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TOWARDS ADOPTING INTEGRATED TRANSPORT SYSTEM FOR ACHIEVING FOOD SECURITY IN THE SOUTH EAST, NIGERIA.

UGWU, Timothy C[1].; **OGBUENE,** Anthony C[2]; **NEBO,** Eunice C[3]. and **Eze,** Regina C[4].
[1,3]School of general studies, Federal Polytechnic Ohodo, Enugu
[2]Department of Public Administration, Federal Polytechnic Ohodo, Enugu
[4]Department of Bursary, Enugu State College of Education Technical, Enugu
[1]timothy.ugwu@fedpod.edu.ng

Abstract
This study examined the effect of integrated transport systems on achieving food security in South-East Nigeria. Specifically, the study investigated the effects of integrated transport systems on farm-to-market travel time, post-harvest food losses, and food price variability, and identified integrated transport systems that could enhance food security in the region. A descriptive cross-sectional survey research design was adopted. The population comprised 4,512 stakeholders involved in agricultural production, transportation, and food distribution in South-East Nigeria. Using the Taro Yamane (1967) formula, a sample size of 367 respondents was determined, of which 353 valid responses were analyzed. Data were collected using a structured five-point Likert scale questionnaire. Descriptive statistics (mean and standard deviation) were used to answer the research questions, while simple linear regression was employed to test the hypotheses at a 5% level of significance. The findings revealed that integrated transport systems significantly improved farm-to-market travel time (Grand Mean = 3.94; Average SD = 1.07; R = 0.782, R^2 = 0.611, F = 549.812, $p < 0.05$). The study also found that integrated transport systems significantly reduced post-harvest food losses (Grand Mean = 3.95; Average SD = 1.08; R = 0.768, R^2 = 0.590, F = 496.731, $p < 0.05$). Furthermore, integrated transport systems significantly reduced food price variability (Grand Mean = 3.97; Average SD = 1.07; R = 0.801, R^2 = 0.642, F = 617.348, $p < 0.05$). Respondents equally supported the adoption of integrated road, rail, and water transport systems (Grand Mean = 3.98; Average SD = 1.07) as a sustainable strategy for enhancing food security. The study concluded that integrated transport systems are indispensable for improving food availability, accessibility, and price stability in South-East Nigeria. It recommended increased investment in multimodal transport infrastructure, rehabilitation of rural feeder roads, strengthened public-private partnerships in transport logistics, and the integration of cold-chain facilities into agricultural transport systems to enhance sustainable food security.

Keywords: Keywords: Integrated transport system, food security, farm-to-market travel time, post-harvest food losses, food price variability, South-East Nigeria.

Background of the Study

Food security remains a critical global development concern, particularly in developing economies where structural inefficiencies continue to undermine food systems. The concept of food security encompasses consistent access to sufficient, safe, and nutritious food necessary for an active and healthy life. Despite global commitments such as the United Nations Sustainable Development Goal 2 (Zero Hunger), progress has been uneven, with Sub-Saharan African countries especially Nigeria, recording rising levels of food insecurity (FAO et al., 2023; World Bank, 2023). Empirical studies further show that food insecurity in developing regions is increasingly linked to systemic constraints such as poor infrastructure, poverty, and institutional inefficiencies (Barrett, 2020; Béné et al., 2021).

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In Nigeria, food insecurity is driven by a combination of factors including rapid population growth, climate variability, insecurity, and poor infrastructure systems. Recent estimates indicate that over 90 million Nigerians experience some level of food insecurity, with the South-East region being particularly vulnerable due to infrastructural deficits and supply chain inefficiencies (World Food Programme, 2023; NBS, 2024). Studies have also demonstrated that poor rural-urban connectivity and inadequate logistics systems significantly hinder agricultural productivity and market access, thereby worsening food insecurity (Dorosh et al., 2012; Stifel & Minten, 2017).

Transportation plays a central role as it directly affects food availability, accessibility, and affordability through its impact on distribution networks and post-harvest losses. Efficient transport systems reduce transaction costs, enhance spatial market integration, and improve price stability across regions (Sweeney et al., 2015; Limao & Venables, 2001). In contrast, poor transport infrastructure contributes to high food prices and significant post-harvest losses, especially in perishable agricultural commodities (Aker, 2010; Kader, 2013).

An Integrated Transport System (ITS) which coordinates road, rail, water, and air transport has been identified as a viable solution to improve food supply chain efficiency. Evidence suggests that multimodal transport integration enhances logistics performance, reduces inefficiencies, and strengthens food distribution networks (Rodrigue, 2020; Notteboom & Rodrigue, 2022). In developing countries, integrated transport systems have been linked to improved agricultural commercialization and rural development outcomes (Gollin & Rogerson, 2014; Aggarwal, 2018).

However, in South-East Nigeria, transport infrastructure remains fragmented, poorly maintained, and insufficiently coordinated, thereby constraining agricultural productivity and food distribution. Studies specific to Nigeria indicate that poor road conditions, insecurity, and high transportation costs are major barriers to efficient food supply chains (Ogundari, 2017; Adeoti et al., 2023). Furthermore, institutional inefficiencies and lack of coordination among stakeholders limit the effectiveness of transport policies and investments (Ighodaro, 2019).

Although successive governments have implemented policies and invested in transport and agricultural development, the expected improvements in food security outcomes have not been fully realized. Empirical evidence suggests that public investments in infrastructure do not automatically translate into improved outcomes (Calderón & Servén, 2014; Estache & Garsous, 2012). This raises critical questions regarding the coordination, sustainability and effectiveness, of transport systems towards ensuring food security in South East Nigeria.

Consequently, there is a need for a systematic evaluation of how integrated transport system support movement of agricultural produce and the effect of integrated transport system on farm-to-market travel time of food products. There is also the need to determine the effect of integrated transport system on post-harvest food losses and the effect of integrated transport system on food price variability in South-East Nigeria. Such an evaluation is essential for informing policy decisions, improving infrastructure planning, and achieving sustainable food security outcomes in the region. The general objective was to assess the effect of integrated transport system on food security in the South East, Nigeria, while the specific objectives were to:

Examine the effect of integrated transport system on farm-to-market travel time of food products in South-East Nigeria. Determine the effect of integrated transport system on post-harvest food losses in South-East Nigeria. Evaluate the effect of integrated transport system on food price variability in South-East Nigeria. Determine integrated transport systems that can be adopted towards improving food security in the Southeast Nigeria.

The following research questions structured in line with the objectives guided the study:

1. What is the effect of integrated transport system on farm-to-market travel time of food products in South-East Nigeria?
2. Does integrated transport system affect post-harvest food losses in South-East Nigeria?
3. What is the effect of integrated transport system on food price variability in South-East Nigeria?

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4. What is the integrated transport systems that can be adopted towards improving food security in the Southeast Nigeria (Road, Rail, Water, Air)?

The following null hypotheses guided the study and were tested at 5% level of significance:

H_{01} Integrated transport system has no significant effect on farm-to-market travel time of food products in South-East Nigeria.

H_{02} Transport system integration has no significant effect on post-harvest food losses in South-East Nigeria.

H_{03} Integrated transport system has no significant effect on food price variability in South-East Nigeria.

Conceptual Review

Integrated Transport System

Integrated transport system refers to the coordinated planned, operation, and management of multiple transport modes (road, rail, waterways) that ensure seamless movement of goods, services and people (Rodrigue et al., 2017; Banister & Berechman, 2001). In agricultural systems, integration enables efficient farm-to-market movement, reduces delays, and lowers operational costs (Adebayo et al., 2021). Integrated transport systems are increasingly recognized as critical for supporting economic development and food security, particularly in regions where fragmented infrastructure leads to high post-harvest losses and price volatility (World Bank, 2018). Transport system integration is the harmonization and coordination of multiple transport modes to optimize movement efficiency, reduce costs, and improve access to markets (Rodrigue et al., 2017; Adebayo et al., 2021). The concept directly informs the independent variable of this study, as the level of integration among road, rail, and water transport will be examined to assess its effect on farm-to-market travel time, post-harvest losses, and food price variability in South-East Nigeria.

Farm-to-Market Travel Time

Farm-to-market travel time is the duration taken for agricultural produce to move from farms to markets, and it is a key indicator of transport efficiency (FAO, 2017; Tijjani et al., 2020). Longer travel times are associated with delays in delivery, increased perishability, and higher logistical costs (Adeoye & Fapohunda, 2018). In integrated transport systems, improved connectivity and route optimization reduce travel time, enhancing the timely delivery of fresh produce (Onuoha & Chukwuemeka, 2019). Farm-to-market travel time is the measured time it takes for agricultural commodities to be transported from production sites to consumer markets (FAO, 2017; Tijjani et al., 2020). Farm-to-market travel time is a primary outcome variable that reflects the efficiency of transport system integration and its influence on food security, particularly on product freshness, losses, and market pricing.

Post-Harvest Food Losses

Post-harvest food losses refer to the reduction in quantity or quality of food that occurs from harvest to consumption due to handling, storage, transport, or processing inefficiencies (Gustavsson et al., 2011; Akinbile et al., 2020). In developing regions, these losses can range from 20% to 50% of total production (FAO, 2019). Factors influencing losses include poor transport integration, inadequate storage facilities, and long transit times (Onuoha & Chukwuemeka, 2019). Effective transport system integration can minimize these losses by facilitating timely and safer movement of produce. Post-harvest food losses are the measurable reduction in quantity or quality of agricultural produce occurring between harvest and consumption due to systemic inefficiencies (Gustavsson et al., 2011; Akinbile et al., 2020). Post-harvest losses serve as a key mediating variable, linking transport system integration and food security outcomes. Reducing losses through integrated transport enhances availability and stability of food supplies.

Food Price Variability

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Food price variability refers to the fluctuation of food prices across time and location, which can affect food accessibility and market stability (Barrett, 2010; Olaniyi & Adeyemo, 2020). Poor transport infrastructure and poor integration often exacerbate variability by increasing transaction costs, delaying supply, and creating supply-demand imbalances (Adebayo et al., 2021). Conversely, efficient transport systems facilitate stable supply flows, reduce price shocks, and improve predictability for producers and consumers. Food price variability is the degree of fluctuation in food prices over time and across different markets due to supply chain and transport inefficiencies (Barrett, 2010; Olaniyi & Adeyemo, 2020). This concept operationalizes one of the key dependent variables of the study. Understanding price variability in relation to transport integration allows for assessment of the economic impacts of transport inefficiency on food security.

Food Security

Food security is a multidimensional concept encompassing the availability, accessibility, utilization, and stability of food (FAO, 2008; Pinstrup-Andersen, 2009). Availability focuses on sufficient supply; accessibility on affordability and physical access; utilization on nutritional value; and stability on consistent supply over time. Transport system efficiency is critical for ensuring both accessibility and stability, as it determines whether food reaches consumers timely and reliably (Tijjani et al., 2020; Onuoha & Chukwuemeka, 2019). Food security is a condition in which all individuals have reliable physical, social, and economic access to sufficient, safe, and nutritious food to meet their dietary needs for an active and healthy life (FAO, 2008; Pinstrup-Andersen, 2009). Food security is the ultimate dependent variable. The study investigates how transport system integration impacts food security outcomes through reductions in travel time, post-harvest losses, and price variability.

The study, towards adopting integrated transport system for achieving food security in south-east Nigeria sort to explain how transport system integration affects key food security outcomes through efficiency and market mechanisms within the South-East Nigerian context. The conceptual framework posits that improved transport system integration enhances the efficiency of agricultural produce movement in South-East Nigeria by reducing farm-to-market travel time. Reduced travel time minimizes exposure of food commodities to spoilage, thereby lowering post-harvest food losses. Lower food losses and improved distribution efficiency contribute to reduced food price variability across markets. The framework assumes that transport system integration directly and indirectly affects food security outcomes through time efficiency and loss reduction mechanisms.

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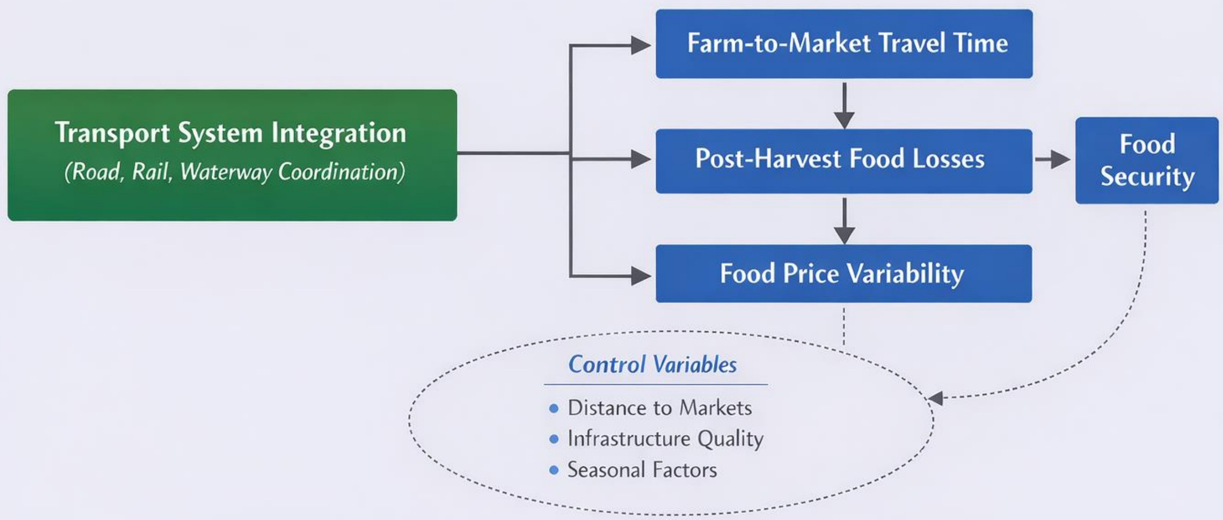

Figure 1: Conceptual Framework Towards Adopting Integrated Transport System for Achieving Food Security in South-East Nigeria

Theoretical Framework of the Study

This study is anchored on Systems Theory, Spatial Interaction Theory, and Food Security Theory to explain the relationship between transport system integration and food security outcomes in South-East Nigeria.

Systems Theory

Systems Theory posits that social and economic outcomes result from the interaction of interrelated components operating as a unified whole (Von Bertalanffy, 1968). In transport economics and regional development, transport modes function as subsystems whose effectiveness depends on coordination and integration (Rodrigue et al., 2017). Applied to this study, road, rail, and inland waterways constitute interconnected subsystems within the agricultural distribution system. Poor or limited integration among these subsystems leads to inefficiencies such as prolonged farm-to-market travel time, increased post-harvest food losses, and unstable food prices, while effective integration improves system performance and food security outcomes.

However, critics argue that Systems Theory is more of abstract and does not sufficiently account for power asymmetries, institutional failures, and political constraints that affect system performance in developing economies (Jackson, 2003). Despite this limitation, Systems Theory is appropriate because it provides a holistic lens for analysing transport integration, which is central to understanding how fragmented transport subsystems jointly affect food distribution efficiency and food security in South-East Nigeria.

Spatial Interaction Theory

Spatial Interaction Theory explains the movement of goods and services between locations based on complementarity, transferability, and intervening opportunities (Ullman, 1956). In agricultural markets, spatial interaction determines how efficiently food commodities move from surplus-producing rural areas to deficit urban markets (Fotheringham & O’Kelly, 1989). In this study, transport system integration enhances transferability by reducing travel time and transportation costs, thereby strengthening spatial interaction between farms and markets. Improved spatial interaction contributes to reduced post-harvest food losses and lower food price variability across markets. However, the theory has been criticised for its heavy reliance on distance and cost variables while underplaying institutional, infrastructural quality, and governance factors that influence mobility, especially in developing regions (Hanson, 2005). Contrary to the criticisms, the theory remains relevant because it directly explains the mechanisms through which transport efficiency affects market connectivity, price dispersion, and food distribution outcomes, which are central to this study.

Food Security Theory

Food Security Theory conceptualises food security as a condition in which all people have physical and economic access to sufficient, safe, and nutritious food at all times (FAO, 2008). The theory identifies four dimensions of food security: availability, accessibility, utilisation, and stability. This study focuses on availability, accessibility, and stability, which are directly influenced by transport system performance. Integrated transport systems reduce post-harvest losses, improve access to markets, and stabilise food prices, thereby strengthening food security outcomes in South-East Nigeria. Criticism of Food Security Theory argue that Food Security Theory often focuses more on supply-side outcomes while insufficiently addressing structural inequalities and socio-political barriers affecting food access (Pinstrup-Andersen, 2009). This criticism notwithstanding, Food Security Theory is appropriate for this study because it provides a well-established framework for measuring food-related outcomes and aligns with policy-oriented research on food systems and transport infrastructure.

The integration of Systems Theory, Spatial Interaction Theory, and Food Security Theory provides a robust explanatory foundation for this study. Systems Theory explains the need for coordinated transport subsystems; Spatial Interaction Theory clarifies how transport efficiency affects movement and pricing of food commodities; while Food Security Theory links these outcomes to food availability, accessibility, and stability. Together, these theories justify the proposed relationships in the conceptual framework and guide empirical investigation.

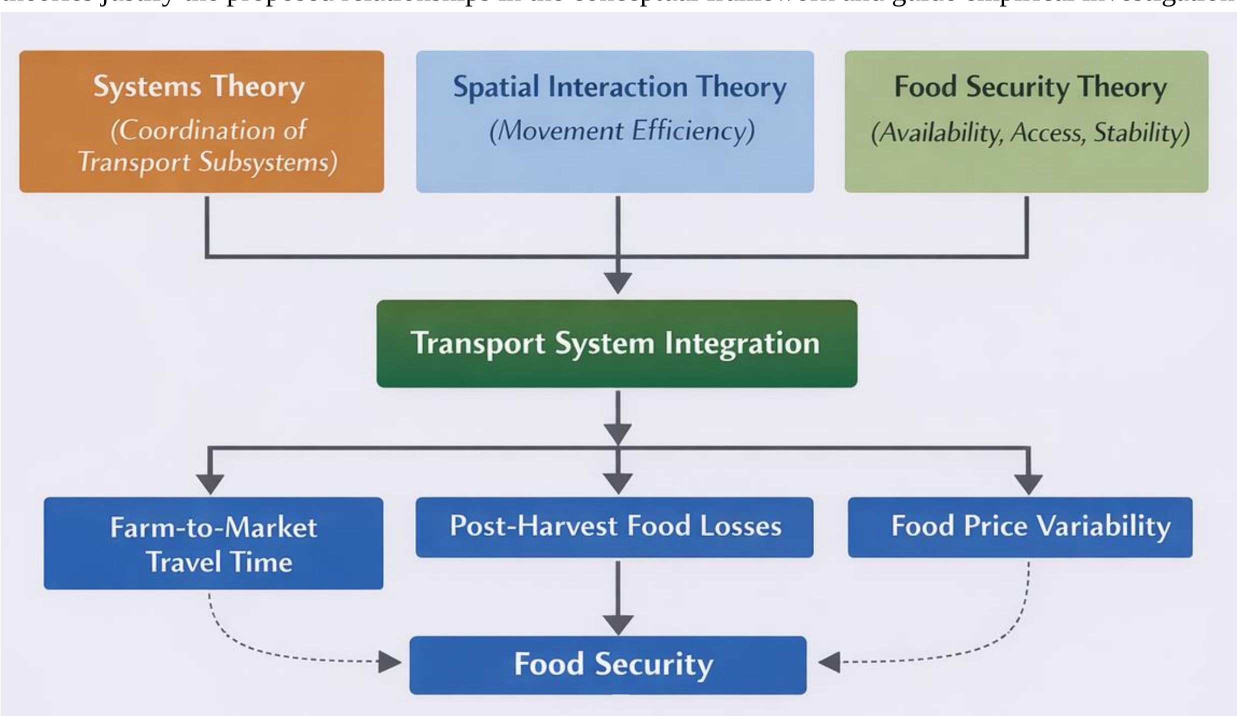

Figure 2: Theoretical Framework Underpinning the Study

EMPIRICAL REVIEW

Empirical studies on transport systems and food security show clear patterns but also important differences in context, methods, and outcomes. Across studies on movement of agricultural products, evidence from Nigeria and other developing countries using secondary datasets and econometric models such as ARDL and system based

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approaches shows that transport constraints reduce distribution efficiency and market access (Mekonnen et al., 2021; Ajiboye et al., 2025), while studies based on primary survey data and micro level regression techniques in countries such as Ghana report stronger direct effects of transport access on farm level market participation (Aidoo et al., 2023). On farm to market travel time, time series and macro level analyses in Nigeria indicate that infrastructure deficits significantly prolong delivery time and reduce food availability (Aliyu et al., 2021), whereas cross sectional household studies suggest that localized transport improvements yield more immediate reductions in travel delays (Ayeni et al., 2025). In the area of post-harvest losses, studies using mixed methods and meta-analysis across Sub Saharan Africa identify transport inefficiency as a dominant cause of losses (Abass et al., 2021; Affognon et al., 2023), yet evidence from Asian panel data studies that incorporate cold chain logistics shows lower loss rates where transport is integrated with storage systems (Zhang et al., 2024), indicating regional disparities in infrastructure development. For food price variability, econometric studies using cointegration and GARCH models in Africa reveal that weak transport networks increase spatial price dispersion and volatility (Minten et al., 2021; Amolegbe et al., 2023), while dynamic panel studies across multiple countries suggest that improvements in transport integration reduce price gaps but with varying magnitudes depending on institutional quality and market structure (Badiane & Collins, 2024). Methodologically, the literature is divided between macro level secondary data analyses and micro level primary data approaches, with differences in analytical tools ranging from descriptive statistics, regression models, and ARDL techniques to structural equation modelling and spatial econometrics, which partly explains inconsistencies in findings. Geographically, most studies are either cross country or focused on specific regions outside Southeast Nigeria, with limited attention to sub national dynamics within Nigeria. The studies do not also reflect recent conditions, as much as they do not adequately capture evolving transport reforms and economic shocks. These differences reveal a clear gap. Existing studies treat transport factors in isolation, focus on single dimensions of food security, and rarely integrate multiple outcomes within a unified analytical framework, especially at the sub regional level. Moreover, they do not sufficiently account for the economic realities of Southeast Nigeria such as high transport costs, infrastructure deficits, and market fragmentation, neither do they account for governance challenges such as poor policy coordination within the region, limited investment in multimodal transport systems, and institutional inefficiencies. Consequently, there is a need for a comprehensive and context specific study that simultaneously examines the effects of an integrated transport system on agricultural product movement, travel time, post-harvest losses, and food price variability within Southeast Nigeria, the overall impact on food security which this study is designed to address.

Methodology

This study adopted a descriptive cross-sectional survey research design. The design is appropriate because it allows the researcher to obtain information from respondents at a single point in time without manipulating the study variables. The study was conducted in the South-East geopolitical zone of Nigeria, comprising Abia, Anambra, Ebonyi, Enugu and Imo States. The region is predominantly agrarian and serves as one of Nigeria's major food-producing zones. The study relied on both primary and secondary sources of data. Primary data were obtained through the administration of structured questionnaires to respondents, while secondary data were sourced from scholarly journals, textbooks, and government publications. The population of the study consisted of 4,512 stakeholders involved in agricultural production, transportation and food distribution within the South-East geopolitical zone of Nigeria. The population comprised registered farmers, transport logistics operators, market aggregators registered with the Nigerian Association of Chambers of Commerce, Industry, Mines and Agriculture (NACCIMA), South-East Chapter, Commissioners for Transport, Permanent Secretaries and Directors of Transport in the Ministries of Transport of the five South-East states, officials of the Federal Road Maintenance Agency (FERMA) South-East Zonal Office, and other relevant stakeholders whose activities directly influence agricultural

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transportation and food security. The sample size for the study was determined using the Taro Yamane (1967) formula for finite populations: In determining the sample size, the Taro Yamane formula was applied and it is stated as follows: $\mathbf{n} = \frac{N}{1+N(e)^2}$ Where, n = sample size; N = total population size; I = is constant and e = error limit which is trained as 5% (0.05). Thus, the sample size for the study was 367 respondents. The study adopted a three-stage multistage sampling technique. In the first stage, Ebonyi and Enugu States were purposively selected because of their strategic importance in agricultural production and accessibility for fieldwork. The second stage involved the simple random selection of three Local Government Areas from each of the two selected states. In the third stage, respondents were selected using proportionate stratified random sampling to ensure adequate representation of each stakeholder group. The estimated population distribution and proportionate allocation of the sample are presented as follows: Farmers (2,950: 65.38% of 4512) = 240; Transport logistics operators (850: 18.84% of 4512) = 69; Market aggregators (NACCIMA) (650: 14.41% of 4512) = 53; Commissioners for Transport (5: 0.11% of 4512) = 1; Permanent Secretaries (5: 0.11% of 4512) = 1; Directors of Transport (5: 0.11% of 4512) = 1; FERMA South-East Zonal officials (3: 0.07% of 4512) = 1 and Other stakeholders (44: 0.97% of 4512) = 1. The proportionate allocation was computed using Cochran (1977) standard proportionate allocation formula : $\boldsymbol{n}_{h=}\left(\frac{N_h}{N}\right)x\,n$ for allocation of sample size for a specific stratum $(\boldsymbol{n_h})$. Data were collected using a structured questionnaire comprising two sections. Section A elicited respondents' demographic information, while Section B contained structured statements measured on a five-point Likert scale of Strongly Agree (5), Agree (4), Neutral (3), Disagree (2) and Strongly Disagree (1). The questionnaire contained both closed-ended and a few open-ended questions to enable respondents provide additional information relevant to the study. The questionnaire was subjected to face and content validity by experts in transportation, logistics, agricultural economics and research methodology to ensure that the instrument adequately measured the study variables. A pilot study was conducted using respondents drawn from states outside the study area. The reliability of the instrument was determined using Cronbach's Alpha, and a reliability coefficient of 0.70 or above was considered acceptable, indicating that the instrument possessed satisfactory internal consistency. Completed questionnaires were carefully screened, coded and entered into the Statistical Package for Social Sciences (SPSS) for analysis. Descriptive statistics, including mean and standard deviation, were used to answer the research questions, while multiple regression analysis was employed to test the hypotheses at a 5% level of significance. The decision rule was to reject the null hypothesis where the probability (p-value) was less than 0.05; otherwise, the null hypothesis was not rejected. The regression model for this study is specified to examine the effect of integrated transport system on food security in Southeast Nigeria.

Model Specification

FS = f(ITS)

Where:

FS = Food Security

ITS = Integrated transport system (Road, Rail, Water, and Air, Transport)

Econometric Form of the Model

FS = $\beta_0 + \beta_1 ITSC + \mu$, Where:

$\boldsymbol{\beta_0}$ = Constant term (intercept)

$\boldsymbol{\beta_1}$ = Coefficient of independent variables

$\boldsymbol{\mu}$ = Error term

Since integrated transport system is measured using sub-variables, the model can be expanded as: FS = $\beta_0 + \beta_1 FMTT + \beta_2 PHFL + \beta_3 FPV + \mu$, Where:

FS = Food Security

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FMTT = Farm-to-Market Travel Time
PHFL = Post-Harvest Food Loses
FPV = food Price Variability

Data Analysis

Table 1: Respondents' Opinion on Integrated Transport System (ITS) and Farm-to-Market Travel time (FMTT)

S/N	Items	SA (5)	A (4)	N (3)	D (2)	SD (1)	Mean	SD	Decision
1	Travel time from farm to market is generally short.	142	121	45	30	15	3.99	1.09	Accepted
2	Road conditions significantly increase travel time.	130	128	52	28	15	3.95	1.06	Accepted
3	Transport delays are common when moving agricultural produce.	125	132	50	30	16	3.91	1.07	Accepted
4	Improved transport systems reduce	118	135	55	30	15	3.88	1.05	Accepted

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S/N	Items	SA (5)	A (4)	N (3)	D (2)	SD (1)	Mean	SD	Decision
	delivery time.								
5	Seasonal conditions such as rain and flooding worsen travel time	140	120	48	30	15	3.98	1.08	Accepted

Grand Mean = 3.94 **| Average Standard Deviation** = 1.07

The result in Table 1 revealed a grand mean of 3.94, which is above the criterion mean of 3.00, indicating that respondents agreed that integrated transport systems significantly improve farm-to-market travel time in South-East Nigeria. Specifically, respondents agreed that poor road conditions and transport delays increase travel time, while improved transport infrastructure reduces delivery time and facilitates timely movement of agricultural produce. The average standard deviation of 1.07 indicates that respondents' opinions were fairly homogeneous, suggesting a high level of consensus on the influence of transport integration on agricultural logistics.

Table 2: Respondents' Opinion on Integrated Transport System (ITS) and Post-Harvest Losses (PHL)

S/N	Items	SA (5)	A (4)	N (3)	D (2)	SD (1)	Mean	SD	Decision
1	A significant portion of agricultural produce is lost during transportation.	145	118	46	28	16	3.99	1.10	Accepted
2	Poor	1	1	4	3	1	3.9	1	Acce

S/N	Items	SA (5)	A (4)	N (3)	D (2)	SD (1)	Mean	SD	Decision
	transport conditions contribute to spoilage of goods.	36	26	2	3	6	4	.09	pted
3	Improved transport systems reduce post-harvest losses.	132	130	45	30	16	3.94	1.07	Accepted
4	Lack of proper handling during transit leads to product damage	125	134	48	31	15	3.91	1.05	Accepted
5	Faster delivery reduces spoilage of perishable goods.	140	120	50	28	15	3.97	1.08	Accepted

Grand Mean = 3.95 **| Average Standard Deviation** = 1.08

Table 2 shows a grand mean of 3.95, indicating that respondents agreed that integrated transport systems play a significant role in reducing post-harvest food losses. The respondents acknowledged that poor transportation contributes to spoilage, while improved transport systems, faster delivery, and proper handling during transit help preserve agricultural produce. The average standard deviation of 1.08 indicates little variation in responses, reflecting substantial agreement among respondents regarding the importance of transport integration in minimizing post-harvest losses.

Table 3: Respondents' Opinion on Integrated Transport System (ITS) and Food Price

Variability (FPV)

S/N	Items	SA (5)	A (4)	N (3)	D (2)	SD (1)	Mean	SD	Decision
1	Transport costs influence the prices of food products.	148	116	44	30	15	4.00	1.09	Accepted
2	Poor transport systems lead to price differences across markets.	140	122	46	29	16	3.96	1.08	Accepted
3	Improved transport systems stabilize food prices.	135	128	45	30	15	3.95	1.06	Accepted
4	Delays in transportation cause price increases.	130	130	48	30	15	3.93	1.05	Accepted
5	Better connectivity between markets reduces price	145	118	47	28	15	3.99	1.07	Accepted

S/N	Items	SA (5)	A (4)	N (3)	D (2)	SD (1)	Mean	SD	Decision
	fluctuations.								

Grand Mean = 3.97 **| Average Standard Deviation** = 1.07

The findings in Table 3 produced a grand mean of 3.97, indicating respondents' agreement that integrated transport systems contribute significantly to food price stability. Respondents agreed that transportation costs influence food prices, poor transport infrastructure increases price differences across markets, while efficient transport systems enhance market connectivity and reduce unnecessary price fluctuations. The average standard deviation of 1.07 indicates consistency in respondents' opinions on the role of transport integration in promoting stable food prices.

Table 4: Respondents' Opinion on the Integrated Transport Systems that can be adopted (Road, Rail, Water, Air)

S/N	Items	SA (5)	A (4)	N (3)	D (2)	SD (1)	Mean	SD	Decision
1	Rail transport system reduces impact of transportation on food availability and affordability	150	118	40	30	15	4.02	1.08	Accepted
2	Air transport system enhances availability of perishable food items and reduces damages	142	124	43	28	16	3.98	1.07	Accepted
3	Water transport is safe and conducive for movement of food products to consumers	138	126	45	29	15	3.97	1.05	Accepted
4	Quality road infrastructure enhances food supply and affordability.	132	130	46	30	15	3.95	1.06	Accepted

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S/N	Items	SA (5)	A (4)	N (3)	D (2)	SD (1)	Mean	SD	Decision
5	I recommend the integrated transport system across southeast states for food security.	145	120	45	28	15	4.00	1.07	Accepted

Grand Mean = 3.98 **| Average Standard Deviation** = 1.07

The grand mean of 3.98 indicates that respondents strongly supported the adoption of an integrated transport system comprising road, rail, water and air transportation for improving food security in South-East Nigeria. They believed that rail transport, improved road infrastructure, inland water transport and air transport collectively enhance food availability, affordability and timely distribution of agricultural products. The average standard deviation of 1.07 shows that respondents shared similar opinions on the necessity of adopting an integrated transport system.

Test of Hypotheses

H_{01} Integrated transport system has no significant effect on farm-to-market travel time of food products in South-East Nigeria.

Table 5: Regression Analysis on the Effect of Integrated transport system has no significant effect on farm-to-market travel time of food products in South-East Nigeria

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.782	0.611	0.607	0.514

ANOVA

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	145.326	1	145.326	549.812	0.000[b]
Residual	92.781	351	0.264		
Total	238.107	352			

Coefficients

Model	Unstandardized Coefficients (B)	Std. Error	Beta	t	Sig.
(Constant)	1.214	0.185		6.562	0.000
Audit Professional Qualification	0.724	0.031	0.782	23.448	0.000

The regression analysis produced R = 0.782, R^2 = 0.611, F = 549.812, p = 0.000 (<0.05). Therefore, the null hypothesis was rejected. This implies that integrated transport systems have a statistically significant positive effect on farm-to-market travel time of food products in South-East Nigeria. Approximately 61.1% of the variation in farm-to-market travel time was explained by integrated transport systems.

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H$_{02.}$ Transport system integration has no significant effect on post-harvest food losses in South-East Nigeria.

Table 6: Regression Analysis on the Effect of integration has no significant effect on post-harvest food losses in South-East Nigeria.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.768	0.590	0.586	0.528

ANOVA

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	138.442	1	138.442	496.731	0.000 b
Residual	97.861	351	0.279		
Total	236.303	352			

Coefficients

Model	Unstandardized Coefficients (B)	Std. Error	Beta	t	Sig.
(Constant)	1.306	0.192		6.802	0.000
Audit Experience	0.698	0.031	0.768	22.288	0.000

The regression results yielded R = 0.768, R^2 = 0.590, F = 496.731, p = 0.000 (<0.05). The null hypothesis was rejected. This indicates that integrated transport systems significantly reduce post-harvest food losses. About 59.0% of the variation in post-harvest losses was explained by transport system integration.

H$_{03:}$Integrated transport system has no significant effect on food price variability in South East Nigeria.

Table 7: Regression Analysis on the effect of integrated transport system on food price variability in South East Nigeria.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.801	0.642	0.639	0.497

ANOVA

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	152.684	1	152.684	617.348	0.000^{b}
Residual	86.829	351	0.247		
Total	239.513	352			

COEFFICIENTS

Model	Unstandardized Coefficients (B)	Std. Error	Beta	t	Sig.
(Constant)	1.148	0.176		6.523	0.000
Audit Technical	0.751	0.030	0.801	24.84	0.000

Model	Unstandardized Coefficients (B)	Std. Error	Beta	t	Sig.
Knowledge and Skills				6	

The regression analysis showed R = 0.801, $R^2 = 0.642$, F = 617.348, p = 0.000 (<0.05). Consequently, the null hypothesis was rejected. Integrated transport systems significantly influence food price variability in South-East Nigeria, explaining approximately 64.2% of the observed variation.

Discussion of Findings

The study found that integrated transport systems significantly reduce farm-to-market travel time in South-East Nigeria. The high mean score and significant regression result indicate that improved transport infrastructure facilitates faster movement of agricultural products from farms to markets. This finding supports Systems Theory, which posits that efficient coordination among transport subsystems enhances overall system performance. It also aligns with Spatial Interaction Theory, which explains that improved transport networks strengthen the movement of goods between production and consumption centres. The finding is consistent with the studies of Aliyu et al. (2021), Ejemeyovwi et al. (2021), Ayeni et al. (2025) and Eneh and Eneh (2025), who reported that improved transport infrastructure reduces travel delays and enhances food accessibility. The finding implies that improving transport connectivity is essential for strengthening agricultural marketing and food security in South-East Nigeria. The study further established that integrated transport systems significantly reduce post-harvest food losses. Respondents agreed that efficient transport systems minimise spoilage through timely delivery and improved handling of agricultural produce. This finding is consistent with Food Security Theory, which emphasizes that food availability depends on efficient distribution systems that reduce losses across the food supply chain. The finding also supports Systems Theory, which views transport as an interconnected component of agricultural distribution. The result agrees with Abass et al. (2021), Kasso and Bekele (2022), Aidoo et al. (2023), Affognon et al. (2023) and Zhang et al. (2024), all of whom concluded that improved transport logistics substantially reduce post-harvest losses and improve food availability. The implication is that investment in integrated transport infrastructure will reduce food waste and improve agricultural productivity.

The study also revealed that integrated transport systems significantly reduce food price variability in South-East Nigeria. Efficient transport networks improve market integration, lower transportation costs and ensure timely movement of food products across markets, thereby promoting price stability. This finding supports Spatial Interaction Theory, which explains that efficient movement of goods enhances market connectivity and reduces regional price disparities, while Food Security Theory identifies price stability as a critical dimension of food security. The finding agrees with Minten et al. (2021), Abdulai (2022), Amolegbe et al. (2023), Badiane and Collins (2024) and Svanidze and Götz (2025), who found that improved transport infrastructure enhances market efficiency and reduces food price volatility. The finding suggests that integrated transport systems are indispensable for achieving sustainable food security and economic stability in South-East Nigeria.

In summary, the study examined the effect of integrated transport systems on achieving food security in South-East Nigeria. The findings revealed that integrated transport systems significantly reduced farm-to-market travel time, thereby improving access to markets. The study also found that integrated transport systems significantly reduced post-harvest food losses through faster and more efficient movement of agricultural produce. Furthermore, the study established that integrated transport systems significantly reduced food price variability by improving market connectivity and reducing transportation costs. Respondents also strongly supported the adoption of integrated road, rail, water and air transport systems as a sustainable strategy for enhancing food security in the South-East.

The study concludes that integrated transport systems are fundamental to achieving sustainable food security in South-East Nigeria. Efficient integration of road, rail, water and air transport enhances agricultural distribution, reduces travel time, minimises post-harvest losses and promotes food price stability. Therefore, improving transport infrastructure and multimodal connectivity will strengthen agricultural productivity, improve farmers' incomes and ensure greater food availability and accessibility. The study recommended that Federal and State Governments should invest in integrated multimodal transport infrastructure to facilitate efficient movement of agricultural products. Rural road networks should be rehabilitated and maintained regularly to reduce farm-to-market travel time. Governments should encourage public-private partnerships in agricultural transportation and logistics. Modern storage and cold-chain facilities should be integrated with transport systems to minimise post-harvest losses. Policies that promote coordinated road, rail and inland water transport should be implemented to improve food distribution and stabilize food prices.

The significance of the study include that the findings provide useful information for governments, transport planners and agricultural policymakers in designing strategies that improve food distribution and strengthen food security. The study will also benefit farmers, transport operators and agribusiness investors by demonstrating the importance of integrated transport systems in reducing transportation challenges and improving market access. Furthermore, the study contributes to existing literature on transport systems and food security and serves as a useful reference for future researchers interested in sustainable transport and agricultural development.

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