

ANALYSIS OF TRANSPORT LOGISTICS AND POSTHARVEST LOSSES IN SOUTHERN KADUNA SENATORIAL DISTRICT, KADUNA STATE, NIGERIA

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ABSTRACT

Agriculture remains the backbone of rural livelihoods and food security in Nigeria, yet inefficiencies in transportation logistics continue to undermine agricultural productivity through significant postharvest losses. This study examined the influence of transport logistics on postharvest losses in agricultural product movement in Southern Kaduna Senatorial District, Kaduna State, Nigeria. A mixed-methods research design was adopted, involving 379 respondents comprising farmers, transporters, traders, agricultural officials, and development partners selected from the eight Local Government Areas of the senatorial district. Primary data were collected using structured questionnaires, key informant interviews, focus group discussions, and field observations. Quantitative data were analyzed using descriptive statistics and multiple regression analysis, while qualitative data were analyzed thematically. The findings revealed that poor rural road conditions (35.4%), high transportation costs (29.0%), inadequate transport vehicles (20.6%), and seasonal road inaccessibility (15.0%) were the principal transportation constraints contributing to postharvest losses. Approximately 70% of respondents reported losing between 10% and 30% of harvested produce during transportation, with ginger identified as the most vulnerable crop. Multiple regression analysis indicated that transportation variables significantly influenced postharvest losses ($R^2 = 0.510$, $F(5,376) = 28.78$, $p < 0.001$). Good road infrastructure and access to technological innovations significantly reduced postharvest losses, whereas long travel time, high transport costs, and poor logistics increased spoilage. The study concludes that improving rural transport infrastructure, promoting integrated logistics systems, strengthening farmer cooperatives, and adopting innovative transportation technologies will substantially reduce postharvest losses, improve farmers' incomes, strengthen food security, and accelerate sustainable rural development in Southern Kaduna.

Keywords: Transport logistics, Postharvest losses, Agricultural transportation, Food security, Rural development, Southern Kaduna.

1.1 INTRODUCTION

Agriculture constitutes one of the most important sectors supporting food production, employment generation, poverty reduction, and rural development across developing countries. According to the Food and Agriculture Organization (FAO, 2023), agriculture provides livelihoods for more than 2.5 billion people

worldwide and contributes significantly to achieving Sustainable Development Goal 2 (Zero Hunger). However, increasing agricultural production alone cannot guarantee food security where transportation systems remain inefficient. Large quantities of agricultural produce are lost after harvest due to poor logistics, inadequate road infrastructure, limited storage facilities, and inefficient market linkages.

Globally, approximately 13–14% of food produced for human consumption is lost between harvest and retail, with transportation accounting for a substantial proportion of these losses (FAO, 2023). In sub-Saharan Africa, postharvest losses remain among the highest worldwide because of weak transportation infrastructure, poor road connectivity, inadequate cold-chain systems, and high logistics costs (World Bank, 2022). These challenges disproportionately affect rural farming communities by reducing farmers' incomes, increasing food prices, limiting market access, and threatening household food security.

Nigeria, Africa's largest agricultural economy, experiences similar transportation challenges. Agriculture contributes approximately 24% of the country's Gross Domestic Product and employs over 70% of the rural labour force (National Bureau of Statistics [NBS], 2023). Despite this contribution, annual postharvest losses are estimated at between 20% and 40% for many perishable agricultural commodities due largely to transportation bottlenecks, poor rural feeder roads, inadequate storage infrastructure, and inefficient logistics systems (Federal Ministry of Agriculture and Food Security, 2024; FAO, 2023). These losses reduce agricultural profitability, discourage investment, and undermine national food security objectives.

Southern Kaduna Senatorial District is one of Nigeria's major agricultural production zones, producing crops such as ginger, maize, rice, cassava, beans, and yam. Despite its enormous agricultural potential, farmers in the area continue to experience considerable transportation constraints characterized by deteriorating rural roads, seasonal flooding, high transport fares, inadequate vehicles, and limited logistics services. These challenges significantly contribute to postharvest losses, reduce market competitiveness, and constrain rural economic development. Consequently, understanding the nature and magnitude of transport logistics

barriers is essential for developing sustainable interventions that will reduce postharvest losses and strengthen food security within the region

1.2 STATEMENT OF THE RESEARCH PROBLEM

Southern Kaduna Senatorial District possesses considerable agricultural potential and serves as one of the major food-producing regions in Kaduna State. Nevertheless, substantial quantities of agricultural produce continue to be lost between farms and markets due to transportation and logistics inefficiencies. Poor rural road infrastructure, high transportation costs, inadequate transport services, seasonal inaccessibility, and insufficient storage facilities continue to limit efficient agricultural product movement, thereby reducing farmers' incomes and weakening food security.

Although governments at Federal and State levels have invested in rural road rehabilitation and agricultural development programmes, empirical evidence indicates that transportation-related postharvest losses remain widespread across Nigeria. The Federal Ministry of Agriculture and Food Security (2024) estimates that Nigeria loses agricultural produce valued at billions of naira annually because of poor transportation systems. Similarly, the Food and Agriculture Organization (2023) reports that transportation-related inefficiencies account for a significant proportion of food losses experienced across sub-Saharan Africa.

Several previous studies have investigated transportation constraints and agricultural marketing in Nigeria (Adebayo et al., 2022; Aina & Usman, 2023; Olukayode, 2023). However, most focused primarily on marketing efficiency, rural road conditions, or agricultural productivity, with limited empirical attention devoted specifically to the relationship between transport logistics and postharvest losses within Southern Kaduna Senatorial District.

Furthermore, few studies have integrated quantitative evidence with stakeholder perspectives to explain how transport logistics influence postharvest losses and food security in the study area.

This empirical and contextual gap necessitated the present study, which investigates transport logistics barriers and their influence on postharvest losses in Southern Kaduna Senatorial District, Kaduna State, Nigeria, with a view to providing evidence-based recommendations for improving agricultural transportation, reducing food losses, and promoting sustainable rural development.

Most previous studies concentrated primarily on rural roads, transportation costs, and market accessibility while giving limited attention to transport logistics as a multidimensional system incorporating infrastructure, transportation services, technological innovations, institutional coordination, and logistics management.

Secondly, existing studies were largely conducted at national or regional scales, with relatively few empirical investigations focusing specifically on Southern Kaduna Senatorial District despite its strategic importance as one of Nigeria's major agricultural production zones.

Thirdly, many previous investigations relied solely on descriptive analysis and paid limited attention to inferential statistical techniques capable of explaining the influence of transportation variables on postharvest losses.

Finally, very few studies integrated quantitative findings with qualitative evidence obtained from key stakeholders such as transporters, agricultural officers, policymakers, and development partners. The present study addresses these methodological, geographical, and empirical gaps by employing a mixed-methods approach to examine how transport logistics influence postharvest losses in Southern

Kaduna Senatorial District and their implications for food security and rural development.

1.3 RESEARCH QUESTIONS

The study seeks to answer the following questions:

- i. What are the socio-economic characteristics of respondents?
- ii. What transport logistics barriers contribute to postharvest losses?
- iii. To what extent do transportation-related postharvest losses occur in Southern Kaduna?
- iv. What relationship exists between transport logistics and postharvest losses?
- v. What are stakeholders' perceptions regarding existing transport interventions?
- vi. Which sustainable logistics strategies can effectively reduce postharvest losses?

1.4 AIM AND OBJECTIVES OF THE STUDY

The aim of this study is to examine the influence of transport logistics on postharvest losses in agricultural product movement in Southern Kaduna Senatorial District, Kaduna State, Nigeria.

The study specifically seeks to:

- i. examine the socio-economic characteristics of farmers, transporters, and agricultural traders in Southern Kaduna Senatorial District;
- ii. Identify the major transport logistics barriers contributing to postharvest losses;
- iii. determine the extent of postharvest losses associated with transportation of agricultural produce;
- iv. examine the relationship between transport logistics variables and postharvest losses;

- v. assess stakeholders' perceptions of existing transportation policies and interventions aimed at reducing postharvest losses;
- vi. propose sustainable transport logistics strategies for minimizing postharvest losses and improving food security in Southern Kaduna.

1.5 RESEARCH HYPOTHESES

H0₁: Road condition has no significant influence on postharvest losses in Southern Kaduna Senatorial District.

H0₂: Transportation cost has no significant influence on postharvest losses.

H0₃: Travel time has no significant influence on postharvest losses.

H0₄: Access to transportation innovations has no significant influence on postharvest losses.

H0₅: Transport logistics variables do not jointly have a significant influence on postharvest losses.

1.6 LITERATURE REVIEW

1.6.1 Conceptual Framework

The conceptual framework for this study posits that transport logistics variables including road condition, transportation cost, travel time, vehicle availability, storage facilities, and access to logistics innovations serve as the independent variables influencing postharvest losses, the dependent variable. High postharvest losses, in turn, negatively affect farmers' income, agricultural productivity, food security, and rural development. Government interventions, public-private partnerships, and technological innovations are considered moderating factors capable of reducing transportation constraints and improving agricultural outcomes.

1.6.2 Concept of Transport Logistics

Transport logistics refers to the planning, implementation, coordination, and control of the movement and storage of goods from the point of production to the point of consumption in order to satisfy customer requirements efficiently and cost-effectively. In agriculture, transport logistics encompasses road transport, handling, packaging, warehousing, loading, unloading, storage, and information management that facilitate the timely movement of agricultural commodities (Christopher, 2022).

Efficient transport logistics constitute one of the critical determinants of agricultural competitiveness because they influence market accessibility, transportation costs, product quality, and farmers' profitability. According to the World Bank (2022), logistics account for between 30% and 50% of total marketing costs in many developing countries, making transportation efficiency an essential driver of agricultural productivity and rural development.

In developing economies, transportation systems remain constrained by deteriorating road infrastructure, inadequate transport services, limited storage facilities, and poor institutional coordination. These deficiencies increase travel time, reduce produce quality, discourage investment, and contribute significantly to food insecurity (African Development Bank [AfDB], 2023).

1.6.3 Concept of Postharvest Losses

Postharvest losses refer to measurable reductions in the quantity and quality of agricultural produce occurring between harvesting and final consumption due to spoilage, mechanical damage, poor transportation, inadequate storage, pest infestation, and inefficient handling (FAO, 2023).

The Food and Agriculture Organization estimates that approximately 14% of global food production is lost before reaching retail markets, with substantially higher losses recorded in Sub-

Saharan Africa owing to poor infrastructure and weak logistics systems (FAO, 2023). In Nigeria, transportation-related losses account for a considerable proportion of postharvest losses, particularly among perishable commodities such as ginger, tomatoes, vegetables, fruits, and root crops.

Besides reducing food availability, postharvest losses decrease farmers' income, increase food prices, reduce export competitiveness, discourage investment, and threaten national food security (Federal Ministry of Agriculture and Food Security, 2024).

1.6.4 Transport Logistics and Agricultural Product Movement

Agricultural product movement involves the physical transfer of harvested commodities from farms to collection centres, processing facilities, storage locations, wholesalers, retailers, and final consumers. Efficient transportation ensures timely delivery while maintaining product quality.

Road transportation remains the dominant means of agricultural commodity movement in Nigeria, accounting for over 90% of domestic agricultural freight transport (Federal Ministry of Transportation, 2023). Unfortunately, poor road conditions, vehicle shortages, high fuel prices, insecurity, seasonal flooding, and inadequate logistics planning continue to hinder efficient movement of agricultural products.

Adebayo et al. (2022) observed that poor logistics significantly increase transportation costs and reduce farmers' market participation. Similarly, Olukayode (2023) found that poor feeder roads delay produce evacuation from rural communities, leading to increased spoilage and reduced market value.

1.6.5 Transport Logistics and Food Security

Food security exists when all people have physical, social, and economic access to sufficient, safe, and nutritious food at all times (FAO, 2023). Efficient transport logistics enhance food security by reducing losses, lowering transportation costs, stabilizing food prices, and improving market accessibility.

The World Bank (2022) reports that inadequate transportation infrastructure contributes significantly to food price inflation across Africa because high logistics costs are transferred directly to consumers. Improved transport networks therefore strengthen food availability, affordability, accessibility, and utilization.

In Southern Kaduna, transportation challenges not only reduce farmers' incomes but also limit the availability of agricultural produce in urban markets, thereby affecting regional food security.

1.7 Theoretical Framework

1.7.1 Sustainable Livelihood Framework (SLF)

This study is anchored on the Sustainable Livelihood Framework (SLF) developed by the Department for International Development (DFID, 1999) and further elaborated by Scoones (1998). The framework explains how rural households combine available livelihood assets including human, natural, physical, financial, and social capital to improve their livelihoods while responding to external vulnerabilities.

Within the framework, transport infrastructure and logistics constitute components of physical capital because they determine farmers' ability to access markets, obtain agricultural inputs, transport harvested produce efficiently, and minimize postharvest losses. Weak transport systems reduce livelihood opportunities by increasing transportation costs, delaying market access, encouraging spoilage, and lowering farm incomes.

The framework further recognizes that institutional arrangements including government policies, transport regulations, public-private partnerships, and agricultural support programmes influence how effectively rural households utilize available assets. Consequently, improvements in transportation infrastructure, logistics services, digital transport platforms, and institutional coordination are expected to reduce postharvest losses, enhance agricultural productivity, strengthen food security, and improve rural livelihoods.

The Sustainable Livelihood Framework is therefore appropriate for this study because it provides a comprehensive explanation of how transportation logistics interact with physical infrastructure, institutional support, and livelihood outcomes to influence postharvest losses and rural development in Southern Kaduna Senatorial District.

1.6.6 Empirical Review

Several empirical studies have examined the relationship between transportation systems and agricultural performance.

Adebayo, Olayemi, and Adeyemi (2022) investigated transport logistics and agricultural marketing in Nigeria using survey data from 420 farmers across three geopolitical zones. Their findings indicated that deteriorating road conditions increased transportation costs by over 35% and contributed significantly to postharvest losses. However, the study focused on marketing efficiency rather than postharvest losses.

Aina and Usman (2023) examined transportation barriers affecting agricultural market access in Southern Kaduna using descriptive survey techniques. They found that poor rural roads and inadequate vehicles reduced farmers' participation in profitable markets. Their study did not investigate the influence of transport logistics on postharvest losses using inferential statistics.

Olukayode (2023) assessed rural transportation and agricultural development in northwestern Nigeria. The study revealed that seasonal road failures significantly increased transportation delays and spoilage, particularly for perishable commodities such as ginger and vegetables. Nevertheless, the research concentrated primarily on infrastructure without examining broader logistics systems.

The African Development Bank (2023) emphasized that integrated transport infrastructure, digital logistics platforms, cold-chain facilities, and public-private partnerships are necessary to reduce agricultural losses and improve rural competitiveness throughout Africa. The World Bank (2022) similarly concluded that investments in rural transportation systems yield substantial improvements in farmers' income, food availability, and market efficiency.

1.7 Methodology

1.7.1 Research Design

This study adopted a mixed-methods research design, integrating quantitative and qualitative approaches to provide a comprehensive understanding of transport logistics and postharvest losses in Southern Kaduna Senatorial District. The quantitative component employed a cross-sectional survey to generate numerical data from farmers, transporters, and traders, while the qualitative component comprised Key Informant Interviews (KIIs), Focus Group Discussions (FGDs), and field observations to obtain in-depth insights into transportation challenges and existing interventions. The mixed-methods approach enhanced triangulation, thereby improving the validity and reliability of the findings (Creswell & Creswell, 2023).

1.7.2 Study Area

The study was conducted in Southern Kaduna Senatorial District, Kaduna State, northwestern Nigeria. The district lies approximately between latitudes 9°12'N and 10°30'N and longitudes 7°12'E and 8°48'E (See Figure 1). It comprises eight Local Government Areas (LGAs): Jema'a, Jaba, Kaura, Sanga, Kachia, Kagarko, Kauru, and Zangon Kataf. Southern Kaduna shares boundaries with Plateau State to the southeast, Nasarawa State to the south, the Federal Capital Territory (FCT) to the southwest, Chikun and Kajuru LGAs to the northwest, and Lere LGA to the northeast. The area occupies an estimated landmass of approximately 11,200 km² and has a predominantly rural settlement pattern characterized by dispersed farming communities. Agriculture constitutes the principal economic activity in the district. Major crops cultivated include ginger, maize, rice, yam, cassava, beans, sorghum, millet, and vegetables. Livestock production is also common.

1.7.3 Climate

Southern Kaduna experiences a tropical wet-and-dry (Aw) climate characterized by distinct rainy and dry seasons. The rainy season usually extends from April to October, while the dry season lasts from November to March. Mean annual rainfall ranges from 1,200 mm to 1,700 mm, with average annual temperatures varying between 22°C and 31°C. Relative humidity during the rainy season ranges from 70% to 85%, creating favourable conditions for agricultural production. However, intense rainfall often renders rural feeder roads impassable, thereby increasing transportation delays and postharvest losses.

1.7.4 Vegetation

The area falls within the Northern Guinea Savannah ecological zone, characterized by tall grasses interspersed with deciduous trees. The fertile soils and favourable climatic conditions support intensive cultivation of cereals, legumes, root crops, and horticultural crops.

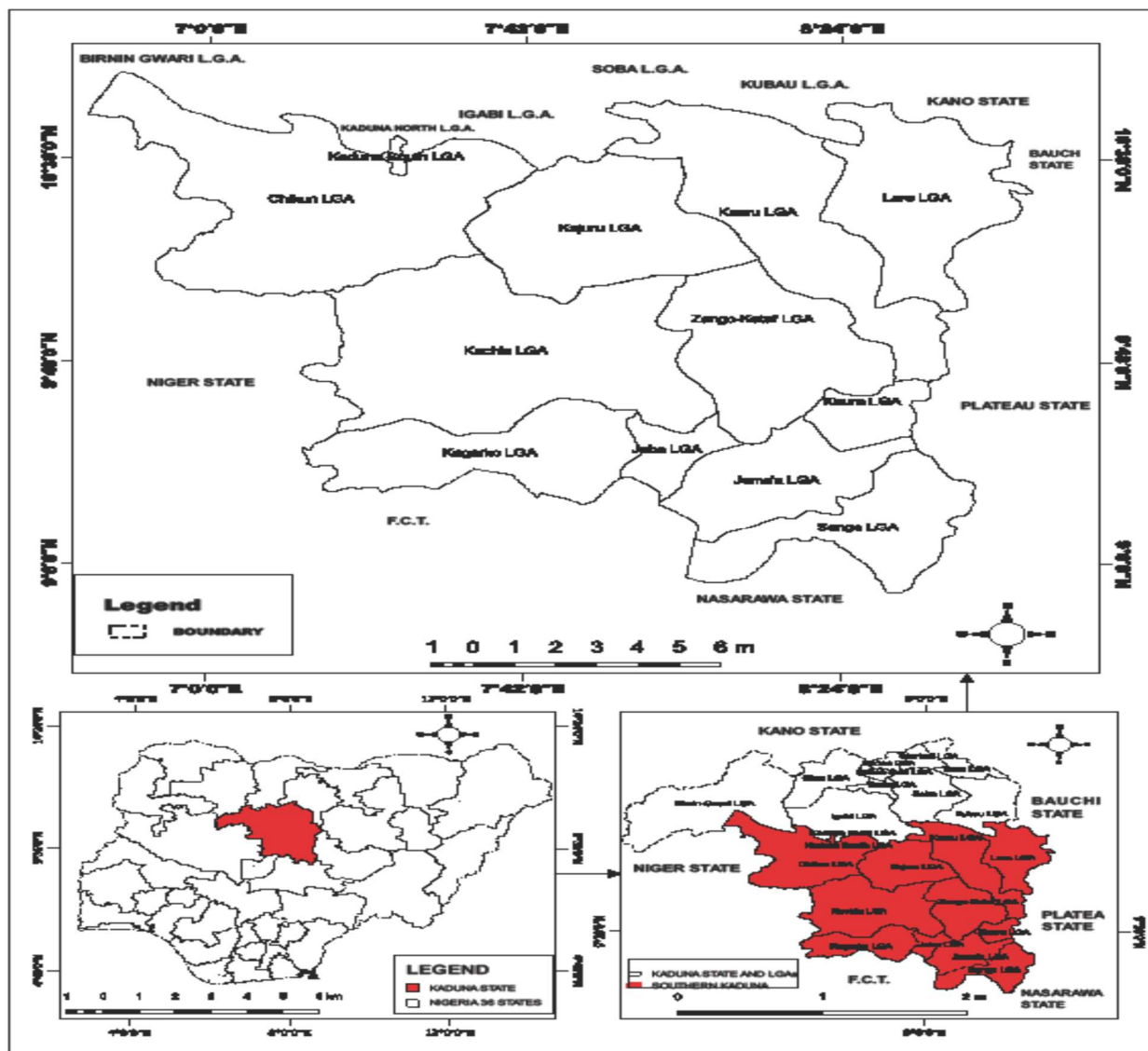


Figure 1: Map of Southern Kaduna Senatorial District showing the eight Local Government Areas.

1.7.5 Population of the Study

The target population comprised:

- i. crop farmers;
- ii. produce transporters;
- iii. agricultural produce traders;
- iv. officials of the Kaduna State Ministry of Agriculture;
- v. officials of Kaduna Agricultural Development Programme (KADP);

vi. cooperative society leaders; and

vii. representatives of agricultural development agencies operating within Southern Kaduna.

These groups were selected because they are directly involved in agricultural production, transportation, marketing, and policy implementation.

1.7.6 Sample Size Determination

The quantitative sample consisted of 382 respondents, determined using the Krejcie and Morgan (1970) sample size determination table for finite populations. After data cleaning and screening for completeness, 379 questionnaires were found valid for analysis, representing a response rate of 99.2%.

1.7.7 Sampling Procedure

A multistage sampling procedure was adopted.

Stage One

The eight Local Government Areas constituting Southern Kaduna Senatorial District was purposively selected because of their high agricultural production.

Stage Two

Major farming communities was identified within each LGA through consultation with agricultural extension officers and local authorities.

Stage Three

Respondents were proportionately allocated across the eight LGAs according to farming population and agricultural intensity.

Stage Four

Simple random sampling was used to select individual farmers, transporters, and traders from community registers and cooperative membership lists.

1.7.8 Qualitative Sampling

Key informants were selected purposively based on experience and professional responsibilities, while Focus Group Discussion participants were selected using purposive sampling to ensure adequate representation of farmers, transporters, traders, and community leaders.

1.7.8.1 Distribution of Sample

Table 1: Distribution of Respondents across the (8) Eight LGAs in Southern Senatorial District

Local Government Area	Farmers	Traders	Transporters	Total
Jema'a	54	10	6	70
Jaba	36	8	4	48
Kaura	40	9	5	54
Sanga	30	6	4	40
Kachia	48	9	5	62
Kagarko	39	8	4	51
Zangon Kataf	34	8	4	46
Kauru	29	6	3	38
Total	310	64	35	409*

Source: Field survey, 2026.

1.7.9 Sources of Data

Both primary and secondary data were utilized.

a. Primary data were collected through:

- i. structured questionnaires;
- ii. Key Informant Interviews (KIIs);
- iii. Focus Group Discussions (FGDs); and
- iv. field observations.

b. Secondary data were obtained from:

- i. Food and Agriculture Organization (FAO);
- ii. National Bureau of Statistics (NBS);
- iii. Kaduna State Agricultural Development Programme (KADP);
- iv. Kaduna State Ministry of Agriculture;
- v. World Bank publications;
- vi. African Development Bank reports; and
- vii. peer-reviewed journal articles.

1.7.10 Instruments for Data Collection

The questionnaire consisted of five sections:

- i. socio-economic characteristics;
- ii. transportation infrastructure;
- iii. logistics challenges;

- iv. postharvest losses;

- v. intervention strategies.

Interview guides and FGD checklists were designed to obtain qualitative information regarding transportation constraints, policy implementation, and sustainable logistics solutions.

1.7.11 Validity of Instruments

Content and face validity was established through expert review by specialists in Geography, Transportation Studies, Agricultural Economics, and Research Methodology. Their observations informed revisions to improve clarity, relevance, and comprehensiveness.

1.7.12 Reliability of Instruments

A pilot study involving respondents from a neighbouring agricultural community outside the study area was conducted. The questionnaire demonstrated satisfactory internal consistency with a Cronbach's Alpha coefficient of 0.84, indicating acceptable reliability.

1.7.13 Methods of Data Analysis

Quantitative data was coded and analyzed using **SPSS Version 27**.

The following statistical techniques were employed

Table 2: Showing the Statistical Techniques employed

Objective	Statistical Technique
Socio-economic characteristics	Frequencies and percentages
Transport logistics barriers	Descriptive statistics
Magnitude of postharvest losses	Frequencies and percentages
Relationship between transport logistics and postharvest losses	Multiple Linear Regression
Test of hypotheses	ANOVA and Regression Analysis

Source: Field survey, 2025

Qualitative data obtained from KIIs and FGDs were transcribed, coded, and analyzed using thematic content analysis. Emerging themes were organized according to transportation infrastructure, logistics challenges, institutional support, technological innovations, and policy recommendations. Qualitative findings were then integrated with quantitative results to provide richer interpretation and explanation.

1.8 RESULTS AND DISCUSSION

1.8.1 Demographic and Socio-economic Characteristics of Respondents

This section looks at personal data of respondents, underneath here are tables showing details of the Results.

Table 3: Presents the socio-economic characteristics of respondents, including age, educational attainment, household size, and primary livelihood

Variable	Frequency	Percentage
Age Group		
Below 30	65	17.2
30–39	124	32.7
40–49	108	28.5
50 and above	82	21.6
Total	379	100
Education Level		
No formal	94	24.8
Primary	106	28.0
Secondary	121	31.9
Tertiary	58	15.3
Total	379	100
Household Size		
1–3 members	74	19.5
4–6 members	142	37.5
7–9 members	102	26.9
10 and above	61	16.1
Total	379	100
Primary Livelihood Source		
Farming only	187	49.3
Farming + trading	98	25.9
Farming + artisan	56	14.8
Other (civil service etc.)	38	10.0
Total	379	100

Source: Field survey, 2025

Discussion

The findings reveal that the majority of respondents (32.7%) were between 30 and 39 years of age, followed by those aged 40–49 years (28.5%). This indicates that agricultural production in Southern Kaduna is dominated by economically active adults who possess the physical capacity required for intensive farming

and transportation activities. Younger farmers are generally more receptive to technological innovations and improved logistics systems, suggesting considerable potential for adopting modern transportation practices.

Educational attainment indicates that 31.9% completed secondary education, 28.0% attained primary education, while only 15.3% possessed

tertiary education. The relatively low proportion of highly educated respondents suggests that many farmers may have limited access to formal training on postharvest management and logistics optimization. This underscores the need for targeted extension services and capacity-building programmes.

Household size was generally large, with 37.5% of respondents reporting households of four to six members. Larger households provide family labour for farming and produce handling but may also increase pressure on household food security where postharvest losses remain high.

Almost half of the respondents (49.3%) depended solely on farming as their principal livelihood, highlighting the critical role agriculture plays in sustaining household incomes within the study area. Consequently,

transportation inefficiencies that reduce agricultural returns directly affect rural livelihoods and welfare.

These findings are consistent with Aina and Usman (2023), who reported that farming households in Southern Kaduna are predominantly middle-aged, possess modest educational attainment, and rely heavily on agriculture for income generation. Similarly, the World Bank (2022) observed that households with limited educational opportunities often experience greater constraints in adopting improved agricultural logistics technologies.

1.8.2 Distribution of Respondents According to Causes of Postharvest Losses

Table 4. Presents respondents' according to causes of Postharvest losses.

Variable	Frequency	Percentage
Poor road conditions	134	35.4
High cost of transport	110	29.0
Lack of vehicles	78	20.6
Seasonal inaccessibility	57	15.0
Total	379	100.0
Frequency of Produce Loss Due to Delays		
Very often	97	25.6
Sometimes	172	45.4
Rarely	76	20.0
Never	34	9.0
Total	379	100.0
Proportion of Produce Lost in Transport		
Less than 10%	115	30.3
10–20%	113	29.8
21–30%	95	25.1
Above 30%	56	14.8
Total	379	100.0
Crop Most Affected by Transport Spoilage		
Maize	97	25.6
Ginger	132	34.8
Rice	77	20.3
Yam	73	19.3
Total	379	100.0

Source: Field survey. 2025

Discussion

The results indicate that poor rural road conditions constitute the most significant transportation challenge (35.4%), followed by high transportation costs (29.0%), inadequate transport vehicles (20.6%), and seasonal road inaccessibility (15.0%).

Poor road infrastructure increases travel time, vehicle operating costs, and mechanical damage to agricultural produce. During the rainy season, many feeder roads become impassable, delaying transportation and exposing perishable commodities to spoilage before reaching markets.

Nearly half of the respondents (45.4%) reported that transportation delays sometimes result in produce losses, while 25.6% indicated that such losses occur very frequently. These findings demonstrate that transport logistics remain a major determinant of postharvest losses within Southern Kaduna.

Regarding the magnitude of losses, approximately 30% of respondents reported losing less than 10% of harvested produce, whereas over 54% experienced losses ranging

between 10% and 30%. Ginger emerged as the crop most severely affected (34.8%), followed by maize, rice, and yam. This reflects the highly perishable nature of ginger and its sensitivity to prolonged transportation delays.

These findings corroborate those of Adebayo et al. (2022), who found that deteriorating transportation infrastructure significantly increases postharvest losses among Nigerian farmers. Likewise, Olukayode (2023) observed that poor feeder roads and seasonal flooding delay market access and increase spoilage of agricultural commodities in northwestern Nigeria.

The findings also support FAO (2023), which estimates that transportation inefficiencies account for a substantial proportion of postharvest food losses across Sub-Saharan Africa.

1.8.3 Regression Analysis of the Influence of Transport Logistics on Postharvest Losses

This section presents the Relationship between Transportation Inefficiencies and agricultural productivity.

Table 5: Regression Model Summary

<i>Dependent Variable</i>	<i>R</i>	<i>R²</i>	<i>Adjusted R²</i>	<i>Std. Errors of Estimate</i>
Postharvest Losses (Y)	0.714	0.510	0.498	0.315

Source: Field survey, 2025

This model Summary indicates that transportation-related predictors jointly explain 51% of variance in postharvest losses ($R^2 = 0.510$). The adjusted R^2 (0.498) confirms the robustness of the model, meaning almost half of the variations in losses among farmers are explain by road conditions, time to market,

transportation cost, and access to innovations. The remaining unexplained variation may be attributed to factors such as storage practices, climatic variability, harvesting methods, pest infestation, and market fluctuations, which were beyond the scope of the present investigation.

Table 6: ANOVA Results for Regression Model

<i>Dependent Variable</i>	<i>Sum of Squares</i>	<i>df</i>	<i>Mean Square</i>	<i>F</i>	<i>Sig.</i>
<i>Postharvest Losses (Y)</i>	45.320	5	9.064	28.780	0.000
<i>Residual</i>	43.540	376	0.116		
Total	88.860	381			

Source: Field Survey, 2025

Dependent Variable: Postharvest

Predictor: (Constant) Road Conditions, Time to Market, Transportation Cost, and Access to Innovations

Discussion

The ANOVA results demonstrate that the overall regression model is statistically significant ($F = 28.780$, $p < 0.001$). Therefore, the null hypothesis stating that transport logistics

variables have no significant influence on postharvest losses is rejected. This implies that transportation logistics constitute an important determinant of agricultural losses within Southern Kaduna. Comparable findings were reported by the World Bank (2022), which concluded that improving transportation infrastructure substantially reduces food losses across developing countries.

1.8.4 ANOVA Results

Table 7: Regression Coefficients for Postharvest Losses Model

Predictor	B (SE)	Beta	T	Sig.
(Constant)	2.12 (0.245)	—	8.65	0.000
X ₁ : Road Condition	0.325 (0.071)	0.310	4.58	0.000
X ₂ : Time to Market	-0.290 (0.066)	-0.280	-4.39	0.000
X ₃ : Transport Cost	-0.215 (0.064)	-0.210	-3.36	0.001
X ₄ : Postharvest Losses	-0.178 (0.059)	-0.175	-3.01	0.003
X ₅ : Access to Innovations	0.210 (0.072)	0.205	2.92	0.004

Dependent Variable: Agricultural Productivity

Source: Field Survey, 2025

Discussion

The regression coefficients reveal that road condition ($\beta = 0.310$) and access to logistics innovations ($\beta = 0.205$) significantly reduce postharvest losses. Better road infrastructure facilitates faster movement of produce, minimizes mechanical damage, and improves farmers' access to profitable markets.

Conversely, increased travel time ($\beta = -0.280$), higher transportation costs ($\beta = -0.210$), and inefficient postharvest handling ($\beta = -0.175$) significantly increase crop losses.

Among these variables, road condition exerts the strongest influence, emphasizing the importance of rural transport infrastructure in minimizing food losses.

These findings align with FAO (2023), which identified transportation infrastructure as one of the most important determinants of postharvest food losses globally. Similarly, the African Development Bank (2023) concluded that investments in rural roads, logistics services, and transport technologies significantly improve agricultural competitiveness throughout Africa.

1.8.5 Thematic Analysis of Stakeholder

Interviews

Table 8: Stakeholder Interviews

<i>Interview Question</i>	<i>Codes (Key Responses)</i>	<i>Theme</i>	<i>Interpretation</i>
<i>Major transportation challenges and their effects on productivity</i>	<i>Poor road conditions, high transport costs, seasonal inaccessibility, insecurity</i>	<i>Infrastructure deficits and cost barriers</i>	<i>Poor feeder roads, especially in rainy seasons, limit farmers' access to markets, increase postharvest losses, and reduce productivity and incomes.</i>
<i>Existing policies and interventions</i>	<i>Adhoc government projects, donor-funded initiatives, lack of sustainability</i>	<i>Policy gaps and ineffective interventions</i>	<i>Government and donor interventions exist but are poorly coordinated, underfunded, and unsustainable, leading to limited impact on agricultural logistics.</i>
<i>Role of Public–Private Partnerships (PPPs)</i>	<i>Shared investment, resource mobilization, collaborative maintenance</i>	<i>Potential of PPPs as a sustainable solution</i>	<i>PPPs can bridge financing gaps by mobilizing resources from government, private enterprises, and communities, offering a viable model for rural transport improvement.</i>
<i>Innovative or technology-driven solutions</i>	<i>Digital logistics platforms, cooperative transport, centralized hubs, refrigerated vehicles</i>	<i>Innovation as a catalyst for efficiency</i>	<i>Adoption of technology-based solutions and cooperative systems can reduce spoilage, improve logistics coordination, and expand farmers' access to profitable markets.</i>
<i>Recommendations for a sustainable framework</i>	<i>Integrated strategy, stakeholder collaboration, capacity building, security measures</i>	<i>Framework for sustainable rural transport</i>	<i>An integrated approach combining infrastructure investment, innovation, farmer training, and stakeholder partnerships is essential for long-term improvements.</i>

Source: Field survey, 2025.

Discussion

The qualitative findings complement the quantitative results by providing practical insights into transportation challenges.

Stakeholders consistently identified deteriorating feeder roads, high transport costs, limited availability of commercial vehicles, and seasonal flooding as the principal barriers to efficient agricultural transportation. Participants further noted that existing government interventions remain fragmented and

inadequately coordinated, thereby limiting their effectiveness.

Respondents emphasized the need for stronger collaboration among government agencies, transport unions, farmer cooperatives, development partners, and private investors. They also recommended increased investment in digital logistics platforms, cooperative transportation systems, and cold-chain facilities to reduce spoilage of highly perishable commodities.

The convergence between the qualitative and quantitative findings strengthens the credibility of the study by demonstrating consistency across multiple sources of evidence.

1.9 SUMMARY OF FINDINGS

The findings of this study demonstrate that transportation logistics remain one of the most significant determinants of postharvest losses in Southern Kaduna Senatorial District. Poor road infrastructure, high transport costs, inadequate transport services, and seasonal road inaccessibility substantially reduce market efficiency and contribute to considerable losses of agricultural produce before reaching consumers.

The regression analysis further establishes that transportation variables significantly influence postharvest losses, accounting for over half of the observed variation. This highlights the importance of improving transport infrastructure and logistics management as effective strategies for reducing food losses and strengthening food security.

The study supports the Sustainable Livelihood Framework by demonstrating that improved physical infrastructure enhances farmers' livelihood assets through better market access, increased income, and reduced vulnerability to postharvest losses.

Generally, the findings agree with previous studies by Adebayo et al. (2022), Aina and Usman (2023), Olukayode (2023), FAO (2023), the World Bank (2022), and the African Development Bank (2023), all of which emphasize the central role of efficient transportation systems in promoting agricultural productivity, minimizing postharvest losses, and improving rural livelihoods.

1.10 CONCLUSION

This study examined the influence of transport logistics on postharvest losses in agricultural product movement in Southern Kaduna Senatorial District, Kaduna State, Nigeria. The findings demonstrate that transport logistics constitute a critical determinant of agricultural efficiency, market accessibility, and food security within the study area.

The study established that poor rural road infrastructure, high transportation costs, inadequate transport services, seasonal road inaccessibility, and limited adoption of logistics innovations significantly contribute to postharvest losses. These transportation challenges not only reduce the quantity and quality of agricultural produce reaching markets but also diminish farmers' incomes, increase food prices, and constrain rural economic development.

The regression analysis further revealed that transport logistics variables significantly explain variations in postharvest losses, indicating that improvements in transportation infrastructure and logistics management could substantially reduce agricultural losses. The qualitative findings reinforced the quantitative results by highlighting the practical experiences of farmers, transporters, traders, and agricultural officials regarding the constraints affecting agricultural product movement.

The findings support the Sustainable Livelihood Framework by demonstrating that improved physical infrastructure enhances livelihood opportunities, strengthens market participation, increases household income, and promotes food security. Consequently, sustainable investments in rural transportation systems, integrated logistics networks, storage infrastructure, and institutional coordination are essential for minimizing postharvest losses and promoting

inclusive agricultural development in Southern Kaduna Senatorial District.

1.11 RECOMMENDATIONS

Based on the findings of this study, the following recommendations are proposed.

i. Rehabilitation of Rural Road Infrastructure

The Federal Ministry of Works, Kaduna State Government, and Local Government Authorities should prioritize the rehabilitation and routine maintenance of rural feeder roads connecting farming communities to major markets. Improved road conditions will reduce transportation delays, minimize mechanical damage to agricultural produce, and lower transportation costs.

ii. Strengthening Rural Transport Services

Government agencies should collaborate with transport unions and private investors to establish affordable and reliable rural agricultural transport services. Incentives such as low-interest credit facilities and tax relief should be provided to encourage investment in agricultural transport vehicles.

iii. Promotion of Modern Logistics Technologies

The Kaduna State Ministry of Agriculture, agricultural development programmes, and extension agencies should promote the adoption of digital logistics platforms, vehicle tracking systems, improved packaging technologies, and cold-chain transportation for highly perishable commodities.

iv. Development of Community Storage Facilities

Modern storage centres equipped with appropriate preservation technologies should be established within strategic farming

communities to reduce the quantity of produce transported under unfavourable conditions and minimize spoilage before marketing.

v. Capacity Building for Farmers and Transporters

Regular training programmes should be organized on postharvest handling, produce packaging, logistics planning, and transportation management to improve stakeholders' knowledge and reduce avoidable losses.

vi. Strengthening Farmer Cooperatives

Farmer cooperatives should be strengthened to facilitate collective transportation, bulk marketing, and shared investment in logistics infrastructure. Cooperative transport arrangements can significantly reduce transportation costs while improving market access.

vii. Increased Government Investment in Agricultural Logistics

Federal and State Governments should increase investment in rural transportation infrastructure through Public–Private Partnerships (PPPs), with particular emphasis on agricultural corridors connecting major production centres to processing industries and urban markets.

viii. Improved Institutional Coordination

Closer collaboration among the Federal Ministry of Agriculture and Food Security, Kaduna State Ministry of Agriculture, Kaduna Agricultural Development Programme (KADP), transport unions, development partners, and farmer organizations should be encouraged to ensure effective implementation of agricultural logistics policies.

ix. Promotion of Research and Innovation

Universities, research institutes, and development agencies should undertake further

studies on innovative transport systems, climate-resilient logistics, and smart agricultural transportation technologies capable of reducing postharvest losses under changing environmental conditions.

x. Policy Implementation and Monitoring

Government should strengthen the monitoring and evaluation of transportation policies affecting agriculture to ensure that infrastructure investments translate into measurable reductions in postharvest losses and improvements in farmers' livelihoods.

1.12 CONTRIBUTION TO KNOWLEDGE

This study makes several significant contributions to the existing body of knowledge:

- i. It provides empirical evidence on the influence of transport logistics on postharvest losses within Southern Kaduna Senatorial District, an area that has received limited scholarly attention.
- ii. It integrates quantitative and qualitative approaches to provide a comprehensive understanding of transportation challenges affecting agricultural product movement.
- iii. It extends the application of the Sustainable Livelihood Framework to explain the relationship between transport logistics, postharvest losses, and rural development.
- iv. It generates evidence-based recommendations that can inform transportation planning, agricultural policy, and rural development interventions in Kaduna State and Nigeria.
- v. It contributes to ongoing discussions on achieving Sustainable Development Goals 2 (Zero Hunger), 9 (Industry, Innovation and Infrastructure), and 12 (Responsible Consumption and Production).

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