The complementary role of indigenous knowledge systems in landslide disaster management in Kanungu District, Uganda

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Abstract

This study aimed to investigate the use and effectiveness of Indigenous Knowledge Systems (IKS) in managing landslides in Kanungu District, Uganda. The study used the Likert scale and the multivariate probit (MVP) model and found that marginalization was a significant challenge facing local interventions in landslide disaster management. Factors such as farm size, credit availability, social group membership, access to extension services, farming experience, accessibility of weather and climatic information, and perception of climatic changes influenced the adoption of IKS, both positively and negatively. The study concludes that education programs should focus on farmer capacity building to mitigate landslide risks and emphasizes the application of IKS in landslide hazard management.

Keywords: climatic information; farming; hazard management; landslides; multivariate probit model
Introduction

Worldwide, landslides are one of the most frequent natural disasters that result in considerable financial and human losses (Ali et al., 2020). Particularly for those living in landslide-prone locations, traditional or indigenous people have significant knowledge and customs that have developed over many generations to deal with and lessen the effects of such calamities (Hadlos et al., 2022). However, indigenous knowledge is in danger of disappearing due to rising urbanization, modernization, and a move away from traditional customs. For example, almost every nation and continent have the potential to have landslides due to geological, topographical, and climatic conditions, some areas are more vulnerable to landslides. Particularly vulnerable areas are those with steep slopes, flimsy or unstable geological formations, high rainfall, earthquake risk, volcanic activity, or rapid urbanization (Costea et al., 2022; Hyka et al., 2022; Sestras et al., 2022, 2023).

There is growing worried that landslides' frequency and features may be impacted by climate change. In some areas, increased rainfall, melting glaciers, and thawing permafrost may result in more frequent and severe landslides. This is attributed to human actions such as constructing on unstable slopes, deforestation, and insufficient drainage systems can increase the risk of landslides and little effort has been made. Indigenous Knowledge Systems (IKS) have not gotten much attention in the worldwide effort to mitigate landslide disasters, which has led to soil erosion and poor agricultural output among local inhabitants in both rural and urban areas (Youssef et al., 2023). Bhat et al. (2019) found that floods alone are responsible for more than 6.8 million fatalities. Taylor et al. (2023) provides valuable insights that indigenous knowledge encompasses various social behaviours, customs, and lifestyles established and practiced by local people, particularly indigenous people, for decades. The authors briefly explain how locals have developed and used indigenous knowledge for many years. However, a thorough examination of the methods and procedures involved in passing along this information from one generation of people to the next is necessary. This would clarify the functions of storytelling, mentorship, and other oral traditions in protecting and sharing indigenous knowledge.

Many international organizations, including the United Nations Office for Disaster Risk Reduction (UNDRR) along with regional projects, work to advance landslide risk reduction and enhance resilience globally (Kontar et al., 2021), but there is a scarcity of current research and monitoring that is necessary for accurately knowing about and dealing with the challenges posed by landslides on a global scale (Ikram et al., 2023).

Communities have relied on indigenous knowledge to survive natural disasters and protect lives and property, as stated by Syahputra (2019) and Abdul rashid (2020). Many indigenous tribes recognize the value of indigenous knowledge and have incorporated it into their daily lives to protect the environment, as noted by Battiste (2005). However, there is a huge study knowledge gap regarding systematic recording and standardization of this information, even though it is accepted that societies depend on indigenous knowledge to withstand natural calamities. It is possible to conserve and spread this priceless knowledge among generations and various indigenous communities by compiling thorough records of the indigenous systems, strategies, and cultural frameworks that contribute to catastrophe resilience (Kader et al., 2022, 2023). For this knowledge to be used sustainably, it is also essential to comprehend the traditional methods of transmission and how it adjusts to shifting environmental conditions.

Based on the text provided, it can be concluded that many communities in sub-Saharan Africa rely on traditional coping mechanisms to lower the risk of disasters (Mawere, 2015), including landslides. However, the effectiveness of institutional disaster management institutions in the region is limited, and low literacy and access barriers exacerbate landslide-related disasters like land degradation (Turyasingura et al., 2023). There is a scarcity of information on the utilization of indigenous knowledge to control landslides and the majority of the literature on the topic focuses on the district’s susceptibility to environmental risks and how to counter these dangers (Nseka et al., 2021). Policies on indigenous knowledge may play a vital role in minimizing...
disasters and improving community preparedness and resilience to disasters, particularly given the high percentage of households affected by landslides due to extreme weather events (Mugyenyi et al., 2011).

Landslides are included in Uganda’s national strategy, which focuses on disaster preparedness and management (Rukundo et al., 2019). In order to respond to catastrophes, including landslides, efficiently, the policy strives to build institutional frameworks, coordination mechanisms, and early warning systems (Omoyo et al., 2022). These systems frequently use technology to send alerts and advisories to vulnerable populations, including weather monitoring stations, rainfall data analysis, and community-based reporting.

To restrict and manage growth in high-risk landslide zones, the government has put in place land use planning and regulating mechanisms (Scott et al., 2020). Thus, by enforcing building laws and standards, these strategies seek to prevent or reduce development activities in sensitive areas. Initiatives exist to inform and educate communities about landslide risks and safety precautions. These programs offer details on early warning indicators, evacuation protocols, and the significance of preserving natural vegetation and slope stability. It’s crucial to remember that these policy initiatives’ effectiveness may vary, and issues like resource scarcity, poor infrastructure, and socioeconomic characteristics may influence how they are carried out and how they turn out.

Currently, indigenous groups frequently have a thorough awareness of their local ecosystems, including the scenery, vegetation, and soil conditions, as well as natural occurrences, indigenous knowledge is essential for managing landslide disasters (Dasanayaka and Matsuda, 2022). This knowledge is passed down through the generations and provides crucial understandings of the factors that affect the frequency of landslides. Indigenous cultures can recognize early warning signs, vulnerable areas, and these processes because they naturally understand the local dynamics that drive landslides. By applying this understanding to landslide catastrophe management, early warning systems’ precision and efficacy can be increased (Ramesh et al., 2023).

The study that was the subject of the article attempted to inform farmers in the Kanungu district about regional responses to landslide disaster management. The results of the study could assist stakeholders in determining the best ways to lessen the effects of landslides in the area, increasing community awareness and resilience to landslide disasters. The study also offered data for policy measures intended to lessen the effects of the risk. The study highlighted the necessity of a bottom-up strategy in which the impacted community actively participates in the creation and application of sustainable policies (Figure 1).

![Figure 1. Landslides in Kanungu (Source: Field study from authors)](image-url)
In Kanungu District, Uganda this qualitative case study explores the function of culture as well as indigenous knowledge in lessening the effects of landslides (Turyasingura and Chavula, 2022). Most of the tragedies that affect them can be predicted by locals thanks to traditional knowledge. Due to the region’s high rainfall and extensive deforestation for agricultural expansion, landslides have become a significant issue (Juventine, 2012; Rahn et al., 2018). Furthermore, while many studies have been conducted on landslides in Uganda, they have mostly focused on vulnerability analyses, resilience development, and community-wide solutions. This study provides significant findings for the scientific community, as it suggests using a framework to incorporate culture and indigenous knowledge to propose mitigation measures against landslides. The results may be helpful for policymakers and other stakeholders in landslide management. The general objective of the study is to investigate the use and effectiveness of IKS in managing landslides in Kanungu District, Uganda.

The scientific knowledge of landslide triggers, patterns, and dynamics must be improved. This entails carrying out research to further understanding of rainfall thresholds, soil conditions, geological elements, and other pertinent characteristics that influence the incidence of landslides. A deeper comprehension of these elements can aid in the creation of earlier warning systems that are more precise and dependable. Additionally, reliable, and current data access is essential for efficient early warning systems. Data quality and availability, particularly in isolated and vulnerable places, are frequently constrained. Investments in infrastructure for data collecting and monitoring, such as weather stations, rain gauges, and ground deformation sensors, are necessary to close this gap. Additionally, efforts should be made to enhance quality control procedures, data sharing mechanisms, and data management systems.

For focused early warning systems, localized assessment of the danger of landslides is necessary. To fill the knowledge gap in terms of localized risk assessment methodologies and instruments, nevertheless, is necessary (Kader and Jaufer, 2022). This entails mapping landslide-prone regions, comprehending community susceptibility, and incorporating socioeconomic aspects into risk evaluations. To acquiring pertinent data and creating frameworks for risk assessment that are particular to a given setting, local expertise and community involvement are essential (Kader et al., 2021). Indigenous knowledge has a strong connection to the local environment, including its ecological, social, and cultural aspects. For risk assessment and management, policy implications include recognizing and respecting indigenous knowledge as a unique source of information. To comprehend indigenous people’ knowledge systems, customs, and coping methods, it is necessary to interact with them. To ensure that risk reduction initiatives are inclusive and culturally relevant, policies should work to develop places for communication and collaboration between indigenous communities and government organizations.

The study aims to assess IKS used by farmers in preventing landslide disasters in Kanungu District. It also seeks to examine the challenges facing IKS in the management of landslide disasters in the region. The research questions guiding the study are (i) What are the IKS used by farmers in preventing landslide disasters in Kanungu District? (ii) What challenges facing IKS in the management of landslide disasters in Kanungu District.

**Methodology**

**Study area details**

The study was conducted in the Kayonza subcounty of Kinkizi West, Kanungu District, and southwestern Uganda. This area was chosen because it is the most affected by landslides during heavy rainfall in the wet seasons (Figure 2). However, the development activities in the area have increased the frequency of landslide disasters.
Climate and landscape

The district has a tropical type of climate receiving moderate and well distributed annual rainfall of about 1200 mm. The district receives a bimodal type of rainfall between the months of March-May and September-December every year. The rest of the months are dry with temperatures ranging from 31 to 46 degree Celsius on average (Figure 3).

The area lies in the fringes of the western rift valley with the Northern part forms part of the Rift valley with undulating plains with the middle part (sub-counties of Rugyeyo, Kirima and parts of Kanyantorogo) comprising of flat topped hills with gentle sloping sides and broad valleys. These hills gradually increase in height to the highlands of Rutenga with Burimbi peak of Mafuga being the highest at 2,503 m above sea level with some parts of Kihhi Subcounty lying in the fringes of the west-eastern African Rift Valley (Turyasingura and Chavula, 2022). Every year, the Kayonza sub-county experiences bimodal rainfall between the months of March-May and September-December. The other months are dry and typically between 31 and 46 °C (Medard, 2015).
Theoretical framework

The random utility maximization theory (Sur et al., 2022) served as the basis for the study and assumes that smallholder farmers in the Kanungu district decide to employ a certain body of indigenous knowledge to control landslide events. According to the hypothesis, a specific indigenous knowledge practice has greater perceived utility than other alternatives. The utility gained by a farmer from using a particular good consists of an observable stochastic element and a random element, and can be well-defined using a formula (Cascetta, 2009b):

\[ U_{mn} = V_{mn} + \varepsilon_{mn} \]  

(1)

According to (Cascetta, 2009b), the utility \( U \) is determined by decisions taken from a collection of \([n]\) indigenous knowledge practices. It is considered that the individual possesses a utility function of the kind:

\[ U_{mn} = V(X_m, Z_m) \]  

(2)

A rational farmer who seeks to manage a landslide disaster using indigenous knowledge during a specific length of time, the student must select from a collection of an indigenous knowledge possibilities. The farmer \( m \) will employ indigenous knowledge \( n \) if the distinguished advantage of such practice outweighs the usefulness of other possibilities, \( k \) if \( U_n > U_k \). The benefit generated from each indigenous knowledge practice is thought to be dependent on the characteristics of practice \( X \), as well as the socioeconomic attributes among farmer to mitigate landslide disasters \( Z \). Albeit a farmer in Kayonza Sub-County, Kanungu District may not pick what appears as the favoured indigenous knowledge choice. An arbitrary element is added to the utility function as a member to help explain these variances in decision-making (Cascetta, 2009a). Then, Equation 2.3 can be rewritten as follows:

\[ U_{mn} = V(X_n, Z_m) + \varepsilon(X_n, Z_m) \]  

(3)

The probability that farmer \( m \) will choose an indigenous knowledge practice \( n \) among the set of disaster management systems \( k \) for landslides would be elaborated as:

\[ \Pr \{m(IK)\} = \Pr \{Un > Uk\}, \forall n \in IK \]

\[ = \Pr \{(Vn + \varepsilon n) > (Vk + \varepsilon k)\} \]

\[ = \Pr \{(Vn - Vk) > \mu\} \]

Where IK is the complete choice set of available IKS.

Determination of research population and sample size

The study population consists of 5701 persons who live in the considered region. To calculate the sample size, the formula proposed by Israel (1992) was utilised to derive the sample size of the population.

\[ n = \frac{N}{1 + N(e)^2} \]

(5)

Where: \( n = \) Sample size, \( N = \) Population size, \( 1 = \) constant, and \( e = \) Precession level on 10%

Therefore, \( N = 57011 = \) constant, and \( e = 10\% \). Ten percent marginal error was varied for this to avoid a lot of respondents due to limited time.

\[ n = \frac{5701}{1 + 5701(0.1)^2} = 98 \]

Purposive sampling was also employed in the selection of (11) important informants. There was one natural resource officer, one environmental officer, one forest officer, one agriculture officer, and one local resident (7) as shown in Table 1.
Table 1. Identification and selection of the study population and sample size (Sur et al., 2022)

<table>
<thead>
<tr>
<th>Category of respondents</th>
<th>Population</th>
<th>Sample</th>
<th>Sampling techniques</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community members</td>
<td>5701</td>
<td>98</td>
<td>Random sampling</td>
</tr>
<tr>
<td>Key informants</td>
<td></td>
<td></td>
<td>Purposive sampling</td>
</tr>
<tr>
<td>1. Natural resource officer</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2. Environment officer</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>3. Forestry officer</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>4. Agriculture officer</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>5. Local people</td>
<td>7</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>109</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Adopted from Sur et al. (2022) and modified by researchers

Definition of variables and working hypothesis

Dependent variable

A multivariate probit (MVP) regression model was used in the study to simulate the influence of a number of independent variables with respect to the five indigenous knowledge practises exercised by the larger percentage of the people living in the area under study (Chekol et al., 2023).

Independent variables

The following variables are expected to influence the dependent variable, which is the farmer’s use of indigenous knowledge to manage landslide disasters. The independent variables include age, gender, household size, level of education, farm size, market distance, credit availability, knowledge of the climate and weather, social group membership, perception of climate change, use of health facilities, ownership of land, decision-making regarding its use, and training (Pello et al., 2021).

Sex of the household head: A dummy variable that responds with 1 if the respondent is male and 0 if not (D’Acunto et al., 2021). This is in line with An-Vo et al. (2022) who reported that gender emphasizes the importance of family head gender in preventing landslide disasters, as both men and women participate in agricultural activities and make decisions. The gender of the family head is expected to have a positive or negative impact on the use of IKS to mitigate landslide disasters. Aryal et al. (2020) found a notable difference between Haryana and Bihar in the contribution of women to technology adoption decisions. When compared to Bihar, Haryana’s participation is noticeably higher, which increases the possibility that CSA will be adopted. Additionally, our research found that things like affluence, education, and market and extension access have a beneficial impact on CSA adoption. The head of the home frequently has a lot of influence over decisions, notably those pertaining to agricultural pursuits. Women’s lack of equal decision-making power in particular situations may influence the selection of crops, financial support for agricultural technologies, and general farm management.

Age of household head in this study: It was expected that the age of the family head would have a favourable or harmful implication on the adoption of IKS (Belachew et al., 2020). The implementation of IKS can be complicated by the age of the head of the family. While their expertise and cultural understanding may make adoption more likely, problems such as reluctance to change and little exposure to contemporary influences could arise. When fostering and maintaining indigenous knowledge for the betterment of future generations, it is crucial to take these elements into account (Son et al., 2019).

Educational level of household head: Education can help individuals gain access to information about disaster management and climate change responses, leading to improved utilization of IKS for adaptation to climate change (Hosen et al., 2020). It is expected that individuals with higher education levels will have a more positive influence on the application of these systems.

Farming experience: a farmer’s propensity to employ conventional knowledge techniques to decrease the impact of landslides on agricultural activity increases with experience (Iwuchukwu et al., 2023).
Farm size: A farm’s size is a continuous variable expressed in acres. The likelihood that the farmer will use the proper methods increases with the size of the farm (Chandio et al., 2020; Ljavić et al., 2022). Soil fertility status while applying techniques from indigenous knowledge to lessen landslide disasters, is a dummy variable that gauges farmers’ understanding of the condition of their soil fertility.

Farm income from agriculture: This is a permanent variable. As they can afford to pay for better crop types and new technologies, households with a larger income from agricultural activities and sufficient assets are better positioned to adopt new farming techniques (Marie et al., 2020).

Access to credit services: The value of this dummy variable is 1 if a household received a credit and 0 otherwise (Twumasi et al., 2020). For the households to close the farmers’ financial gap and enable them to purchase the necessary agricultural inputs, access to credit and its effective use are essential components (Van Dijk et al., 2020).

Access to climate and weather information: If the farmer gets access to information about climate change, the dummy variable will take the value of 1. Otherwise, it will take the value of 0. Farmers are better able to adopt appropriate adaptation strategies that best suit the altered climatic circumstances as a result of having access for weather and climate details, which increases their comprehension of temperature and rainfall changes (Tanti and Jena, 2023).

Training in agriculture: The dummy variable has a value of 1 if the farmer has access to training on adopting indigenous knowledge methods to decrease landslide disasters and a value of 0 otherwise (Wink Junior et al., 2023).

Membership in a social group: This dummy variable has two possible values: 1 if the farmer belongs to a social group, and 0 otherwise. The study’s main hypothesis was that belonging to a social group would have a favourable impact on the use of indigenous knowledge techniques to lessen landslide tragedies.

Market distance: A continuous variable that is calculated as the amount of time required to walk to the closest market. In this study, it was expected that distance from the market centre would have a favourable impact on the utilization of IKS (Adeleke and Luetz, 2023).

Perceived changes in climate: This is a dummy variable which assumes the value 1 when the farmer notices change and the value 0 otherwise. According to this study, farmers’ opinions about landslide disasters, particularly those brought on by soil erosion and flooding, have changed (Tibasiima et al., 2023; Zejak et al., 2022). As a result, this study postulated that the utilization of IKS would benefit from perceptions of changes in landslides.

Land ownership: This continuous variable is expressed in acres. As they are not constrained by a rental arrangement, households which own their own land are likely to apply IKS more readily. Therefore, it was anticipated in this study that land ownership has an impact on whether or not people choose to adopt traditional knowledge techniques to cope with landslide catastrophes in Uganda (Nkuba et al., 2020).

Results

Gender was included in the research study due to the central role that gender plays in IKS in disasters. Results of Table 2 illustrates that female are of 63% respondents, the majority of 41% were young adults (18-29 years), 64% were single, and 46% followed by 54% and post-secondary education. More than 80% of the respondents were farmers.

Table 3 presents the IKS that farmers used to prevent landslide disasters. Most respondents strongly agreed that terracing is the most effective means of preventing landslides. In addition, 37% of the participants strongly agreed that the use of terracing reduces landslides, 29% agreed with mixed farming, 18% were not sure if intercropping reduces landslides, and 16% disagreed with slash and burn as a local intervention in landslide disaster management.
Table 2. Demographic characteristics of the respondents

<table>
<thead>
<tr>
<th>Study item questions</th>
<th>Variables options</th>
<th>Frequency (N=109)</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main occupation</td>
<td>Top management</td>
<td>20</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Lower management</td>
<td>89</td>
<td>82</td>
</tr>
<tr>
<td>Education levels</td>
<td>Secondary</td>
<td>50</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td>Certificate</td>
<td>15</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Diploma</td>
<td>31</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>Degree</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>Gender</td>
<td>Female</td>
<td>69</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>40</td>
<td>37</td>
</tr>
<tr>
<td>Age of student</td>
<td>18-29 years</td>
<td>45</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>30-35 years</td>
<td>30</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>36-44</td>
<td>20</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>44 years and above</td>
<td>14</td>
<td>13</td>
</tr>
<tr>
<td>Marital status</td>
<td>Single</td>
<td>70</td>
<td>64</td>
</tr>
<tr>
<td></td>
<td>Married</td>
<td>39</td>
<td>36</td>
</tr>
</tbody>
</table>

Table 3. IKS that farmers used to prevent landslide disasters

<table>
<thead>
<tr>
<th>Variable</th>
<th>Response</th>
<th>Frequency (N=109)</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terracing</td>
<td>Strongly agree</td>
<td>40</td>
<td>37</td>
</tr>
<tr>
<td>Mixed farming</td>
<td>Agree</td>
<td>32</td>
<td>29</td>
</tr>
<tr>
<td>Intercropping</td>
<td>Not sure</td>
<td>20</td>
<td>18</td>
</tr>
<tr>
<td>Slash and burn</td>
<td>Disagree</td>
<td>17</td>
<td>16</td>
</tr>
</tbody>
</table>

Most respondents agree that IKS face challenges in managing landslide disasters (Table 4). Marginalization is identified as the biggest challenge by 45% of participants, followed by community ignorance of farming systems (28%). Some respondents are uncertain about the disappearance of indigenous knowledge (18%), while only 9% strongly disagree with poor management of indigenous knowledge. The study finds that women and most community members lack access to local interventions in managing landslides.

Table 4. The challenges facing Indigenous Knowledge Systems (IKS) in the management of landslide disasters

<table>
<thead>
<tr>
<th>Variable</th>
<th>Response</th>
<th>Frequency (N=109)</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marginalization</td>
<td>Strongly agree</td>
<td>49</td>
<td>45</td>
</tr>
<tr>
<td>Ignorance</td>
<td>Agree</td>
<td>30</td>
<td>28</td>
</tr>
<tr>
<td>Disappearance</td>
<td>Not sure</td>
<td>20</td>
<td>18</td>
</tr>
<tr>
<td>Poor management of indigenous knowledge</td>
<td>Disagree</td>
<td>10</td>
<td>9</td>
</tr>
</tbody>
</table>

Factors such as farming experience, farm size, access to financing, extension services, weather/climatic information, social group membership, perception of soil fertility, perception of climate change, health facilities, and household decision on land use significantly influence the use of IKS in landslide hazard control (Table 5). For example, longer farming experience and larger farm size have a positive impact on the use of terracing and slash and burn techniques, respectively. Access to financing, extension services, and weather/climatic information positively influence the use of agroforestry and mixed farming techniques, while perception of soil fertility and health facilities have a negative influence on mixed farming.
common procedures show significance at various thresholds: 1%, 5%, and 10%. Strategies may be responsible for this reliance. As shown in Table 6, the correlated coefficients of the five most techniques along with other household-specific or missing elements that affect the use of all adaptation various landslide adaption strategies are interdependent. The complementarity of various adaptation techniques used by farmers in the study area exhibit both mutually beneficial relationships (positive correlation) as well as substitutability (negative correlation). This implies that choosing 1.12 (Singh and Kumar, 2021). The data were discovered to have no evidence of multicollinearity issues depending upon the VIF results shown in Table 7 below.

Table 5. Multivariate probit estimation results for Indigenous Knowledge Systems (IKS) used in landslide disaster management (Coef. – coefficient and SE – standard error)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Terracing</th>
<th>Agroforestry</th>
<th>Mixed farming</th>
<th>Intercropping</th>
<th>Slash and Burn</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coef.</td>
<td>SE</td>
<td>Coef.</td>
<td>SE</td>
<td>Coef.</td>
</tr>
<tr>
<td>Sex</td>
<td>0.019</td>
<td>0.075</td>
<td>0.023</td>
<td>0.078</td>
<td>-0.064</td>
</tr>
<tr>
<td>Age</td>
<td>0.001</td>
<td>0.004</td>
<td>0.004</td>
<td>0.004</td>
<td>0.001</td>
</tr>
<tr>
<td>Farming experience</td>
<td>0.004**</td>
<td>0.003</td>
<td>0.001</td>
<td>0.003</td>
<td>0.003*</td>
</tr>
<tr>
<td>Household size</td>
<td>0.022</td>
<td>0.020</td>
<td>0.021</td>
<td>0.021</td>
<td>0.020</td>
</tr>
<tr>
<td>Education status</td>
<td>0.033</td>
<td>0.041</td>
<td>0.015</td>
<td>0.043</td>
<td>0.078</td>
</tr>
<tr>
<td>Farm size</td>
<td>0.065**</td>
<td>0.043</td>
<td>-0.040</td>
<td>0.045</td>
<td>0.056</td>
</tr>
<tr>
<td>Market distance</td>
<td>0.001</td>
<td>0.002</td>
<td>0.001</td>
<td>0.002</td>
<td>0.000</td>
</tr>
<tr>
<td>Access to credit</td>
<td>0.542</td>
<td>0.368</td>
<td>0.502*</td>
<td>0.382</td>
<td>0.498**</td>
</tr>
<tr>
<td>Extension services access</td>
<td>-0.094</td>
<td>0.076</td>
<td>0.046**</td>
<td>0.079</td>
<td>0.036</td>
</tr>
<tr>
<td>Weather and climate information</td>
<td>0.182*</td>
<td>0.076</td>
<td>0.008*</td>
<td>0.079</td>
<td>0.054</td>
</tr>
<tr>
<td>Social group membership</td>
<td>0.044**</td>
<td>0.026</td>
<td>0.032</td>
<td>0.027</td>
<td>0.006*</td>
</tr>
<tr>
<td>Soil fertility</td>
<td>-0.065</td>
<td>0.056</td>
<td>-0.031</td>
<td>0.058</td>
<td>0.036*</td>
</tr>
<tr>
<td>Climate change perception</td>
<td>-0.056</td>
<td>0.147*</td>
<td>-0.130</td>
<td>0.153</td>
<td>0.039</td>
</tr>
<tr>
<td>Health facility</td>
<td>0.009</td>
<td>0.100</td>
<td>0.056</td>
<td>0.104</td>
<td>0.191**</td>
</tr>
<tr>
<td>Land ownership</td>
<td>-0.015</td>
<td>0.034</td>
<td>-0.018</td>
<td>0.036</td>
<td>-0.003</td>
</tr>
<tr>
<td>Land use decision</td>
<td>-0.025</td>
<td>0.045</td>
<td>-0.019</td>
<td>0.047</td>
<td>0.100*</td>
</tr>
<tr>
<td>Training</td>
<td>0.034</td>
<td>0.113</td>
<td>-0.026</td>
<td>0.117</td>
<td>0.116</td>
</tr>
<tr>
<td>Constant</td>
<td>0.757</td>
<td>0.384</td>
<td>0.434</td>
<td>0.398</td>
<td>0.495</td>
</tr>
</tbody>
</table>

Notes: *significant at α<0.5; **significant at α<0.01.

According to the research’s findings involving the correlation coefficients of term errors, the diverse indigenous knowledge techniques used by farmers in the study area exhibit both mutually beneficial relationships (positive correlation) as well as substitutability (negative correlation). This implies that choosing to employ one technique has an impact on choosing to use another. These findings offer proof for the idea that various landslide adaption strategies are interdependent. The complementarity of various adaptation techniques along with other household-specific or missing elements that affect the use of all adaptation strategies may be responsible for this reliance. As shown in Table 6, the correlated coefficients of the five most common procedures show significance at various thresholds: 1%, 5%, and 10%.

Table 6. The correlation matrix for the Indigenous Knowledge Systems (IKS)

<table>
<thead>
<tr>
<th>Correlated parameters</th>
<th>Terracing</th>
<th>Agroforestry</th>
<th>Mixed farming</th>
<th>Intercropping</th>
<th>Slash and burn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terracing</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agroforestry</td>
<td>-0.012*</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mixed farming</td>
<td>0.036*</td>
<td>-0.051</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercropping</td>
<td>0.019</td>
<td>0.007</td>
<td>0.040***</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Slash and burn</td>
<td>0.044**</td>
<td>0.216**</td>
<td>0.057*</td>
<td>-0.049</td>
<td>1</td>
</tr>
</tbody>
</table>

Notes: *significant at α<0.5; **significant at α<0.01; ***significant at α<0.001.

The variance inflation factor, or VIF, analysis was used to find the multicollinearity issue among the explanatory variables. VIF = (1-Ri²)-1 if Ri² is the square of the combination of correlation coefficients that emerges from regressing a single explanation variable (xi) against all the additional explanatory variables. When VIF is larger than 10, it is frequently assumed that there is a multicollinearity issue with the model (Bahadir et al., 2022). For all evaluated factors in the present investigation, all VIF were less than 10, with an average of 1.12 (Singh and Kumar, 2021). The data were discovered to have no evidence of multicollinearity issues depending upon the VIF results shown in Table 7 below.
Table 7. Variance Inflation Factor (VIF) for Continuous Explanatory Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>VIF</th>
<th>1/VIF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>1.103</td>
<td>0.907</td>
</tr>
<tr>
<td>Farming Experience</td>
<td>1.118</td>
<td>0.894</td>
</tr>
<tr>
<td>Household size</td>
<td>1.067</td>
<td>0.938</td>
</tr>
<tr>
<td>Farm size</td>
<td>1.122</td>
<td>0.891</td>
</tr>
<tr>
<td>Market distance</td>
<td>1.195</td>
<td>0.837</td>
</tr>
<tr>
<td>In-farm income</td>
<td>1.114</td>
<td>0.898</td>
</tr>
<tr>
<td>Off-farm income</td>
<td>1.112</td>
<td>0.899</td>
</tr>
<tr>
<td>Soil fertility</td>
<td>1.102</td>
<td>0.860</td>
</tr>
<tr>
<td>Mean VIF</td>
<td></td>
<td>1.12</td>
</tr>
</tbody>
</table>

Source: Field data, 2023

Discussion

Local knowledge systems in landslide disaster management

Table 3 shows that 37% of participants strongly agreed that terracing can reduce landslides and the risk of drought (Wen et al., 2021). This is in line with Highland and Bobrowsky (2008) who reported that on steep slopes, excessive water runoff frequently causes landslides. Cui (2022) found that terracing makes it possible to direct water in a controlled way, reducing accumulation and undue hydrostatic pressure on the slope. Also, Deng et al. (2022) reported that the terraced steps aid in minimizing the force that could cause landslides by slowing down water flow and encouraging infiltration. It is crucial to remember that while terracing has many advantages for preventing landslides, it is not a universally effective solution. Terracing’s effectiveness is influenced by several variables, including the regional geology, climate, and upkeep habits. To fully address landslide hazards, it may occasionally be necessary to combine various erosion control techniques, but little effort has been made.

Most community members lack local intervention in the management of landslide disasters, according to Booth et al. (2020). Lack of local involvement in landslide disaster management can seriously impede successful mitigation efforts and raise the susceptibility of communities to such dangers. Work to reduce landslide risks locally might be hampered by poor administration, inadequate policies, and a lack of enforcement. Communities may be left at danger when there is no defined framework for disaster risk reduction as well as no accountability for putting measures into place.

Key informant 1 notes that farmers use terracing to control soil erosion caused by primitive tools like hand hoes and crude iron blades. Key informant 2 reveals that local people in Kanungu district use simple tools, slash, and burn, mixed farming, packing stones in bags (sacks), and conserve trees in hilly areas to reduce landslides and manage disasters. Key informant 3 stated that in Kayonza sub-county, the most popular way of clearing land for tilling is by clearing a small section of ground, harvesting grass, and burning it. However, environmentalists oppose this practice as unsustainable, as burning may destroy soil nutrients and other living species, which needs assessment. Key informants 4 and 5 reported that intercropping and mixed farming were used in sacred places of worship located in dense woods, and that permission was required to enter these forests. This indirectly contributed to the conservation of the forests, which have important functions like forming rains in the area. Key informant 5 also mentioned that the local communities are trained on how to create rock terraces with stones to reduce landslides, particularly on properties with at least a 30% slope gradient. Key informants 8 reported that “We were taught to read nature’s cues by our forefathers when I first moved to this hamlet many years ago. We can predict the possibility of a landslide when birds fly abnormally low or the color of the river water changes. We transmit this information to the next generation. It serves as our alerting mechanism”. Key informants 9 said that “Our elders have shown us how to build our homes along with terraces.
in a way that reduces the risk of landslides. They instructed us to plant specific trees and bushes to improve soil stability. In the past, our customary behaviors have prevented devastating catastrophes”.

The research results also show that local indigenous knowledge and systems in Ugandan communities are neither recorded or included in formal education as it serves practical functions in the societies in question, and it is actively passed down through the generations through use in real-world situations and oral tradition. This study’s new knowledge is its identification of the potential for existing disaster management techniques to be modified, opening the door to sustainable and affordable means of shielding the neighbourhood from the effects of natural disasters including landslides. Through the introduction of a different perspective on how to understand the folkways of the populace, this essay paves the way for useful improvements in Uganda’s disaster management.

**The challenges facing IKS in the management of landslide disasters.**

In a study on landslide disaster management, Ruszcz yk et al. (2020) found that 45% of participants strongly agreed that marginalization was a significant challenge facing local interventions. Most community members, particularly women, lack access to such interventions due to patriarchal institutions and a perception that indigenous knowledge is archaic and outdated (Amare and Simane, 2017). Key informants 1 and 2 from the current study noted that indigenous knowledge is in danger of extinction due to a lack of documentation, preservation, and education. Efforts should be made to investigate and document medicinal plants, which can lead to the development of new therapies and promote biodiversity conservation. Key informants 3, 4, and 5 suggested filling the gap in farming systems by bringing in others who can teach local farmers how to apply traditional knowledge in landslide disaster management. Applying local expertise in agriculture, gardening, and fishing could make a significant difference (Santoro et al., 2020).

One of the challenges facing indigenous according to Cuaton and Su (2020) is that indigenous wisdom is frequently passed down verbally from generation to generation. It is possible that there are not many written recordings of this knowledge, if any at all, leaving it open to oblivion or oversight. Since a large portion of indigenous knowledge is preserved and transmitted in regional tongues, communication with outside agencies and groups in charge of disaster management may be hampered (Hausknecht at al., 2021). Key informants 3 and 4 said that “We are willing to share our expertise with the authorities and work together on disaster management plans, but they hardly ever ask for our opinion. The government agencies and our community don’t communicate well, which makes it difficult to effectively incorporate indigenous knowledge into official strategies”. Various factors, such as construction projects or natural calamities, may cause indigenous communities to leave their ancestral lands (Ahmed et al., 2021). This may interfere with their ability to successfully control landslides and their traditional knowledge systems.

**Multivariate analysis results regarding the effectiveness of IKS and characteristics of respondents in the management of landslide disasters**

Stankevich et al. (2020) conducted a study on landslide disaster management and found that the number of years a farmer has spent in farming activities significantly influences the use of terracing as an indigenous knowledge system in landslide disaster management. Farmers with more experience in farming are more likely to use indigenous farming knowledge to manage landslides. The study also revealed that access to finance among small holding farmers had a significant positive impact on the utilization of agroforestry and mixed farming in landslide disaster management. Smallholder farmers who have access to credit can invest in purchasing tree seedlings and different techniques, allowing them to conserve degraded areas due to landslides and face financial constraints in landslide management.

Access to extension services positively influenced the utilisation of agroforestry at a significance of 5%; access to weather and climate information positively influenced terracing and intercropping at 10% significance level. This is in line Turyasingura and Chavula (2022) with who said that extension provision facilitates farmers by giving them knowledge on better methods of farming in Uganda.
It was found that perception on soil fertility negatively influenced the implementation of intercropping at 10% significance level; it also had a negative influence on slash and burn at 5% significance. Climate change perception had a positive influence on slash and burn at 5% significance level (Turyasingura et al., 2023). Healthy facilities negatively influence the use of mixed farming at a 5% significance level. Indigenous wisdom, which evolved to reduce risk (Benzougagh et al., 2022a), managing and surviving recent natural catastrophes is a very important source of knowledge for disaster risk reduction practitioners and policymakers, and this is supported by Popov et al. (2021), to manage high valuable regional and national resources. Engagement of Native community, integration, and mainstreaming, as well as indigenous knowledge, will become increasingly important for disaster risk mitigation and management in future.

It is important to educate the public about indigenous systems in landslide risk reduction and create awareness among the population. This can be achieved through mass education, which can increase people’s capacity to address environmental and sustainable development challenges. The informants also emphasize the importance of considering long-term management of wetlands to support ecosystem functions, such as flood control, food production, and water provision, for stakeholders such as farmers, wildlife, and future generations. Therefore, it is crucial to preserve and protect these services to accommodate the demands of subsequent generations.

**Policy recommendations**

The disaster risk policy implications of the age of the respondents are that there is a huge knowledge gap regarding the systematic recording and standardization of this information, even though it is accepted that societies depend on indigenous knowledge to withstand natural calamities. It is possible to conserve and spread this knowledge among generations and various indigenous communities by compiling records of the indigenous systems, strategies, and cultural frameworks that contribute to catastrophe resilience. For this knowledge to be used sustainably, it is also essential to comprehend the traditional methods of transmission and how they adjust to shifting environmental conditions among different age groups.

Disaster risk strategies need to take gender equality into account, as men and women may experience different dangers and play different roles in managing disasters. Important policy issues include addressing gender-specific vulnerabilities, encouraging women’s participation in decision-making, and guaranteeing fair access to resources and information. The current study proved that larger households may require varying levels of resources and have different vulnerabilities during disasters. Policies addressing disaster risk should consider the difficulties and resources required to serve larger households during emergencies.

Education levels can have a significant impact on the ability to plan for and respond to disasters. The improvement of education and awareness surrounding disaster risk reduction should be the focus of policies, ensuring that all members of the community have access to vital knowledge and abilities to respond to dangers. To enable communities to successfully comprehend and respond to ever-shifting environmental circumstances, policies should place an emphasis on climate and weather awareness. It might also be advantageous to include indigenous knowledge and conventional methods of weather forecasting.

Disaster risk reduction depends on funding programs for capacity-building and training. To improve the skills and knowledge of community members, government officials, and first responders in preparing for disasters, response, and recovery, policies should give priority to providing training opportunities. Additionally, for comprehensive disaster risk strategies to be effective, social group dynamics within a community must be recognized and understood. To meet their particular risk profiles, those who are vulnerable, such as racial or ethnic minorities or indigenous populations, may need specialized support and focused interventions.
Conclusion

The study found that terracing is believed to reduce landslides by 37% of the respondents, and locals should cultivate marginal and steep areas for terracing. Marginalization was found to be the biggest obstacle to local interventions in modern science for landslide disaster management by 45% of the respondents. The study used an MVP model to analyze the effectiveness of IKS and the characteristics of respondents in landslide disasters. The model showed that farming experience, farm size, access to extension services, access to credit, membership in the social group, access to weather and climate information, as well as the perception of climate change influenced the use of IKS in both positive and negative ways. Land ownership, land use decisions, and perception of soil fertility influenced both negatively and positively the use of mixed farming, intercropping, and slash and burn, while access to agricultural training influences positively the adoption of intercropping. Lastly, the extent of land used for agricultural holdings can have an impact on a community’s ability to withstand disasters. There is a need for policies to help small-scale farmers, encourage sustainable agricultural systems, and devise plans to lessen the effects of catastrophes caused by climate change on agricultural output.

Authors’ Contributions


Acknowledgements

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors. There are no relationships, memberships, funding sources, or financial holdings that the authors are aware of that would be thought to compromise this article’s objectivity.

Conflict of Interests

The authors have not declared any conflict of interest.

Funding

The authors received no funding for this research.

Availability of data and materials

Data generated and analyzed during the current study are included in the body of this paper.
**Ethics Statement**

In compliance with local law and institutional regulations, an ethical evaluation and approval were not necessary for the study involving human subjects. To take part in this study, the subjects gave their informed consent.

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