, A., Mwanjalolo, J.-G. M., Tietjen, B., Bedadi, B., Gabiri, G., & Luswata, K. C. (2021). Climate Smart Agriculture Practices in Rainfed Systems in Uganda: Effectivity and Results. *SSRN Electronic Journal*, *January*. https://doi.org/10.2139/ssrn.3937099
17. Zizinga, A., Mwanjalolo, J. G. M., Tietjen, B., Bedadi, B., Gabiri, G., & Luswata, K. C. (2022). Impacts of Climate Smart Agriculture Practices on Soil Water Conservation and Maize Productivity in Rainfed Cropping Systems of Uganda. *Frontiers in Sustainable Food Systems*, *6*(May), 1–12. https://doi.org/10.3389/fsufs.2022.889830