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POST-HARVEST LOSS REDUCTION STRATEGIES AND THEIR CONTRIBUTION TO HOUSEHOLD FOOD SECURITY AND NUTRITION IN KITUI COUNTY, KENYA

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ABSTRACT

Post-harvest losses (PHL) continue to threaten food security and nutrition in sub-Saharan Africa, where estimates suggest that 20–40% of cereals are lost before consumption. These losses diminish household income, reduce food availability, and worsen nutritional outcomes. Semi-arid regions such as Kitui County, Kenya, face even greater risks due to climatic variability, dependence on rain-fed agriculture, and the widespread use of traditional storage methods. This study sought to determine the main causes of PHL, document strategies used by smallholder farmers, and assess their perceived effectiveness. A cross-sectional descriptive survey was conducted in Kitui County, targeting 150 smallholder farmers selected through proportionate stratified random sampling. Data were collected using interviewer-administered questionnaires and observational checklists, then analysed with SPSS Version 23.0. Descriptive statistics, including frequencies and percentages, summarized the findings. Results revealed pest infestation as the leading cause of losses (62.7%), followed by poor storage facilities (54.7%) and inadequate drying practices (49.3%). Additional contributors included mold and rot from moisture (42.0%), delayed harvesting (38.7%), and poor transport or handling (30.7%). These findings mirror regional evidence highlighting similar structural and technical challenges. Farmers reported practicing proper drying (68.0%), sorting and grading (58.0%), and pest control (50.7%). Improved storage was less common: 43.3% used hermetic bags, while 34.0% used metal or plastic silos. Among all strategies, proper drying and silos were rated as the most effective. This aligns with broader research that underscores the importance of integrated post-harvest management for reducing cereal losses. Despite awareness of modern technologies, adoption remains low due to high costs, limited extension services, and weak rural infrastructure. Addressing these barriers will require scaling up affordable hermetic storage through subsidies or credit schemes, investing in drying infrastructure such as solar dryers and raised platforms, and strengthening farmer training on integrated PHL management. Reducing losses would not only safeguard household food stocks but also enhance food safety, improve rural incomes, and contribute to Kenya's broader goal of resilience against food insecurity. Effective interventions in Kitui and similar semi-arid regions could provide scalable lessons for improving food systems across sub-Saharan Africa.

Key words: post-harvest losses, smallholder farmers, Kitui County, hermetic storage, food security

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INTRODUCTION

Post-harvest losses (PHL) remain a significant challenge to food security and nutrition in sub-Saharan Africa, where an estimated 20–40% of harvested cereals are lost before consumption [1]. These losses reduce the supply of staple foods, diminish household incomes, and weaken nutritional outcomes. In semi-arid regions such as Kitui County, Kenya, the challenge is particularly severe. Erratic rainfall, high temperatures, and resource limitations interact with biological and socio-economic factors, intensifying risks of loss [2].

Kitui County's semi-arid farming relies on rain-fed crops. Maize dominates but suffers from unreliable rainfall, while sorghum and millet provide drought tolerance. Legumes such as beans, green grams, pigeon peas, and cowpeas are vital for food and income, with green grams valued for early maturity and market demand.

The causes of PHL are multifaceted. Insect pests, rodents, and fungal contamination are major contributors, but their impact is often exacerbated by weak infrastructure and limited farmer resources. Studies show that traditional storage structures, often constructed from mud, wood, or unsealed iron sheets, provide insufficient protection against pests and moisture. In contrast, hermetic bags and metal silos have proven effective in reducing losses, yet adoption remains constrained by high costs and limited accessibility [3,4]. This reflects a critical gap between the availability of technologies and farmers' capacity to access and use them effectively.

Moreover, moisture management remains central to grain preservation. Inadequate drying before storage creates conditions that favor fungal growth and aflatoxin contamination, with serious public health implications. Research from Kenyan maize systems shows that poor post-harvest practices not only increase losses but also compromise food safety [5]. This highlights the need for integrated strategies that address both technical and structural dimensions of PHL.

This study addresses the persistent challenge of post-harvest losses among smallholder farmers in Kitui County. It was guided by three main objectives: first, to identify the key drivers of post-harvest losses; second, to document the practices that farmers currently employ to reduce these losses; and third, to assess how farmers perceive the effectiveness of these strategies. By grounding the analysis in the realities of a semi-arid setting, the study not only generates evidence that is highly relevant to local conditions but also contributes to wider regional and global conversations on food security, agricultural resilience, and sustainable livelihoods.

The contribution of this research is threefold. Theoretically, it enriches the literature on PHL by showing how technical, socio-economic, and institutional factors intersect in smallholder systems. Practically, it captures farmers' experiences and identifies areas where interventions succeed or fall short, providing guidance for extension

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services, non-governmental organizations, and development partners. At the policy level, the findings align with Kenya's Post-Harvest Management Strategy: Food Loss and Waste Reduction Strategy 2024 [6], offering data to support targeted interventions such as subsidies for improved storage technologies, investment in rural infrastructure, and farmer training programs.

In summary, PHL in Kitui County are not only a result of pests and poor storage but also reflect broader structural and institutional barriers. By examining causes, practices, and perceptions, this study contributes to evidence-based solutions aimed at reducing losses, safeguarding food safety, and strengthening livelihoods in Kenya's semi-arid regions.

MATERIALS AND METHODS

This study was carried out in Kitui County, located in eastern Kenya approximately 160 kilometres southeast of Nairobi. The county is classified as semi-arid and is characterized by smallholder farming systems that are highly vulnerable to climatic variability.

A cross-sectional descriptive study design was adopted to investigate the main causes of post-harvest losses (PHL), the strategies employed to mitigate them, and farmers' perceptions of their effectiveness. This design was considered appropriate because it enabled the collection of data reflecting farmer practices and experiences at a single point in time.

The study population comprised smallholder farmers engaged in both crop production and storage. For the purpose of this research, smallholders were defined as those cultivating less than five hectares of land, relying primarily on family labour, and producing mainly for household consumption with only a limited surplus for sale [7]. Large-scale commercial farmers, who manage larger tracts of land, employ hired labour, and primarily produce for commercial markets, were excluded. Eligibility criteria required participants to be at least 18 years old, to have been engaged in crop production and storage within the preceding 12 months, and to provide informed consent. Farmers who had not stored produce from the most recent harvest or who were unable to participate due to illness or communication barriers were excluded.

A sample size of 150 respondents was determined to ensure adequate representation of farmers across the county. Proportionate stratified random sampling was employed, with administrative wards serving as strata. Lists of farmers were compiled with the assistance of local administration and agricultural extension officers, and respondents were then randomly selected within each stratum. This procedure enhanced representativeness and minimized selection bias.

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Data were collected using a structured, interviewer-administered questionnaire that elicited information on socio-demographic characteristics, farming practices, perceived causes of PHL, mitigation strategies, and assessments of their effectiveness. The questionnaire contained both closed- and open-ended items, allowing for quantitative analysis while capturing contextual insights. To complement self-reported data, an observational checklist was used to document the condition of storage facilities, drying surfaces, and other relevant infrastructure, thereby strengthening the reliability of findings.

Study variables were defined in advance to guide the analysis. The dependent variables comprised the reported causes of post-harvest losses, such as pest infestation, inadequate drying, mold growth, poor storage facilities, and handling constraints. They also included the strategies that farmers employed to mitigate these losses, such as proper drying, sorting and grading, hermetic storage, the use of silos, refrigeration, and traditional preservation methods. In addition, the perceived effectiveness of each strategy was measured and classified as very effective, moderately effective, slightly effective, or not effective. The estimated proportion of the harvest lost was also considered a dependent variable. The independent variables included socio-demographic characteristics such as age, gender, and level of education, as well as farming characteristics including land size under cultivation and the main livelihood activity. Access to storage facilities and agricultural extension services were also examined as independent variables likely to influence outcomes.

Data were checked for completeness, coded, and analyzed using the Statistical Package for the Social Sciences (SPSS, Version 23.0; IBM Corp., Armonk, NY, USA). Descriptive statistics, including frequencies and percentages, were used to summarize categorical variables, while means and ranges were computed for continuous variables such as land size. Results were presented in tables and narrative summaries to illustrate key patterns and trends.

Ethical principles were observed throughout the study. Written informed consent was obtained from all participants, and participation was voluntary. Confidentiality and anonymity of responses were assured, and the local administration was informed prior to data collection.

RESULTS AND DISCUSSION

Demographic Characteristics of Study Participants

The demographic characteristics of farmers in Kitui County provide valuable insights into the social and structural contexts within which post-harvest practices occur. The study revealed a relatively balanced gender distribution, with women slightly outnumbering men. This balance underscores the shared responsibilities of men and

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women in agricultural production and post-harvest handling, while also reflecting women's traditional role in food storage, household nutrition, and small-scale marketing, which likely explains their modest overrepresentation [8]. Recognizing the gendered dimensions of post-harvest management is essential for designing interventions that are inclusive, effective, and responsive to the lived realities of farming households.

The age profile indicated that farming is primarily sustained by younger and middle-aged adults, though older farmers continue to make significant contributions. This generational mix demonstrates that while experience remains a valuable asset, the bulk of agricultural labour is carried out by younger cohorts who form the backbone of farm productivity [9]. However, this reliance on younger adults also raises concerns about the sustainability of labour supply, as recent studies highlight the declining interest of youth in agriculture due to limited profitability, migration to urban areas, and aspirations for non-farm employment. These dynamics present both opportunities for innovation and challenges for the continuity of farming traditions in semi-arid areas such as Kitui.

Educational attainment among respondents varied considerably, with 40 percent reporting tertiary or university-level training. For a rural setting, this is a relatively high proportion, signalling expanded access to education and potentially greater openness to adopting new technologies and practices. Education enhances farmers' ability to access extension services, manage farm records, and critically evaluate innovations, thereby strengthening their adaptive capacity [10]. At the same time, the presence of farmers with only primary or secondary education, and some with no formal schooling, highlights disparities that must be accounted for in the design of communication and training strategies. Extension messages and technical innovations should therefore be tailored to accommodate different levels of literacy and technical understanding.

Livelihood strategies also reflected considerable diversity, with households engaging in mixed farming, specialized crop or livestock farming, and non-farm activities. This diversification demonstrates the pragmatic adaptation of households to the risks and uncertainties associated with semi-arid environments. Non-farm income provides a buffer against agricultural shocks, while mixed farming spreads risks across production systems [11]. However, livelihood diversification can also dilute labour and investment in farming, potentially constraining the adoption of intensive or specialized post-harvest management practices.

The average cultivated land size of 2.82 acres places most respondents firmly within the smallholder category. Such small landholdings, which are consistent with national and regional trends, reflect structural challenges such as land fragmentation

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and inheritance practices. Limited farm sizes constrain economies of scale, reduce surplus production for the market, and restrict the capacity to invest in improved technologies or infrastructure [12]. This structural limitation not only undermines productivity but also exacerbates vulnerability to post-harvest losses, since smaller harvest volumes offer less margin to absorb losses.

Taken together, the demographic profile of farmers in Kitui County highlights both strengths and vulnerabilities. The active participation of women, the dominance of younger age groups, and relatively high levels of education signal potential for innovation and adoption of improved post-harvest practices. Yet, constraints related to small land sizes, diverse but fragile livelihood strategies, and uneven educational attainment limit resilience. These findings underscore the need for gender-sensitive, youth-focused, and context-specific interventions that enhance the adaptive capacity of farmers while addressing structural barriers to productivity and food security.

Causes of post-harvest losses among farmers in Kitui County

The study highlights the multifactorial nature of post-harvest losses among smallholder farmers in Kitui County, with pest infestation emerging as the most significant contributor, followed closely by poor storage facilities, inadequate drying, and moisture-related damage. These findings underscore that losses are not driven by a single cause but arise from interconnected weaknesses across the post-harvest value chain, encompassing storage, drying, harvesting, transport, and market dynamics [13]. The dominance of pest infestation, reported by 62.7% of respondents, reflects systemic vulnerabilities in pest management and the continued reliance on traditional storage structures that offer limited protection against insects and rodents. Such pests not only reduce the volume of marketable produce but also compromise grain quality, diminishing household food reserves and market value.

Poor storage facilities, cited by 54.7% of farmers, and inadequate drying, reported by 49.3%, further reveal how structural constraints and environmental variability exacerbate losses. Traditional mud-walled granaries and open-air drying practices remain widespread in semi-arid regions, leaving produce vulnerable to moisture fluctuations and contamination. The consequences of these practices are evident in the 42.0% of respondents who attributed losses to mold and rot, highlighting both quantitative losses and qualitative risks such as aflatoxin contamination, which is a major public health concern in Kenya [14].

These findings align with recent studies across sub-Saharan Africa that consistently identify pest infestation and poor storage as the most persistent contributors to grain losses [15,16]. The role of moisture-induced spoilage mirrors evidence from Kenya and Tanzania, where open-air drying under unpredictable weather conditions leaves

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crops susceptible to aflatoxin contamination with severe implications for both human health and international trade [17]. Similarly, delayed harvesting, reported by 38.7% of respondents, is consistent with research from Malawi and Zambia showing that harvest timing significantly affects grain quality and vulnerability to field pests [18]. Crops left in the field beyond their physiological maturity are more likely to be attacked by insects, over-dried, or damaged by rainfall, all of which reduce both yield and quality.

Transport and handling challenges, identified by 30.7% of farmers, also illustrate another weak link in the post-harvest chain. Inadequate road infrastructure, the use of poor-quality sacks, and reliance on manual handling increase risks of spillage, breakage, and contamination. Regional evidence confirms that infrastructure bottlenecks remain structural drivers of post-harvest losses, particularly in remote rural areas where farmers face long distances to markets and limited access to affordable packaging [17].

The identification of market delays and low prices by 23.3% of farmers highlights that post-harvest losses are not only technical problems but also institutional and economic challenges. Farmers often postpone sales in anticipation of better prices, but weak market systems and storage constraints force them to keep produce under suboptimal conditions, thereby increasing exposure to pests, mold, and spoilage. This finding builds on recent work in Kenya showing that poor market integration and price volatility exacerbate losses in smallholder systems [10].

Taken together, these findings demonstrate that post-harvest losses in Kitui County are shaped by a complex interplay of biological, technical, infrastructural, and economic factors. Addressing them requires an integrated approach that goes beyond technical fixes to include investments in infrastructure, strengthened market systems, and improved extension services. Only by tackling the multifaceted nature of these losses can food security, farmer livelihoods, and public health be meaningfully improved in semi-arid Kenya.

Post-Harvest Loss Reduction Strategies in Kitui County

The study shows that smallholder farmers in Kitui County use a variety of strategies to reduce post-harvest losses. These approaches reflect both the persistence of long-established traditional practices and the gradual uptake of modern technologies [13]. The range of methods demonstrates farmers' ability to adapt to the risks of semi-arid conditions, while at the same time highlighting the structural and economic barriers that limit wider access to improved solutions.

Proper drying before storage was the most widely reported method, practiced by 68.0 percent of respondents. Drying is fundamental to grain preservation because moisture levels strongly influence storage quality, pest infestation, and fungal

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contamination. In Kenya, inadequate drying has been directly linked to aflatoxin contamination, which threatens both public health and agricultural trade [22]. Although many farmers are aware of the importance of drying, reliance on open-air techniques exposes produce to sudden rainfall, dust, and livestock. Investment in affordable technologies such as solar dryers and raised drying platforms would help address these vulnerabilities.

Sorting and grading were reported by 58.0 percent of farmers. These practices reduce losses by removing damaged or infested grains and also improve market value, since buyers increasingly demand higher quality produce. Pest control was another common strategy, reported by 50.7 percent of respondents. While many farmers depend on chemical pesticides, these methods present risks of high costs, environmental impacts, and health concerns [23]. Expanding access to integrated pest management approaches could provide safer and more sustainable alternatives.

Hermetic storage bags and silos have begun to gain traction, with 43.3 percent of farmers reporting use of hermetic bags and 34.0 percent using silos. These technologies reduce oxygen in storage environments, limiting pest survival and maintaining grain quality (15). Despite their proven effectiveness, adoption remains moderate. Similar to evidence from other counties in Kenya and from Tanzania, slow uptake is attributed to high initial costs, limited availability in rural areas, and inadequate extension support to promote knowledge and skills [14,23].

Other strategies included milling or additional drying, reported by 29.3 percent of respondents, and the use of pallets to keep produce off the ground, reported by 25.3 percent. These methods extend storage life but do not fully protect against systemic challenges such as aflatoxin contamination. Refrigeration, reported by 12.7 percent of farmers, was mainly used for perishable produce such as fruits and vegetables. Its limited adoption reflects challenges of affordability and access to reliable electricity. Traditional practices, including the use of ash, plant extracts, and raised platforms, were reported by 8.0 percent of farmers. Although their effectiveness is limited, they persist because of cultural familiarity and low cost.

These findings are consistent with studies that identify drying and hermetic storage as among the most effective interventions for reducing cereal losses in sub-Saharan Africa [24]. The continued reliance on traditional methods is also consistent with evidence from Ethiopia and Uganda, where cultural familiarity and affordability sustain their use despite limited effectiveness [21]. The moderate adoption of improved storage technologies suggests that farmers in Kitui are in a transition phase of post-harvest management. While knowledge and awareness of effective technologies are increasing, systemic barriers such as affordability, limited

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infrastructure, and weak extension services continue to constrain widespread adoption.

The evidence underscores the need for integrated approaches that combine farmer training, affordable access to hermetic storage, investment in drying technologies, and promotion of safe pest management practices. By addressing these barriers, policymakers and development partners can help accelerate the transition from traditional to modern approaches, reduce losses, improve food safety, and enhance rural livelihoods in semi-arid Kenya.

CONCLUSION AND RECOMMENDATIONS FOR DEVELOPMENT

This study shows that post-harvest losses in Kitui County are primarily caused by pest infestation, poor storage facilities, and inadequate drying practices. While many farmers are aware of preventive measures such as proper drying and sorting, the use of modern technologies like hermetic bags and silos remains limited. Barriers such as high costs, weak extension services, and poor rural infrastructure reduce the effectiveness of existing interventions. These findings highlight that PHL are not only technical problems but also structural and institutional challenges.

Addressing these losses requires a development-oriented approach that expands access to affordable storage technologies through subsidies or credit schemes, supports investment in drying infrastructure such as solar dryers, and strengthens extension services to promote integrated management practices that combine drying, storage, and pest control. Rural infrastructure improvements, including better roads, markets, and storage facilities, are equally essential to reduce transport and handling-related losses. Blending traditional methods like botanical repellents with modern innovations can also improve acceptance and cost-effectiveness. Development policies should therefore prioritize post-harvest management as a pathway to improved household resilience, nutrition, and income security, directly supporting Kenya's food loss reduction strategy and the global goal of zero hunger.

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Conflict of interest

The authors declare that they have no conflict of interest.

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370 **Table 1: Demographic characteristics of the study participants (n = 150)**

Variable	Category	Frequency	Percentage (%)
Gender	Male	72	48.0
	Female	78	52.0
Age group (years)	18–29	38	25.3
	30–39	43	28.7
	40–49	38	25.3
	50+	31	20.7
Education level	None	24	16.0
	Primary	33	22.0
	Secondary	33	22.0
	Tertiary/College/University	60	40.0
Main livelihood	Crop farming	27	18.0
	Livestock farming	36	24.0
	Both crop and livestock farming	46	30.7
	Other (non-farming)	41	27.3
Land size (acres)	Mean (± SD)	2.82	—
	Median	2.75	—
	Minimum	0.6	—
	Maximum	5.0	—

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Table 2: Causes of post-harvest losses among farmers in Kitui County (n = 150)

Cause of post-harvest loss	Frequency	Percentage (%)
Pest infestation (insects, rodents)	94	62.7
Poor storage facilities	82	54.7
Poor drying practices	74	49.3
Mold or rot due to moisture	63	42.0
Delayed harvesting	58	38.7
Poor transport/handling	46	30.7
Market delays/low prices	35	23.3
Other (weather, labour shortages)	11	7.3

Table 3: Strategies for reducing post-harvest losses among farmers in Kitui County (n = 150)

Strategy	Frequency	Percentage (%)
Proper drying before storage	102	68.0
Sorting and grading	87	58.0
Pest control (chemical/natural)	76	50.7
Use of hermetic storage bags	65	43.3
Use of metal/plastic silos	51	34.0
Processing (milling, drying)	44	29.3
Use of pallets (off-floor)	38	25.3
Refrigeration (perishables)	19	12.7
Other (traditional methods)	12	8.0

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