

Access to Agricultural Extension Services and Post-Harvest Losses among Smallholder Sweet Potato Farmers in Kuria West Sub-County, Migori County, Kenya

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ABSTRACT

Post-harvest losses (PHL) remain a challenge for smallholder sweet potato farmers in Kenya. Agricultural extension services can provide the knowledge needed to reduce them, yet evidence linking extension access to PHL is limited. This study examined the association between access to agricultural extension services and sweet potato PHL among smallholder farmers in Kuria West Sub-County, Migori County. Guided by Diffusion of Innovations Theory, a cross-sectional correlational survey was conducted: 376 farmers were selected by stratified random sampling from 16,303 farming households, and 376 responded. Data were analysed in SPSS (Version 30) using descriptive statistics, Pearson's correlation and an independent-samples t-test. Only 29.52% of farmers reported access to extension services. Losses were experienced by 93.62% of respondents; the mean total PHL among those reporting losses was 34.54%, with handling accounting for the largest share (10.37%), followed by transportation (8.69%), marketing (7.75%) and storage (7.73%). Among farmers with access, extension access quality was weakly and negatively associated with PHL ($r = -.202$, $p = .039$). Farmers without access had higher mean PHL ($M = 37.66\%$) than those with access ($M = 27.07\%$), a difference of 10.59 percentage points ($t(374) = 8.50$, $p < .001$; Cohen's $d = 0.96$). Because the design was cross-sectional, losses were self-reported and no adjusted analyses were conducted, the findings indicate associations, not causation. Expanding extension coverage, practical training on handling and storage, and stronger collaboration among extension providers are recommended.

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1. INTRODUCTION

Post-harvest losses (PHL) remain a persistent challenge to agricultural productivity, food security, and the livelihoods of smallholder farmers, particularly in developing countries where inadequate post-harvest management practices contribute to substantial losses. Food losses reduce the quantity and quality of agricultural produce available for consumption and marketing, while also wasting the land, water, labour, energy, and other resources invested in food production (FAO, 2017, 2023). The problem has implications for the achievement of the Sustainable Development Goals, particularly SDG 2 (Zero Hunger) and SDG 12 (Responsible Consumption and Production) (FAO, 2022). Food loss and waste also have environmental implications, with the United Nations Framework Convention on Climate Change (UNFCCC, 2024) estimating that they account for approximately 8–10% of global greenhouse gas emissions. Climate variability, including changing rainfall patterns and increasing temperatures, may further accelerate deterioration of agricultural commodities and increase the need for climate-resilient post-harvest management systems (FAO, 2017; UNEP, 2017).

Sweet potato is an important food-security crop cultivated across diverse agro-ecological environments because of its adaptability, nutritional value, and relatively short production cycle (FAO, 2017). Despite these advantages, the crop is highly susceptible to post-harvest deterioration because of its perishability and vulnerability to physical damage. Losses may occur throughout the value chain, particularly during harvesting, handling, transportation, storage, and marketing, resulting in reductions in both the quantity and quality of produce reaching consumers and markets (Stathers et al., 2018). Evidence indicates that sweet potato PHL are influenced by several interacting factors, including farmer knowledge, storage conditions, access to appropriate technologies, market arrangements, and institutional support (Bechoff et al., 2022; Shee et al., 2019). Consequently, reducing PHL requires an integrated approach involving appropriate technologies, improved infrastructure, effective extension services, and stronger coordination among value-chain actors.

Agricultural extension services are particularly important in addressing PHL because they provide farmers with technical information, knowledge, training, and practical guidance on improved management practices. According to Fatty et al. (2021) extension providers can facilitate farmers' access to information on appropriate harvesting techniques, handling, curing, storage, packaging, transportation, and marketing practices, while also supporting the adoption and application of improved technologies. Evidence from agricultural value chains demonstrates that access to technical information and training can strengthen farmers' knowledge and uptake of recommended post-harvest technologies and practices (Odiaka & Ahungwa, 2021). Similarly, improved post-harvest technologies and infrastructure, when complemented by effective advisory services, can contribute to better management of agricultural produce and reduction of avoidable losses (Bechoff et al., 2022; Stathers et al., 2020). However, access to extension services remains uneven among smallholder farmers because of inadequate staffing, limited financial and logistical resources, geographical constraints, and weak farmer-extension linkages (Masanja et al., 2023).

Across Africa, PHL remain a significant constraint to food security, household income, and the efficiency of agricultural value chains. Smallholder farmers frequently operate under conditions characterised by inadequate post-harvest infrastructure, limited access to improved technologies, weak market systems, and insufficient technical support (Qwabe et al., 2022). In the sweet potato value chain, these constraints may contribute to losses arising from poor harvesting and handling practices, inadequate storage, transportation challenges, and limited value-chain coordination (Bechoff et al., 2022; Stathers et al., 2020). Evidence from South Africa, for example, indicates that losses in the sweet potato value chain are associated with handling practices, storage limitations, processing constraints, and weaknesses in coordination among value-chain actors (Motsa et al., 2025). More broadly, studies across African farming systems have demonstrated that extension-supported interventions can enhance farmers' awareness and uptake of recommended post-harvest practices. Fatty et al. (2021) reported that access to extension information enhanced farmers' knowledge of post-harvest technologies among horticultural farmers in The Gambia. Nevertheless, institutional and farmer-level factors continue to influence the accessibility and effectiveness of extension services among rural smallholders (Masanja et al., 2023).

In Kenya, agriculture remains central to rural livelihoods, food security, employment creation, and economic development, supporting millions of households through crop production and agricultural value chains (Kenya National Bureau of Statistics [KNBS], 2024). Sweet potato is an important crop for smallholder farmers because of its nutritional value, adaptability to diverse agro-ecological conditions, and contribution to household food security. However, the crop continues to experience post-harvest challenges associated with harvesting, handling, transportation, storage, pest infestation, and inadequate access to technical information (Victoria et al., 2021). These challenges can reduce the quantity and quality of marketable produce and consequently limit the income-generating potential of sweet potato production. Victoria et al. (2021), in studies conducted in Bungoma and Homa Bay Counties, identified weaknesses in harvesting, transportation, storage, and marketing practices that affected the quality and quantity of sweet potato reaching consumers. Similarly, Shee et al. (2019) demonstrated that PHL among smallholder producers are influenced by farmer characteristics, management practices, access to information, and supporting institutional services.

Despite the importance of sweet potato to food security and rural livelihoods, limited empirical evidence exists on the association between access to agricultural extension services and the magnitude of sweet potato post-harvest losses among smallholder farmers in Migori County, particularly in Kuria West Sub-County. Existing studies have largely focused on describing post-harvest losses, identifying their causes, or assessing post-harvest handling practices, with comparatively limited attention to differences in loss levels associated with farmers' access to agricultural extension services (Shee et al., 2019; Victoria et al., 2021). Furthermore, findings from other geographical settings may not adequately reflect conditions in Kuria West because PHL are shaped by local production systems, infrastructure, market conditions, farmer practices, and institutional support. This creates a need for context-specific evidence on the relationship between extension access and sweet potato PHL. Therefore, this study examined the association between access to agricultural extension services and PHL among smallholder sweet potato farmers in Kuria West Sub-County, Migori County, Kenya. The findings are intended to provide evidence for

strengthening extension interventions and post-harvest management strategies aimed at reducing losses and improving the livelihoods of sweet potato-growing households.

1.1 Objectives and Hypotheses

The specific objectives of the study were to: (i) determine farmers' access to agricultural extension services related to sweet potato post-harvest management; (ii) assess the quality of extension access among farmers who accessed the services; (iii) determine the magnitude of sweet potato post-harvest losses across the handling, transportation, storage and marketing stages; and (iv) examine the association between extension access quality and post-harvest losses, and compare loss percentages between farmers with and without access. Two null hypotheses were tested. H_{01} : there is no statistically significant relationship between the Extension Access Quality Index (EAQI) and the sweet potato post-harvest loss percentage among farmers who accessed extension services. H_{02} : there is no statistically significant difference in mean post-harvest loss percentage between farmers who accessed extension services and those who did not.

2. LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1 Access to Extension Services and Post-Harvest Losses

Agricultural extension services are important in helping farmers acquire and apply knowledge that can improve post-harvest management. However, their effectiveness depends not only on whether farmers receive information but also on the quality of services provided. Kassem et al. (2020) examined agricultural extension service quality in Egypt, highlighting the importance of accessibility and responsiveness in supporting farmers. Similarly, Kassem et al. (2021) assessed extension service quality using dimensions such as accessibility, relevance and effectiveness. These studies indicate that extension services should provide information that is accessible, timely and relevant to farmers' needs. For smallholder sweet potato farmers, this includes practical advice on handling, transportation, storage and marketing, since the usefulness of extension services depends partly on how well the information addresses farmers' post-harvest challenges.

Extension access quality is also important in determining whether agricultural advisory services respond effectively to farmers' needs. Kassem et al. (2020) examined farmers' access to and experiences with extension services, while Kassem et al. (2021) considered service quality in relation to accessibility, relevance and effectiveness. Their work suggests that the value of extension services depends on whether farmers can access the services, receive relevant information in good time and find the advice useful. Farmers' satisfaction and interaction with extension providers are also important considerations when evaluating service delivery. For smallholder sweet potato farmers, these dimensions are particularly relevant because advice must address practical post-harvest challenges, including handling, transportation, storage and marketing. Nevertheless, the extent to which these dimensions of extension access quality are associated with the percentage of sweet potato post-harvest losses among farmers in Kuria West Sub-County remains insufficiently established.

Research on sweet potato post-harvest losses shows that the magnitude of losses varies across locations, value-chain stages and measurement methods. Bechoff et al. (2022) estimated nutritional postharvest losses along the value chains of three food security commodities in sub-Saharan Africa, one of which was sweet potato, demonstrating that post-harvest losses can involve nutritional deterioration as well as physical loss. Richard et al. (2023) identified deterioration, dehydration and mechanical damage among the causes of sweet potato losses in Tanzania. Although these studies provide evidence of post-harvest challenges, nutritional loss estimates and reports of the causes of losses do not necessarily indicate the percentage of harvested roots physically lost by individual farmers. It is therefore important to distinguish between the prevalence of losses among farmers, nutritional deterioration and the proportion of harvested produce lost when comparing findings across studies.

Evidence from Kenya and other African countries further indicates that sweet potato losses occur at several stages of the value chain. Onyango et al. (2022) reported that handling and marketing activities contributed to physical damage and quality deterioration in sweet potato roots in western Kenya. Kimako et al. (2023) examined losses in sweet potato marketing channels, highlighting losses associated with wholesale and retail activities. Shee et al. (2019) also linked poor storage and transportation practices with physical damage and post-harvest losses in Uganda. Collectively, these studies suggest that losses can accumulate as sweet potatoes move from farms to markets. However, estimates based on traders, retailers or entire marketing channels may not represent the proportion of harvested produce lost by individual farming households. These differences highlight the importance of measuring losses consistently across handling, transportation, storage and marketing at the farm level.

2.2 Research Gap

Existing studies have examined agricultural extension service quality and sweet potato post-harvest losses, but the relationship between these variables remains insufficiently established in the context of smallholder farmers in Kuria

West Sub-County, Migori County. Kassem et al. (2020, 2021) examined dimensions of extension service quality, while Bechoff et al. (2022), Richard et al. (2023), Onyango et al. (2022), and Shee et al. (2019) investigated post-harvest losses or related management challenges across different geographical settings and value-chain stages. However, these studies do not directly establish whether the quality of farmers' access to extension services is associated with the percentage of sweet potato losses at the household level in Kuria West. Furthermore, differences in measurement approaches limit direct comparisons of loss estimates across studies. The present study addresses this geographical and empirical gap by examining farmers' access to agricultural extension services, assessing the quality of access in terms of accessibility, timeliness, usefulness, satisfaction and interaction with providers, and quantifying losses during handling, transportation, storage and marketing. It also examines the association between extension access quality and post-harvest losses among farmers who accessed services and compares loss percentages between farmers who accessed extension services and those who did not. The findings provide context-specific evidence to inform agricultural extension strategies aimed at reducing sweet potato post-harvest losses.

2.3 Theoretical Framework

This study was guided by the Diffusion of Innovations Theory developed by Rogers (2003), which explains how new ideas, technologies and practices are communicated and adopted within a social system over time. The theory identifies four key elements of diffusion: innovation, communication channels, time and the social system. In this study, improved sweet potato post-harvest management practices, including appropriate handling, sorting, grading and storage, represent the innovations, while agricultural extension services serve as important communication channels through which farmers receive relevant information and technical guidance. The theory is relevant because farmers' access to extension services may influence their awareness and understanding of recommended practices, while the perceived usefulness and practical applicability of the information may influence their willingness to adopt them.

The theory relates directly to the study variables: access to agricultural extension services and the percentage of sweet potato post-harvest losses. Extension access quality was assessed using five indicators: accessibility, timeliness, usefulness, satisfaction and interaction with extension providers. These indicators informed the Extension Access Quality Index (EAQI), which was correlated with post-harvest loss percentages among the 111 farmers who accessed extension services. An independent-samples t-test was also used to compare loss percentages between farmers who accessed extension services and those who did not. The theory provides a basis for interpreting these analyses by explaining how access to information may be associated with the application of improved post-harvest practices. However, because the study employed a cross-sectional design and did not directly measure the full innovation-adoption process, the findings establish associations and group differences rather than causation. Furthermore, factors such as storage facilities, transportation conditions and market arrangements may also contribute to variation in post-harvest losses.

3. MATERIALS AND METHODS

3.1 Study Area

The study was conducted in Kuria West Sub-County, Migori County, Kenya, which lies approximately between latitudes 1°00'S and 1°30'S and longitudes 34°20'E and 34°40'E, covering an estimated area of 210–250 km² (Kenya National Bureau of Statistics [KNBS], 2019). The area falls within the Lower Midland agro-ecological zone and receives approximately 800–1,200 mm of annual rainfall, with long rains occurring from March to May and short rains from October to December; temperatures range from approximately 18°C to 28°C (Jaetzold et al., 2019). Kuria West was purposively selected because the Kuria region is recognised as a major sweet potato-producing area in Migori County, with production supporting household food security and income generation. Reports on the region indicate that sweet potato cultivation expanded considerably, while the establishment of the Getong'anya sweet potato processing plant in Kuria West reflected the crop's production and value-addition potential. These characteristics make the sub-county an appropriate setting for examining farmers' access to agricultural extension services and post-harvest losses during handling, transportation, storage and marketing. The findings should, however, be generalised to other areas cautiously because production conditions and access to extension services may differ.

3.2 Research Design

This study used a cross-sectional correlational survey design. A cross-sectional survey was suitable because it allowed data collection at a single point in time, providing a snapshot of farmers' access to extension services and post-harvest losses (Creswell & Creswell, 2018). The correlational approach was appropriate for assessing the strength and direction of the relationship between extension access and PHL without manipulating variables, which was necessary in natural field settings (Kothari, 2004). While this design cannot establish causality, it enabled efficient data collection from a representative sample, helping the researcher determine whether improved access to

agricultural extension correlated with lower PHL, thereby guiding policy decisions and targeted extension programs (Creswell & Creswell, 2018).

3.3 Target Population and Sampling Procedures

The target population comprised smallholder households engaged in sweet potato farming in Kuria West Sub-County. According to KNBS (2019), the sub-county had approximately 53,465 households, of which 16,303 households actively participate in sweet potato farming. Therefore, the study focused on these 16,303 smallholder sweet potato farming households because they are directly involved in production, harvesting, handling, and post-harvest management activities.

Respondents were selected from the seven administrative wards of Kuria West Sub-County: Bukira East, Bukira Central, Isibania, Makerero, Masaba, Tagare, and Nyamosense. Stratified random sampling was used to ensure adequate representation of farmers across the wards. The population was divided into administrative strata, after which respondents were proportionately selected based on the number of sweet potato farming households in each ward. A sample size of 376 respondents was determined using the Krejcie and Morgan (1970) sample size determination approach.

3.4 Data Collection and Measurement of Variables

Data were collected using a structured household questionnaire administered to smallholder sweet potato farmers in Kuria West Sub-County. The questionnaire was designed to collect information aligned with the study objectives, including farmers' socio-demographic characteristics, access to agricultural extension services, extension service characteristics, and the magnitude of sweet potato post-harvest losses. The instrument captured information on extension service providers, channels of extension delivery, frequency of interaction with extension providers, accessibility, usefulness, timeliness, and farmers' satisfaction with extension services. PHL were assessed across four stages of the sweet potato value chain: handling, transportation, storage and marketing.

The questionnaire was pre-tested among 38 sweet potato farmers in Uiri Sub-County, Migori County, which has similar agro-ecological and socio-economic characteristics to Kuria West Sub-County. The pilot study was conducted to assess the clarity, validity, and reliability of the research instrument. Internal consistency was evaluated using Cronbach's alpha, with the overall reliability coefficient recorded at 0.96, indicating excellent internal consistency of the extension access measurement items. The independent variable was farmers' access to agricultural extension services, while the dependent variable was sweet potato post-harvest losses. Extension access was measured using both access status and quality dimensions, including accessibility, usefulness, timeliness, satisfaction, and frequency of interaction with extension providers. Post-harvest losses were measured as the percentage of harvested sweet potatoes lost during the post-harvest stages.

3.5 Data Analysis

Data were analysed using the Statistical Package for the Social Sciences (SPSS) Version 30. Descriptive statistics, including frequencies, percentages, means, and standard deviations, were used to summarise farmers' characteristics, access to agricultural extension services, and the magnitude of sweet potato post-harvest losses.

For the assessment of extension access, farmers were first categorised according to whether they had accessed agricultural extension services related to sweet potato post-harvest management. Farmers who reported access were further analysed based on service providers and extension delivery channels. Extension access quality was assessed using Likert-scale indicators covering accessibility, usefulness, timeliness, satisfaction, and frequency of interaction. Factor analysis was conducted to establish whether these indicators represented a common underlying construct, after which standardised factor scores were generated to create an Extension Access Quality Index.

The magnitude of sweet potato post-harvest losses was determined by calculating losses experienced during handling, transportation, storage and marketing. Farmers reported harvested quantities and quantities lost at each stage, which were converted into percentage losses to allow comparison among farmers with different production levels.

Pearson's correlation analysis was used to determine the relationship between extension access quality and sweet potato post-harvest losses among farmers who had accessed extension services. The analysis examined the direction and strength of association between the Extension Access Quality Index and post-harvest loss percentage. Before conducting correlation analysis, assumptions including normality, linearity, and absence of influential outliers were assessed.

An independent samples t-test was conducted to determine whether significant differences existed in post-harvest loss percentages between farmers who accessed agricultural extension services and those who did not. Farmers were grouped according to extension access status, and mean differences in post-harvest losses were compared between the two groups. Statistical significance was evaluated at the 5% probability level.

4. RESULTS AND DISCUSSION

4.1 Farmers' Access to Agricultural Extension Services

The study assessed farmers' access status to agricultural extension services related to sweet potato post-harvest management practices. Extension access status was measured based on whether respondents had received agricultural extension support for sweet potato production and post-harvest management activities. The distribution of farmers according to extension access status is presented in Figure 1.

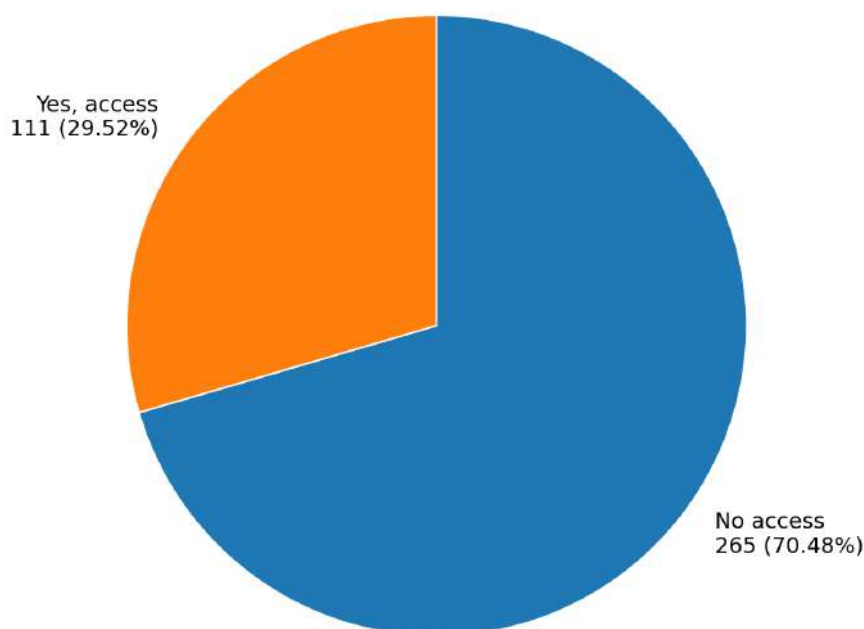


Figure 1. Extension Services Access Status of Respondents (N = 376)

The findings show that the majority of respondents ($n = 265$, 70.48%) reported no access to agricultural extension services, while ($n = 111$, 29.52%) reported having access. This pattern reflects a substantial gap in extension service coverage among sweet potato farmers, suggesting that most farmers remain outside the formal agricultural advisory system. This finding aligns with Masanja et al. (2023), who found that only 18.3% of rural farmers in Kibondo District, Tanzania, accessed agricultural extension services provided by private organizations. Although access was slightly higher in the present study, both studies show that many rural smallholder farmers remain underserved by agricultural advisory systems. Masanja et al. also reported that access to agricultural extension services among rural farmers in Tanzania remains constrained by institutional limitations, inadequate resources, and uneven service delivery. This suggests that limited access to extension services is not unique to Kuria West but reflects a wider challenge affecting smallholder farmers in East Africa.

Among the 111 farmers who reported access, the most frequently reported extension delivery channels were farmer field schools (78.38%), group meetings (70.27%), farm visits (29.73%) and demonstrations (14.41%) (Figure 2). Because respondents could report more than one channel, the percentages sum to more than 100%.

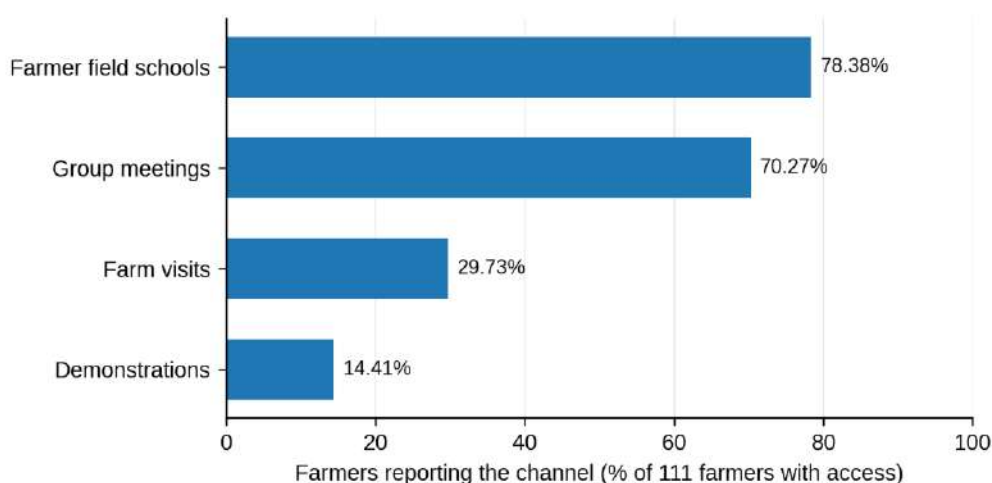


Figure 2. Extension Delivery Channels Reported by Farmers with Access to Extension Services ($n = 111$; Multiple Responses Possible)

4.2 Extension Access Quality

Extension access quality was assessed only among farmers who had accessed agricultural extension services. The five Likert-scale indicators included: satisfaction with extension services, perceived usefulness, timeliness of service delivery, ease of access, and frequency of interaction with extension providers. Satisfaction was scored from 1 = Very dissatisfied to 5 = Very satisfied; usefulness from 1 = Not useful to 5 = Very useful; timeliness from 1 = Very late to 5 = Very timely; and ease of access from 1 = Not accessible to 5 = Very easily accessible. Frequency of interaction was recoded as 1 = None, 2 = Once per year, 3 = 2–3 times per year, 4 = Monthly, and 5 = More than once per month, so higher scores consistently indicated better extension access quality.

The use of a multidimensional index was appropriate because agricultural extension quality is a complex construct that extends beyond whether farmers simply received extension services. Previous studies have demonstrated that farmers evaluate extension services based on multiple attributes, including accessibility, relevance, availability, responsiveness, and satisfaction with advisory support (Kassem et al., 2021).

The suitability of the five indicators for factor analysis was assessed using the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy and Bartlett’s Test of Sphericity. As presented in Table 1, the KMO statistic was 0.828, indicating good sampling adequacy, while Bartlett’s Test of Sphericity was statistically significant, $\chi^2 = 269.87$, $p < .001$. These results indicated that the correlation matrix was suitable for factor analysis. Principal Factor Analysis was used to examine the underlying dimensionality of the indicators.

Table 1. Sampling Adequacy Tests for Factor Analysis ($n = 111$)

Test	Statistic	Decision
Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy	0.828	Meritorious sampling adequacy
Bartlett’s test of sphericity	$\chi^2 = 269.87$, $p < .001$	Suitable for factor analysis

Note: KMO values above 0.60 indicate adequate sampling suitability for factor analysis.

Factor retention was guided by the initial eigenvalues and scree plot, with the eigenvalue-greater-than-one criterion also considered. As shown in Table 2, the first factor had an eigenvalue of 3.205 and explained 64.10% of the total variance. The remaining four factors had eigenvalues below 1.0 and were not retained. The scree plot was reported to show a clear break after the first factor, supporting a one-factor solution. Regression-based factor scores were subsequently generated to construct the Extension Access Quality Index (EAQI). The continuous factor scores were used in inferential analyses, while tertile categories were used only for descriptive presentation.

Table 2. Factor Retention for the Extension Access Quality Construct (n = 111)

Factor	Initial Eigenvalue	Variance Explained (%)	Cumulative Variance (%)	Decision
1	3.205	64.10	64.10	Retained
2	0.751	15.02	79.12	Not retained
3	0.492	9.83	88.95	Not retained
4	0.357	7.13	96.09	Not retained
5	0.196	3.91	100.00	Not retained

Principal Factor Analysis (Table 3) extracted one dominant factor, with standardised factor loadings ranging from 0.507 to 0.905. Satisfaction with extension services had the highest loading (0.905), followed by accessibility (0.784), timeliness (0.768), and perceived usefulness (0.766). Interaction with extension officers had the lowest loading (0.507) and the highest uniqueness (0.720). Although this indicator was less well represented by the retained factor than the other indicators, it was retained because interaction with extension officers represents a substantively relevant aspect of farmers' experience of agricultural extension services. Its retention was therefore based on its conceptual relevance to the construct, rather than on statistical performance alone.

Table 3. Factor Loadings for Extension Access Quality Indicators (n = 111)

Indicator	Factor loading	Uniqueness
Satisfaction with extension services	0.905	0.18
Accessibility of extension services	0.784	0.38
Timeliness of extension services	0.768	0.37
Perceived usefulness of extension services	0.766	0.38
Interaction with extension officers	0.507	0.72

Note: Extraction method: principal factor analysis. Only farmers who accessed extension services were included.

The uniqueness values ranged from 0.177 for satisfaction with extension services to 0.720 for interaction with extension providers, indicating the proportion of variance in each indicator not explained by the retained factor. The consistent factor loadings support the internal structure of the Extension Access Quality Index, suggesting that the five indicators captured a common underlying dimension of perceived EAQI.

The descriptive statistics for the EAQI are presented in Table 4. The index was treated as a standardised, regression-based factor score rather than a raw average of questionnaire responses. Higher scores represented relatively better perceived extension access quality within the study sample, whereas lower scores represented relatively poorer perceived quality. The continuous index was retained for inferential analysis, while tertile categories were used only to describe relative differences in perceived extension access quality.

Table 4. Farmers' Factor-Based Extension Access Quality Index (n = 111)

Index	Mean	Standard deviation	Minimum	Maximum
Extension Access Quality Index (EAQI)	0.00	1.00	-3.28	0.75

The EAQI had a mean of 0.00 and a standard deviation of 1.00, indicating that the regression-based factor scores were standardised. Therefore, the index does not represent a raw Likert average but rather a relative measure of perceived extension access quality among farmers who accessed extension services. Negative values indicate below-average perceived extension access quality, while positive values indicate above-average perceived quality within the study sample. The scores ranged from -3.28 to 0.75, demonstrating variation in farmers' experiences with extension services. This suggests that access to extension services did not necessarily provide uniform experiences regarding accessibility, usefulness, timeliness, satisfaction, and interaction.

The use of composite measures for extension service quality is supported by previous research, which shows that extension quality is multidimensional and influenced by several service attributes rather than a single indicator. For example, Kassem et al. (2021) assessed extension quality using dimensions such as accessibility, relevance, availability, and satisfaction, demonstrating that farmers' perceptions of service quality depend on multiple characteristics of advisory delivery. Similarly, Kumar et al. (2024) developed a multidimensional scale for assessing

agricultural helpline service quality, reinforcing the importance of composite measurement approaches for agricultural advisory services.

4.3 Magnitude of Sweet Potato Post-Harvest Losses

The study determined the magnitude of sweet potato post-harvest losses among smallholder farmers. The results showed that post-harvest losses were widespread among farmers. Out of 376 respondents, 352 (93.62%) experienced post-harvest losses during the harvesting season under study, while only 24 farmers (6.38%) reported no losses.

Thus, PHL for each respondent was expressed in kilograms using the formula.

$$\text{Total PHL (kg)} = H + T + S + M \quad (1)$$

where: H = handling losses (kg), T = transportation losses (kg), S = storage losses (kg), and M = marketing losses (kg).

$$\text{Total PHL (\%)} = [\text{Average losses in all stages of post-harvest management (kg)} \div \text{Average of total harvested (kg)}] \times 100 \quad (2)$$

After determining the total post-harvest loss percentage, the percentage attributable to each stage was calculated by dividing the quantity lost at that stage by the total quantity lost across all four stages and multiplying the result by the total post-harvest loss percentage:

$$\text{Stage-wise PHL (\%)} = [\text{Losses at specific stage (kg)} \div \text{Total losses at all stages (kg)}] \times \text{Total PHL (\%)} \quad (3)$$

Table 5. Experience of Sweet Potato Post-Harvest Losses among Farmers (N = 376)

Experience of post-harvest losses	Frequency	Percentage (%)
Experienced losses	352	93.62
Did not experience losses	24	6.38
Total	376	100.00

Source: Survey data (2026).

The high prevalence of post-harvest losses indicates that losses remain a major challenge within the sweet potato value chain in Kuria West Sub-County. This suggests that most farmers experience difficulties maintaining produce quality after harvesting, which may reduce household income and marketable output. The reported mean total post-harvest loss of 34.54% was based on the 352 respondents who reported experiencing post-harvest losses during the reference farming season. It represents the mean loss magnitude among these respondents rather than the proportion of farmers who experienced losses. The prevalence of post-harvest loss was assessed separately: 352 of the 376 respondents (93.62%) reported losses, while 24 (6.38%) reported no losses. These distinctions are important when interpreting the findings because the prevalence of loss, the magnitude of loss, and the relationship between extension access quality and loss magnitude represent different outcomes and analyses.

The quantitative magnitude of losses was further analysed across different post-harvest stages and results summarised in Table 6.

Table 6. Quantitative Magnitude of Sweet Potato Post-Harvest Losses (n = 352)

Variable	M (kg)	SD (kg)	Percentage (%)
Handling losses	235.31	131.31	10.37
Transportation losses	195.63	122.53	8.69
Storage losses	171.76	111.18	7.73
Marketing losses	177.14	130.50	7.75
Total post-harvest losses	779.84	353.93	34.54

Note: Only respondents who experienced losses were included. Source: Survey data (2026).

The results indicate that farmers lost an average of 34.54% of harvested sweet potato produce after harvesting. Handling losses constituted the largest proportion (10.37%), followed by transportation (8.69%), marketing (7.75%), and storage losses (7.73%).

The magnitude of losses observed in this study is consistent with evidence that post-harvest losses remain a major constraint within smallholder food systems in sub-Saharan Africa. Bechoff et al. (2022) demonstrated that losses

along food value chains reduce both nutritional availability and economic benefits, particularly where handling and storage systems are inadequate. Similarly, Stathers et al. (2020) reported that post-harvest loss reduction requires interventions across multiple stages of agricultural value chains rather than focusing on a single loss point. The finding also agrees with Richard et al. (2023), who identified handling and storage challenges as important contributors to sweet potato losses in Tanzania. However, the average loss level observed in the present study differs from some studies conducted in other contexts because post-harvest losses are influenced by crop varieties, climatic conditions, infrastructure availability, market arrangements, and farmer management practices.

4.4 Relationship between Extension Access Quality and Post-Harvest Losses

Pearson's product-moment correlation was used to test H_{01} by examining the association between the EAQI and post-harvest loss percentage among farmers who accessed agricultural extension services. Diagnostic assessment included examination of normality, linearity, and influential outliers. The Shapiro–Wilk test indicated a marginal departure from normality for EAQI ($p = .049$) and a statistically significant departure for PHL percentage ($p = .010$). However, the Q–Q plots showed only minor tail deviations, and the skewness coefficients were close to zero (EAQI = .043; PHL percentage = .055). Visual inspection of the scatterplot, fitted regression line, and LOWESS curve indicated an approximately linear relationship, and no influential outliers were identified. These findings supported the use of Pearson's correlation, although the departure from normality in PHL percentage should be acknowledged when interpreting the result. The association was statistically significant at the 5% level but weak in magnitude and does not establish causation.

Table 7. Pearson Correlation between the Extension Access Quality Index and Post-Harvest Loss Percentage ($n = 111$)

Variables	r	p	n
Extension Access Quality Index and post-harvest loss percentage	−0.202*	0.039	111

Note: * Significant at the 5% level. Source: Survey data (2026).

The correlation analysis revealed a low but statistically significant negative relationship between extension access quality and sweet potato post-harvest losses ($r = -.202$, $p = .039$). This indicates that improvements in extension access quality were associated with reductions in post-harvest losses among farmers who accessed extension services. The finding is consistent with the possibility that better extension access quality is associated with improved post-harvest outcomes through farmers' access to relevant knowledge and management practices. Farmers who receive timely and useful information may be better equipped to apply appropriate harvesting, handling, storage, and marketing practices.

The finding is consistent with Odiaka and Ahungwa (2021), who reported that agricultural extension services helped reduce post-harvest losses among yam farmers by improving farmers' knowledge and adoption of recommended practices. However, the low correlation observed in this study indicates that extension quality alone does not fully explain variations in sweet potato post-harvest losses. This finding is consistent with Stathers et al. (2020), who argued that successful post-harvest loss reduction requires complementary interventions, including improved technologies, storage facilities, infrastructure, and market systems. Therefore, while extension services represent an important pathway for reducing losses, their effectiveness depends on integration with broader value-chain interventions. Effective agricultural extension services should provide farmers with practical knowledge on post-harvest handling, storage, transportation, and loss reduction strategies. Kihoro et al. (2026) reported that farmers' training exposure and institutional support influence the adoption of post-harvest practices among smallholder farmers in Kenya.

4.5 Comparison of Post-Harvest Losses by Extension Access Status

Additionally, an independent samples t-test was performed to compare the mean PHL percentages between farmers who used agricultural extension services and those who did not, and to determine whether the difference was statistically significant. Before analysing the t-test results, the assumption of homogeneity of variance was checked using Levene's test. The magnitude of the difference between the two groups was further evaluated with effect size estimates, specifically Cohen's d and Hedges' g . The results are shown in Table 8.

Table 8. Independent-Samples t-Test of Post-Harvest Loss Percentage by Extension Access Status

Variable	No access ($n = 265$) M (%)	No access SD	Access ($n = 111$) M (%)	Access SD	$t(374)$	p
Post-harvest loss percentage	37.66	11.89	27.07	8.60	8.50	< .001

Note: $N = 376$; mean difference = 10.59 percentage points; 95% CI [8.14, 13.04]; Cohen's $d = 0.96$.

The results in Table 8 showed that smallholder farmers who did not access agricultural extension services had a higher average PHL percentage ($M = 37.66$, $SD = 11.89$) compared to farmers who did access these services ($M = 27.07$, $SD = 8.60$). This indicates a mean difference of 10.59 percentage points, with a 95% confidence interval from 8.14 to 13.04. Levene's test was not statistically significant ($F = 1.281$, $p = .259$), indicating that the assumption of homogeneity of variance was satisfied. Based on the assumption test, the appropriate independent-samples t-test results were analysed. The test revealed that the difference in mean PHL percentage between the two groups was statistically significant, $t(374) = 8.50$, $p < .001$.

The null hypothesis (H_{02}) stated that there was no statistically significant difference in the average post-harvest losses between farmers who used agricultural extension services and those who did not. The alternative hypothesis stated that there was a significant difference between the two groups. Since the p-value was less than the significance level of $\alpha = .05$, the null hypothesis was rejected, and the alternative hypothesis was supported. As a result, the study found a significant difference in sweet potato post-harvest loss percentages between farmers who accessed extension services and those who did not, with users experiencing lower average losses.

The magnitude of the difference was further analysed using Cohen's d and Hedges' g . The results indicated that Cohen's d was 0.96, and Hedges' g was also 0.96, signifying a large effect size following Cohen's (1988) guidelines. Therefore, the difference between farmers who accessed agricultural extension services and those who did not was not only statistically significant but also practically meaningful. The 10.59-percentage-point lower mean post-harvest loss observed among farmers with extension access suggests that access to extension services is strongly associated with reduced sweet potato post-harvest losses. However, since the independent samples t-test identifies group differences rather than causality, the findings should not be interpreted as evidence that extension access directly caused the reduction in post-harvest losses.

The findings also align with Odiaka and Ahungwa (2021), who studied the impact of agricultural extension services on post-harvest losses among yam producers in Benue State, Nigeria. Their research showed that agricultural extension services play a key role in reducing PHL by introducing farmers to better post-harvest management practices. Similarly, Njabulo et al. (2026) found that extension services were a significant factor influencing post-harvest losses among farmers growing grains, pulses, vegetables, and tree crops in KwaZulu-Natal, South Africa. These results support the notable difference observed in the current study between farmers with and without access to agricultural extension services. The current study is consistent with this, showing that, among smallholder sweet potato farmers in Kuria West Sub-County, access to extension services was linked to significantly lower post-harvest loss rates.

The findings are further supported by Amadu and McNamara (2024), who examined agricultural stakeholder panels and PHL reduction in Malawi, demonstrating the importance of institutional arrangements that enable access to post-harvest information and interventions. Similarly, Midamba and Kizito (2022) showed that access to training on post-harvest loss management among maize farmers in Uganda is crucial because training equips farmers with the knowledge and skills needed for better post-harvest practices. These studies emphasize the importance of access to agricultural information and capacity-building mechanisms in reducing PHL. In the context of this study, agricultural extension services may serve as a pathway for sweet potato farmers to receive guidance on harvesting, handling, storage, transportation, and other recommended post-harvest practices. Therefore, the significantly lower losses observed among farmers with extension access may partly result from differences in exposure to technical information and post-harvest management knowledge between the two groups.

4.6 Study Limitations

This study had several limitations that should be considered when interpreting the findings.

1. The cross-sectional design limited the ability to establish causal relationships between access to agricultural extension services and post-harvest losses. This limitation was addressed by interpreting the findings as associations rather than evidence that extension access directly caused a reduction in losses.
2. Post-harvest losses were based on farmers' self-reported estimates, which may have been affected by recall errors or inaccuracies in estimating quantities lost at different stages of the sweet potato value chain. The study assessed losses across handling, transportation, storage, and marketing stages to provide a structured account of reported losses. Nevertheless, the estimates should be interpreted with caution because they were not independently verified through direct physical measurements.
3. The correlation analysis between the EAQI and post-harvest losses was restricted to the 111 farmers who reported accessing agricultural extension services. This restriction was necessary because the EAQI measured perceptions of extension service quality among service users. Accordingly, the correlation was interpreted only in relation to these farmers and was not generalised to farmers who had not accessed extension services.

4. The study did not report adjusted analyses accounting for potential confounding factors. Storage facilities, transportation infrastructure, market conditions, and other relevant factors may have influenced post-harvest losses and the observed relationship with extension access. This limitation was acknowledged when interpreting the findings, and the results were not treated as establishing an independent causal effect of extension services. Future studies should incorporate these factors into multivariable analyses to determine whether the observed associations remain after accounting for their potential influence.

5. CONCLUSION AND POLICY IMPLICATIONS

This study examined access to agricultural extension services and sweet potato post-harvest losses among smallholder farmers in Kuria West Sub-County. Only 29.52% of respondents reported access to extension services, and 93.62% experienced post-harvest losses; among those reporting losses, the mean total loss was 34.54%, largest at the handling stage (10.37%) and followed by transportation (8.69%), marketing (7.75%) and storage (7.73%). Among farmers with access, extension access quality was weakly and negatively associated with post-harvest loss percentage ($r = -.202, p = .039$), and farmers without access had a higher mean loss (37.66%) than those with access (27.07%), a difference of 10.59 percentage points (95% CI [8.14, 13.04]; Cohen's $d = 0.96$). Because the design was cross-sectional, losses were self-reported and no adjusted analyses were conducted, these results indicate associations and group differences rather than a causal effect of extension services.

The findings suggest several policy priorities for agricultural extension and post-harvest loss reduction among smallholder sweet potato farmers in Kuria West Sub-County. Given that only 29.52% of respondents reported accessing agricultural extension services, the County Government of Migori and relevant agricultural agencies could consider strengthening extension coverage through improved deployment of extension officers and training of lead farmers in underserved communities. These measures may provide additional opportunities for farmers to receive practical guidance, although their effectiveness would need to be evaluated through subsequent implementation and monitoring.

The reported handling losses of 10.37% suggest that practical training in careful handling, sorting, grading, and packaging should be considered a priority within extension programmes. Such training could be coordinated with appropriate storage initiatives, improved transportation arrangements, and stronger links to buyers and processors. The Getong'anya plant could also be considered as a potential component of local market-support initiatives, subject to verification of its operational capacity and suitability for sweet potato processing or procurement.

These recommendations should be implemented alongside monitoring of extension coverage, farmer participation, storage access, market linkages, and changes in post-harvest losses. Future evaluations should assess whether the proposed measures are associated with measurable improvements in loss reduction and should account for relevant infrastructure, storage, and market conditions. The present study identifies priorities for policy consideration but does not establish the causal effectiveness of any particular intervention.

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