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Logistics Management Practices and Post-Harvest-Loss Among Small-Scale Banana Farmers in Selected Counties in Kenya

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Abstract

Banana production as a food crop component cannot be underestimated. Bananas are currently ranked fourth among foods produced worldwide. The study aimed to investigate the effects of logistics management practices on post-harvest loss among small-scale banana farmers in selected counties in Kenya. The study used a cross-sectional research design. The target populations were small- scale banana farmers from three selected banana-producing counties in Kenya. The study's sampling frame was a list of 14,447 farmers from three selected counties. The researcher stratified the counties and used a table of random numbers to pick farmers. Data were collected using a semi-structured questionnaire. Descriptive and inferential statistics were used to analyze the data in SPSS. The findings reveal a significant negative relationship between logistics management practices and post-harvest losses among small-scale banana farmers ($\beta = -0.536$, $p = 0.000$). The study concludes that effective logistics management can significantly reduce post-harvest losses. The study recommends that small-scale banana farmers focus on efficient transportation methods and consider traditional technologies. County governments need to train banana farmers on best practices for handling bananas to prevent damage during harvest and post-harvest stages.

Keywords: *Logistics Management Practices, Post-Harvest Loss, Small-Scale Banana Farmers*

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1. Introduction

Post-Harvest Loss (PHL) is a global challenge that does not occur by chance but results from inadequate logistics management practices (LMP) throughout the food value chain, especially in developing countries (Tarabay et al., 2018; Parmar et al., 2018; Shee et al., 2023; Kasso et al., 2018; Shahbazi, 2025). PHL significantly impacts global food production, leading to serious issues such as food insecurity, economic losses, and environmental degradation. Addressing this problem has attracted global attention due to its far-reaching consequences; it is therefore included in the SDGs agenda. Reducing PHL can lead to multiple benefits, including improved food security and nutrition, reduced hunger, environmental conservation, and poverty alleviation, as stated in SDG 1 and SDG 2 (Osabohien et al., 2023; Ali et al., 2025).

Post-harvest losses contribute to reducing greenhouse gas emissions and easing the strain on natural resources such as land and water (Totobesola et al., 2022). Achieving these outcomes requires farmers and supply chain actors to adopt effective LMPs that minimize losses and enhance sustainability across the food system.

The debate on PHL management began in 2014, when African countries committed to the Malabo Declaration to end hunger by 2025. The declaration focused on PHL management, emphasizing the effective use of LMP to achieve its hunger management objective. The PHL challenge affects both non-perishable and perishable food products. EAC (2022) report suggests that up to "70% of fruits and vegetables, 50% of cereals, and 30% of tubers of total production are lost in the supply chain" due to inefficient logistics practices. To increase food security in the region, the session developed a public-private collaboration platform to address PHL issues in fruits and vegetables by identifying best PHL practices and integrating modern logistics technologies to curb them. The suggested practices included establishing collection points, developing community cold storage facilities, and using improved post-harvest handling equipment to reduce PHL.

Horticultural losses amount to 20%-30% of total farm production, and 60% of these losses occur in horticultural products, according to a study conducted in Kenya on inefficient logistics practices (Ridolfi, 2018). reports that post-harvest losses of fruits and vegetables account for the largest share of supply chain losses, estimated at 30% to 50%, according to Oballah (2026). A study conducted in Ethiopia by Kasso et al. (2024) on PHL horticultural products suggests that 20%-50% of products are lost between harvesting and consumption due to poor handling practices. The studies further suggest that PHL not only depletes natural resources but also negatively impacts the triple bottom line of farmers and all actors in the supply chain. Teffera (2022) suggests that PHL in developing countries occurs at the post-harvest and processing stages, accounting for more than 40% of the produce, whereas in developed countries it occurs at the retail and consumption stages at the same 40%. Rockefeller Foundation (2018) further suggests that food lost during PHL could feed an estimated 48 million people in Sub-Saharan Africa, thereby easing pressure on the hungry population and helping achieve SDG 2.

Ridolfi et al (2018), in a study of PHL of fruits and vegetables in Kenya, conducted on two horticulture farm products, that is, mangoes and tomatoes, determined that PHL problems in the two products can be viewed from three perspectives, which are technological, economical, and institutional. Previous studies on mangoes in PHL reported losses of 25% to 44% across the entire SC. A high percentage of losses occur on the farm before or during harvesting due to improper LMP caused by inefficiencies in harvesting, handling, packaging, storage, and transportation. Lastly, a lack of market information and insufficient market facilities are also cited as causes of PHL. The study's findings suggest that PHL leads to economic losses for SC actors. The study further suggests that institutional arrangements, such as contract farming, could be used to minimize these transaction costs and PHL.

1.1 Problem Statement

The surging world population is exacerbating food insecurity, especially in the Global South, where structural problems in food production, distribution, consumption, and pricing remain widespread. Additionally, post- harvest loss is a major problem in developing countries where around 470 million smallholder farmers who are part of the global supply chain, lose up to 15%

of their income to food losses and 15% -70% of farm produce due to inefficient logistics management practices (FAO et al., 2017; Etefa, 2022).

Post-harvest losses have been a long-standing problem in Africa for nearly two decades. Post-harvest loss is a global problem that does not happen by accident; it results from sub-optimal decisions by supply chain actors, leading to low farmer incomes, poor nutritional value, and high consumer prices (IGAD report, 2018). Several IGAD states suggest that poor logistics management practices and insufficient funding for post-harvest investment are common causes of PHL in the agricultural supply chain (IGAD, 2021).

Additionally, the PHL problem is compounded by the fact that many researchers in developing countries focus on increasing food production in the upstream supply chain, leaving PHL management unaddressed. In the Kenyan context, most research, including Karienye et al. (2020) and Wahome et al. (2021), has focused on improving banana production and managing banana diseases, with PHL management largely disregarded in recent studies. Moreover, in Sub-Saharan Africa, major causes of post-harvest loss of non-perishable products result from insufficient logistics management practices (Stathers, 2020). The PHL problem has been identified through the methodologies applied, which indicate that most PHL data are derived from secondary estimates that may be inaccurate (FAO, 2023; AUC, 2018; 2020). For example, the FAO (2023) estimate is based on academic literature, which may not be sufficient to describe the PHL problem.

Furthermore, from a policy perspective, PHL problems are tied to SDG 12, which calls for sustainable production and consumption to enhance food security, and SDG 2, which calls for the elimination of hunger by 2030. The AUC (2018) report indicates that despite Kenya having identified agriculture as a key pillar in Vision 2030, and Kenya having a number of policy documents, including "*The Kenya Strategy for Post-Harvest Loss Reduction: 2018 – 2025*", Agriculture Sector Development Strategy, Food and Nutrition Security Policy, and the National Food Safety Policy. PHL management was not identified as a key constraint to achieving food security in Kenya, yet it is a global problem. These frameworks provide limited emphasis on logistics-specific interventions.

Finally, based on several literature reviews, PHL studies have also focused on non-perishable products, and most available data concern them. In this case, the study will focus on bananas, a perishable product. The study is further supported by FAO (2023) & AUC (2018) reports, which call for extensive research on PHL studies of perishable products and analyses of PHL estimations. Post-harvest loss is one of the major problems identified in the SDGs goals as a major contributor to global food insecurity. PHL, if well managed, can reduce hunger and improve the overall efficiency of the agricultural supply chain. PHL problems have been better managed in developed countries, leaving developing countries to struggle with the situation. The PHL problem identified creates a significant empirical gap, particularly for perishable crops such as bananas, where losses are highly sensitive to handling, transportation, and storage conditions.

1.2 Research Objective

To examine the effect of logistics management practices on post-harvest loss among small-scale banana farmers in selected counties in Kenya.

1.3 Research Hypothesis

Ho_1: There is no relationship between Logistics management practices and post-harvest loss among small-scale banana farmers in selected counties in Kenya.

2. Literature Review

2.1 Theoretical Review

Coase (1937) coined the term Transaction Cost Theory and focused on the "nature of the firm," arguing that organizations are formed to maximize profit and that the only way to achieve this objective is to minimize transaction costs. Um et al. (2019) view transaction costs as a means of exchanging information, knowledge, and other resources, and coordinating them across an integrated network of organizations, with the aim of reducing operational costs. Ketokivi (2020) demonstrates that the relationship between transaction costs and firm governance is vital and highlights the need for actors to coordinate and collaborate to reduce operational costs.

TCT was further advanced by Williamson (1993), who argues that transaction costs are integral to a firm's operations and seeks to identify areas within an organization where costs can be minimized to gain an advantage over competitors in an industry. Williamson (1975) explains transaction costs in relation to human beings and the problem of making decisions under limited resources. Um et al. (2019) suggest that transaction costs can be minimized by engaging in SCC, in which partners acquire and use each other's resources. To minimize transaction costs, partners in SC can engage in opportunistic behavior that favors them. It is therefore important for small-scale farmers to consider both human and environmental factors at every stage of the SC to manage PHL and reduce transaction costs.

Williamson (1998) categorizes a firm's assets into five: site or location, physical assets, human capital, linkages, and dedicated relationships. The location of members in the supply chain has a major effect on logistics-related operational costs, which can increase PHL if not well managed. Secondly, physical assets are part of logistics management practices and technological resources used by the organization to carry out the firm's daily operations. Thirdly, human capital and time investment are required to enable supply chain collaboration among members and to integrate the logistics process within the supply chain. Finally, linkages occur through relationship management and supply chain collaboration, which use technology to bring people and products together. To minimize PHL, farmers must invest in appropriate post-harvest logistics facilities, resources, knowledge, and technology, and leverage market information and SC governance to curb PHL in banana.

Information-related costs are part of transaction costs and account for up to 70% of transaction costs, representing 15% of total farmers' production costs (Tripathi et al., 2023). The transaction costs problem affects farmers far from the market due to inadequate market information. According to Patil et al. (2024), transaction costs are related to market information costs and include information-gathering, transportation and storage, and technology-related costs to ensure products remain in good condition as they move along the SC. Chen et al. (2022), suggests that market information costs are related to the use of technology and could be a barrier to farmers accessing markets if not availed at the right time, leading to failure of farmers reaching the market at the right time and selling their products at the required prices, which in turn reduces farmers' profits and incase of fresh products, increases PHL.

According to Patil et al. (2024), access to market information provides farmers with timely, accurate, and reliable information on prices and market trends, giving them an upper hand in negotiations. Saparova et al. (2024) suggest that access to timely information helps farmers decide when and where to sell their produce, thereby reducing transaction costs. Market information helps farmers make better decisions about production quantities and related logistics. According to Ketokivi et al. (2020), Market information helps farmers better understand the market, which in turn helps them optimize transportation and storage, thereby reducing transaction costs.

According to Liao et al. (2017), who argue that despite the importance of access to market information, small-holder farmers face challenges ranging from high transaction costs related to insufficient information. Rutatola et al. (2024) argue that market information affects farmers' participation in the market. Farmers in remote areas face information asymmetry, which sometimes forces them to rely on intermediaries with better market knowledge to provide logistics and distribution services. Farmers' failure to make such decisions on time and on where and when to sell fresh produce will automatically increase PHL in the supply chain.

Ketokivi et al. (2020) view transaction costs as a firm's ability to economize on its operations by identifying areas prone to waste and reducing them. Chen et al. (2022) suggest that transaction-related costs could be eliminated through the use of information technology in SC governance, thereby improving economic efficiency. structure. A food governance structure is required in any food supply to manage transaction costs. Governance structures tend to manage interrelations within the food supply chain to mitigate related or potential supply chain risks, as noted by PHL Cuypers et al. (2021). The TCT suggests that transaction costs affect governance and depend on three factors: competency, which ensures that activities are assigned correctly to the appropriate technology; the actors' influence on others' actions in the SC; and the efficiency of transactions in SC governance. Ketokivi et al. (2020) suggest that digitization and technology use have enabled supply chain governance to reduce transaction costs in logistics activities.

Kraak et al. (2024) argue that food governance requires the convergence of food actors across different levels and the integration of SC operations, thereby enabling their convergence in the supply chain. The convergence of supply chain actors enables effective management of logistics activities. Borella et al. (2018) suggest that governance mechanisms include collaborative actions and joint efforts when managing logistics activities to reduce waste and PHL. The governance structure consists of those who wield power, e.g., in the food SC, the government, suppliers of inputs, logistics providers, and brokers, and those down the chain who depend on the power brokers, like farmers. For supply governance to be successful, all parties must be involved. Governance structures encourage transparency and information sharing across the supply chain through digital platforms, thereby reducing risks related to overproduction and a lack of market information, which could otherwise have increased PHL.

The TCT is of great importance to this study as it will help the farmers to determine transaction costs of supply chain operations, including coordination, collaboration, integration, logistics operations, waste reduction aspects, and technology aspects, which can help small-scale farmers to minimize the transaction costs and maximize their profits by reducing PHL. The application of the theory also informs the study of how small-scale banana farmers assess

uncertainty in their operating environment, including technological, demand, and behavioral uncertainty.

2.2 Empirical Review

Logistics management is the art and science of planning, controlling, and managing the flow of goods from the point of origin to the point of consumption, including activities such as packaging, storage, warehousing, materials handling, and transportation, in an efficient and effective manner.

According to Regattieri (2018), packaging is a component of logistics management that protects and contains products during storage and transport. Packaging is a coordinated system used to contain and protect goods, enabling safe transportation, distribution, storage, and retailing (Etefa et al., 2022). Packages are used to minimize damage to goods during storage and transit (Verghese et al., 2015; Schudel et al., 2023). Packaging plays an important role in food SC by protecting against food loss, waste, and PHL. Apart from protection, packaging provides information on product use, preparation, shelf life, preservation, convenience, handling, and transportation, all of which help guard against PHL (Verghese et al., 2015; Chen et al., 2020).

According to Molina-Besch et al. (2018), packaging decisions not only directly influence PHL in the food supply chain but also affect operational costs and environmental impact; hence, the need to ensure that supply chain actors, including small-scale banana farmers, make the right packaging decisions. FAO (2017) and Parmar et al. (2017). suggests that the major cause of agricultural post-harvest losses in fresh fruit and vegetables in SC is bulk packaging and the use of extended packages, especially in developing countries. Issa et al.'s (2022) findings suggest that supply chain members, from farmers to retailers, do not understand the importance of packaging and its contribution to PHL, nor do they understand the use of unconventional packaging.

Ghosh et al. (2018) suggest using Modified Atmosphere Packaging (MAP) to reduce banana deterioration during storage and transportation. Ghosh et al. (2018) suggest that “Bhimkol” bananas lose the acceptability quality within 10–12 days after harvest due to their short shelf-lifecycle, hence the need to use (MAP) to extend their shelf life. Use of (MAP) during the post-harvest period, especially in storage, can extend the shelf life of the product and maintain the banana quality over long-distance transportation.

Mendoza et al. (2016) argue that packaging plays an important role in minimizing post-harvest losses and increasing the shelf life of fruit and vegetables by primarily controlling water loss in fruits, balancing low O2 levels, and moderating CO2 levels. Appropriate use of improved packaging technologies can enhance the quality of fresh fruits and extend their shelf life.

Secondly, according to Parmar et al. (2017), transportation is a logistics management process used to move products and people between locations within the supply chain to create place utility and add value to agricultural food products. Transport is a major contributor to PHL, especially where there is no proper planning and coordination. Morgan (2019) suggests that transportation creates time utility by bringing together a geographically dispersed group of farmers, distributors, and consumers. Small-scale banana farmers and distributors enter into contracts with commercial carriers to move products to locations where they are required to avoid PHL. By partnering with carriers, geographically dispersed farmers will reduce the time

it takes for the product to reach the final market, resulting in a lower PHL experienced by individual farmers in the supply chain.

Ishangulyyev et al. (2019) identified transportation as a major cause of post-harvest loss in SC, among other factors. The study also identified less-developed countries as prone to food losses during transportation from production sites to harvesters and from harvesters to markets. According to Issa et al. (2021), PHL results from poor road conditions, inadequate use of handling facilities during loading and unloading, and inadequate transport facilities. The study further suggests that reducing food loss and PHL requires an interdisciplinary approach to managing PHL. Logistics management is a cross-cutting area that requires appropriate management of all logistics resources that affect transaction costs, including transportation, packaging, and storage. PHL and transaction costs can be managed through the integration and collaboration of logistics activities among supply chain members.

Thirdly, insufficient storage facilities are part of logistics practices identified as contributors to post-harvest losses in developing countries (FAO, 2017). Etefa et al. (2022) suggest that between 5% and 10% of fruits and vegetables are lost during storage. The author further notes that inadequate storage facilities and traditional storage methods contribute to post-harvest losses of all fruits and vegetables in Ethiopia. According to Issa et al. (2021), modern storage facilities are nonexistent or inaccessible to most smallholder farmers in sub-Saharan Africa. Fruits and vegetables are stored in poor conditions at home after harvesting, before reaching the market. Schudel et al. (2022) suggest that highly perishable produce requires adequate temperature-controlled storage facilities with well-maintained conditions to prolong product shelf life and reduce PHL among small-scale farmers.

Lastly, Parmar et al. (2017) define post-harvest handling and storage as the tasks, functions, and routines involved in moving products from the point of production to the next stage in the supply chain. Ishangulyyev et al. (2019) suggest that 29% of PHL in developing countries occurs due to inadequate handling and storage facilities. Tarekegn et al. (2020) suggest that up to 73% of mango PHL is caused by improper handling. According to Issa et al. (2021), in their study on PHL of fruits and vegetables in Dar es Salaam, up to 73% of PHL is attributed to poor and inappropriate handling tools and distribution, and 56% to poor loading and offloading technology. Kiprono et al. (2018) suggest that efficient movement of materials requires not only proper handling but also the use of tertiary packaging. Ishangulyyev et al. (2019) suggest that PHL may experience spillage and degradation during handling, mechanical injury and damage during storage, and transportation between the farm and the distribution point.

2.3 Conceptual Framework

The conceptual framework illustrates that logistics management practices, specifically packaging, handling, transportation, and storage, influence the level of post-harvest loss among small-scale banana farmers, as is shown in Figure 1.

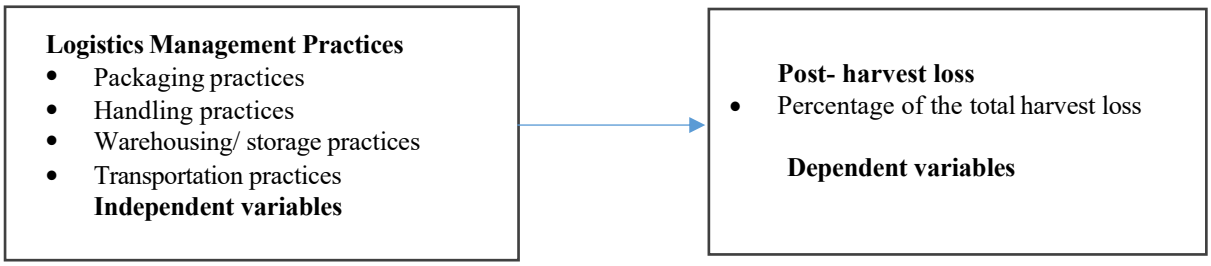

Figure 1: Conceptual framework

3. Methodology

The study used a cross-sectional research design. The target populations were small-scale banana farmers from three selected banana-producing counties in Kenya. The study's target population comprised 14,447 farmers in three selected counties. The researcher stratified the counties and used a table of random numbers to pick farmers. From this population, the simple size of small-scale banana farmers was determined using Yamane's (1967) formula, as shown below:

Assuming the level of precision is 0.05, N= 14,447

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

Where n = sample size

e = level of significance (5% level of significance)

N = target population

$$n = \frac{14{,}447}{1 + 14{,}447\ (0.05)^2}$$

$$n = \frac{14{,}447}{37.1175}$$

$n = 400$

Data were collected using a semi-structured questionnaire. Reliability and validity tests were carried out. Descriptive statistics such as mean, standard deviation, and percentages were used to describe logistics management practices, including transportation, handling practices, packaging, and storage, while inferential statistics were used to analyze the data using SPSS statistical software. Chi-Square tests were conducted to determine the association between logistics management practices and other variables. A Tobit regression model was used to assess the effect of logistics management practices on post-harvest losses among small-scale banana farmers.

4. Results and Discussion

4.1 Descriptive Statistics

Descriptive statistics are specific methods used to calculate, describe, and summarize collected research data in a logical, meaningful, and efficient way. In this study, descriptive statistics include means and standard deviations.

4.1.1 Logistics Management Practices

Logistics management practices were examined as the predictor variable to assess their influence on post-harvest loss among small-scale banana farmers in selected counties in Kenya. Respondents indicated their level of agreement with statements relating to packaging, handling, transportation, and storage practices.

The results show that packaging practices received a high mean score (M = 4.07, SD = 0.72), indicating that most respondents agreed that appropriate packaging practices are applied and important for minimizing post-harvest loss. This finding is consistent with previous studies by Priyadarshi et al. (2021) and Schudel et al. (2023), which report that inadequate or non-standard packaging contributes significantly to fresh produce losses. Similarly, Parmar et al. (2017) note that the use of inappropriate packaging materials, such as extended sacks, increases handling damage and spoilage. These findings suggest that improved packaging practices can enhance product protection and prolong shelf life, thereby reducing post-harvest loss.

Handling practices also showed a high mean (M = 4.30, SD = 0.82), suggesting that respondents acknowledged the importance of proper handling during harvesting, transportation, and storage to reduce banana damage and spoilage. This finding aligns with Parmar et al. (2017), who observed that inappropriate handling methods, such as dropping produce from excessive heights, significantly increase post-harvest loss. The results further support the argument that investing in training farmers and supply chain actors in proper handling techniques is critical to reducing losses in perishable crop supply chains.

Transportation practices had a higher mean score (M = 4.51, SD = 0.76), implying strong agreement among respondents that transportation plays a critical role in minimizing post-harvest loss. This reflects the importance of timely transport, appropriate loading and unloading methods, and adequate transport facilities for perishable produce. This finding corroborates the work of Ishangulyyev et al. (2019), who identified poor transportation infrastructure and inadequate loading and unloading facilities as major contributors to post-harvest losses in developing countries. Sengupta et al. (2024) similarly emphasize that inefficient transport systems and insufficient cold-chain infrastructure exacerbate losses, particularly over long distances. These results highlight the importance of improving rural transport infrastructure and logistics coordination to reduce post-harvest losses.

Similarly, storage practices recorded the highest mean score (M = 4.57, SD = 0.73), indicating that respondents strongly agreed that adequate storage conditions are essential in reducing deterioration and spoilage of harvested bananas. This finding is consistent with Amentae et al. (2017), who reported that insufficient storage facilities at farm and household levels significantly increase post-harvest loss. Furthermore, studies by Tarabay et al. (2018) and Priyadarshi et al. (2020) confirm that improved storage facilities and controlled conditions effectively reduce deterioration and extend banana shelf life.

Overall, logistics management practices recorded a high composite mean score (M = 4.36), suggesting that small-scale banana farmers generally perceive them as highly important for reducing post-harvest loss. This indicates that how bananas are packaged, handled, transported, and stored during the post-harvest phase plays a critical role in determining the extent of loss.

The overall findings of this study support the view that logistics management practices are a critical pathway for reducing post-harvest losses in agricultural supply chains. These results

are consistent with previous studies (Mohan et al., 2023; Priyadarshi et al., 2020; Tarabay et al., 2018; Schudel et al., 2023), which emphasize that efficient logistics systems add value at each stage of the supply chain by preserving product quality and minimizing losses. From a theoretical perspective, the findings align with Transaction Cost Theory, which posits that inefficiencies in logistics-related activities increase operational costs and waste. By improving logistics management practices, small-scale banana farmers can reduce transaction costs, enhance market participation, and improve overall supply chain efficiency.

Table 1: Logistics management practices

N=376	**Mean**	**Std. Dev**
Packaging practices	4.07	0.72
Handling practices	4.30	0.82
Transportation practices	4.51	0.76
Storage practices	4.57	0.73
Overall mean	**4.36**	

4.1.2 Post-harvest loss among small-scale banana farmers

Post-harvest loss was the study's dependent variable, measured among small-scale banana farmers in selected counties in Kenya. As shown in Table 2, the majority of farmers experienced moderate levels of post-harvest loss (198 respondents, 52.7%), followed by high (111 respondents, 29.5%) and low (67 respondents, 17.8%). These results indicate that post-harvest loss remains a prevalent challenge among small-scale banana farmers, with most farmers experiencing moderate levels of loss.

Table 2: Post-Harvest Loss among Small-Scale Banana Farmers

	Frequency	**Percent**
Low	67	17.8
Moderate	198	52.7
High	111	29.5
Total	376	100

In addition, the respondents were asked to describe any post-harvest loss at the farm level. The respondents indicated that other post-harvest losses include mechanical damage, over-ripening, temperature and humidity issues, and damage from pests and diseases. This is consistent with FAO (2017), which finds that the major cause of agricultural post-harvest losses of fresh fruit and vegetables in SC is mechanical damage and pest and disease infestations during harvesting and post-harvest management. The study findings also aligned with Etefa et al. (2022), who indicated that highly perishable produce requires adequate temperature-controlled storage facilities with well-maintained conditions to prolong shelf life and reduce PHL.

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Table 3: Logistics Management Practices and Demographics

		Logistics Management Practices			
		Disagree	Agree	Chi square	p value
Gender	Female	54	161	9.905	0.002
	Male	65	96		
Age	18 - 30 years	16	62	10.42	0.015
	31-40 years	41	93		
	41-50 years	53	76		
	51+ years	9	26		
Years involved in banana farming	11-15 years	44	52	17.279	0.001
	3-10 years	51	113		
	Less than 3years	20	86		
	Over16 years	4	6		
Education	Certificate	2	9	6.397	0.171
	Diploma	0	1		
	Non-formal	16	17		
	Primary	41	103		
	Secondary	60	127		
Land ownership	Family	52	145	11.374	0.023
	Leased	26	32		
	Man	25	53		
	Other	1	8		
	Woman	15	19		
Acreage under banana farming	0.1-0.5 acre	32	95	38.503	0.000
	0.6-1.0 acre	33	78		
	1.1-1.5 acre	25	73		
	1.6-2.0 acre	13	8		
	2.1-2.5 acre	10	3		
	2.6-3.0 acre	5	0		
	More than 3.0 acres	1	0		

Table 3 shows that logistics management practices are significantly associated with several demographic characteristics of small-scale banana farmers. Specifically, significant associations were observed between logistics management practices and gender ($\chi^2 = 9.905$, $p = 0.002$), age ($\chi^2 = 10.42$, $p = 0.015$), years of involvement in banana farming ($\chi^2 = 17.279$, $p = 0.001$), land ownership ($\chi^2 = 11.374$, $p = 0.023$), and acreage under banana farming ($\chi^2 = 38.503$, $p < 0.001$). These findings indicate that farmers' socio-demographic and farm characteristics influence the adoption and application of logistics management practices.

4.2 Estimation of the Main Effect Regression Model

A Tobit regression model was used to assess the effect of logistics management practices on post-harvest losses among small-scale banana farmers. The findings showed a significant negative relationship between Logistics management practices and post-harvest loss (β = -0.356, p = 0.000) at the 5% significance level. This implies that logistics management practices would significantly reduce post-harvest losses. Based on this finding, the Ho is rejected, indicating that logistics management practices significantly affect post-harvest losses among small-scale banana farmers in selected counties in Kenya. The finding aligns with Issa et al. (2021), who suggest that inadequate transport and infrastructure, along with poor market storage, contribute to PHL in the supply chain. The study findings also aligned with Etefa et al. (2022), who indicated that the increase in PHL in fruits in Ethiopia results from logistical activities, including poor storage facilities, inadequate transportation, poor packaging, and minimal adoption of technologies for harvesting and handling.

Table 4: Effect of Logistics Management Practices on Post-Harvest Loss

Dependent Variable	Predictor Variable	Coefficient (β)	Std. Error	t-value	p-value	95% Confidence Interval
Post-Harvest Loss	Logistics Management Practices	-0.356	0.034	-10.62	0.000	-0.422 to -0.290

The Tobit regression results indicate that logistics management practices have a significant negative effect on post-harvest loss (β = -0.356, p < 0.001). This implies that improvements in logistics management practices, such as packaging, handling, transportation, and storage, are associated with reduced post-harvest losses among small-scale banana farmers.

5. Conclusion

The study concluded that logistics management practices significantly affect post-harvest losses among small-scale banana farmers in selected counties in Kenya. Effective logistics management can significantly reduce post-harvest losses by ensuring proper handling, timely transportation, appropriate storage conditions, and optimized packaging, thus minimizing damage to perishable produce throughout the supply chain. This ultimately leads to less spoilage and waste throughout the journey from farm to consumer.

6. Recommendations

To improve their logistics management, small-scale banana farmers should focus on using efficient transportation methods and planning for seasonal fluctuations to ensure the timely delivery of produce while minimizing losses. Farmers should also prioritize using packaging materials appropriate for bananas, such as perforated polyethylene bags within cardboard cartons and plastic or wooden crates. They should also ensure proper ventilation to protect produce from damage during transport. The supply chain actors should also ensure appropriate packaging, regularly monitor for potential damage, ensure proper storage conditions, and train workers on best practices.

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