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Modelling The Cost of Transportation and Distribution of Food Commodities in the South-West, Nigeria

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ABSTRACT
Food security remains a critical global challenge, particularly in developing nations where agricultural productivity, transportation, road infrastructure, and distribution systems are often inadequate or impeded by social, environmental, and infrastructural challenges. This study focused on modeling the costs of transportation and distribution of agricultural produce in South-West Nigeria. The South-West region of Nigeria comprises six (6) states: Lagos, Ogun, Oyo, Osun, Ekiti, and Ondo. Three of the six (6) states that constitute the South-West region were purposively selected for the study based on rurality, vegetation type, presence of rural markets, and prevalence of farming activities. The selected states for the study include Oyo, Osun, and Ekiti. Primary data were obtained through the administration of a structured questionnaire using the purposive-random sampling technique. One Thousand Two Hundred (1,200) copies of the structured questionnaire were administered using the Dillman (2014) formula. One Thousand One Hundred and Twelve (1,112) representing 92.6% of the returned questionnaires were adjudged suitable for the study. The data obtained were analyzed using both descriptive and Inferential Statistics. The findings show that youths constitute (30.8%) of the respondents, and are between the ages of 35and 45 who are actively involved in the transportation of food commodities. Among transport service providers, 33.50% had 6-10 years of experience in transport service operations. Bad rural roads accounted for 13.80% of the challenges in transporting agricultural produce in the region, followed by high energy prices (13.360%), seasonal road disruption (12.60%), and traffic congestion (11.46%). All these challenges have hindered the efficient flow of the agricultural distribution chain. The result of Multiple Linear Regression (MLR)indicates that the combined effect of all predictors on transportation and distribution cost was statistically robust and not attributable to random variation.
Key words: Transportation, challenges, food insecurity, post-harvest losses.

I. INTRODUCTION

Efficient transportation and distribution systems are critical to food security, especially in agrarian economies. The transportation of food crops from production centers to consumption areas determines the availability and affordability of food and influences post-harvest losses, market prices, and rural livelihoods (World Bank, 2020). In developing countries, including Nigeria, inefficiencies in road infrastructure and distribution logistics are significant constraints on the optimal movement of agricultural produce (Oni &Okanlawon, 2010).

Globally, studies have shown that inadequate transport infrastructure and poor rural connectivity significantly hinder the performance of agricultural supply chains. According to the Food and Agriculture Organization (FAO, 2021), transport bottlenecks in sub-Saharan Africa result in up to 40% post-harvest losses of perishable food crops, primarily due to delays and poor storage conditions during transit. The World Bank (2020) also reported that the cost of transporting goods in Africa is 2 to 3 times higher than in developed countries due to poor roads, multiple checkpoints, and inefficiencies in logistics systems.

In Nigeria, agriculture remains a major contributor to the economy, employing more than 35% of the population and accounting for about 22.35% of the GDP in Q4 2023 (National Bureau of Statistics [NBS], 2024). However, the transportation and distribution of food crops remain major bottlenecks. Several studies have emphasized the role of transportation infrastructure in enhancing or limiting agricultural productivity and market access (Akinbami & Lawal, 2021).

Moreover, the dominance of informal, fragmented distribution channels characterized by intermediaries, poorly coordinated logistics, and a lack of cold storage has been identified as a major challenge affecting food distribution in Nigeria (Ogunleye & Alabi, 2021). These inefficiencies contribute to significant price differentials between rural production zones and urban markets.Despite these challenges, there is a need to systematically analyze cost drivers and quantify the effects of transport costs on the market prices of food crops. Such assessment is crucial for developing sustainable planning models that enhance food security, reduce wastage, and improve farmers' incomes.

1.2 Study Area

The South-West region of Nigeria encompasses a diverse and vibrant landscape, comprising six states: Lagos, Ogun, Oyo, Osun, Ondo, and Ekiti, and lies between longitude 2°31′E and 6°00′E andlatitude 6°21′N and 8°37′N, covering approximately77,818 km² land area. (Akinbile and colleagues, 2021). This region is characterized by its mix of urban centers and agricultural landscapes. The region's weather varies between two distinct seasons of the country: the wet season (March-November) and the dry season (November-February).

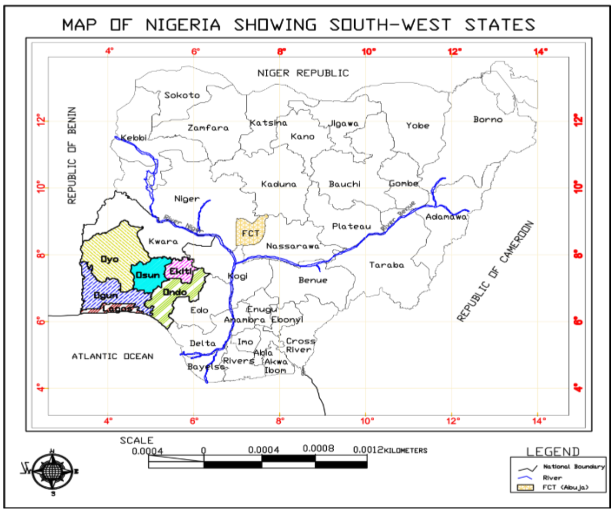

Figure 1:States that made up the Southwestern Region
Source: Author's GIS Design (2025)

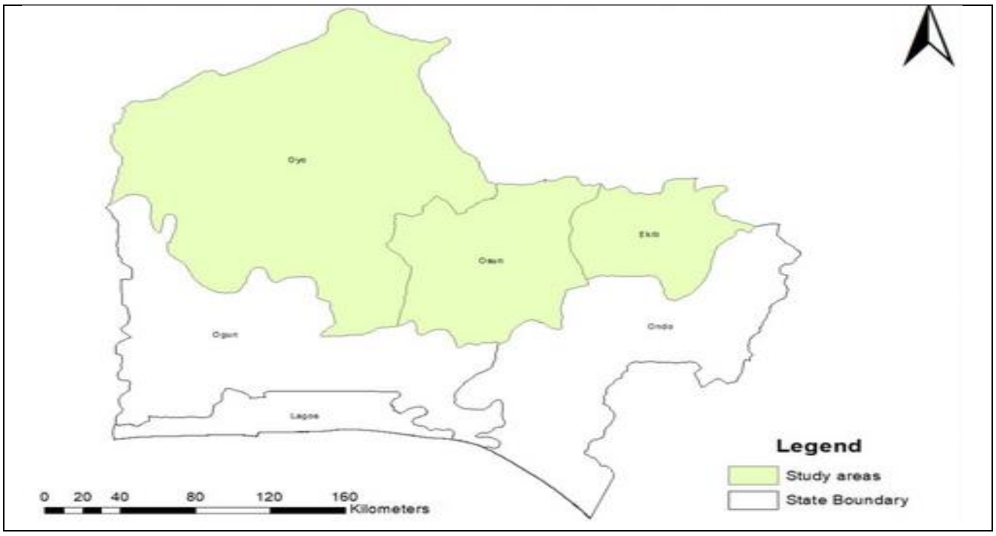

Figure 2:Map of South-west, Nigeria, showing the study area
Source: Author's GIS Design (2025).

II. EMPIRICAL REVIEW

Ibrahim et al. (2014) believethat inadequate transport infrastructure, instability in rural transport service, delays, harassment by law enforcement officers, multiple taxation, and fluctuations in gasoline prices are factors contributing to the inefficient distribution of agricultural commodities. The study advocates stability in gasoline prices and ensuring its availability, adopting better means of tax collection from freight drivers, and reorientinglaw enforcement officers as measures to address these challenges. Similarly, Fasina et al. (2020) observed that the deplorable state of the rural access road is responsible for the herculean task faced by farmers, traders, and transport service providers in the efficient distribution of agricultural produce, which results in delay in travel time, high transport cost, an increase in agricultural wastages, and a reduction in the profit margin of the farmers and traders. The creation of a produce database, the provision of storage facilities, extensive road rehabilitation and construction, and the implementation of adequate maintenance will enhance food distribution.

According to the World Bank (2021), challenges in transporting and distributing food commodities in Southwestern Nigeria result in 5%-50% loss of goods in transit and 15%-25% in financial losses annually.

Transportation models are used to forecast the outcomes of new decisions in the transportation and distribution process. According to Zhang (2025), the Transportation Model is a mathematical optimization process used to determine the cost-effective way to move goods from the point of origin to the destination whilst simultaneously addressing supply and demand constraints. In developing the transportation model, factors to consider include transportation costs, supply capacities, and demand requirements at each destination. The models play a significant role in solving logistical challenges in food crop transportation and distribution.

Pasaribu (2019) argues that transportation models provide the least-cost method of transporting goods from the point of origin (suppliers) to multiple destinations (consumers). These models aimto determine an optimal transportation plan that satisfies the demand for goods/commodities at each destination and the supply at each source.

Hillier and Lieberman (2021) observed that transport models utilize algorithms to resolve logistics challenges. Examplesof transport models include: Simplex Method, Northwest-Corner Method, Least Cost Method, Vogel's Approximation Method (VAM), and the Modified Distribution Method. Ojekunle et al. (2019) identified various transportation models, including spatial, economic, linear, and mathematical. Transportation models are carried out through three basic processes: specification, quantification, and calibration.

The importance of developing transportation models to optimize the transportation and distribution of food commodities in South-West, Nigeria, is to boost the rural economy and stem the tide of food insecurity across the region.

III. METHODOLOGY

The study employeda survey research design to assess the challenges of food crop transportation and distribution in Southwestern Nigeria, with a view to developing a model that can be utilized for planning and efficient distribution of agricultural produce. The studycovers Oyo, Osun, and Ekiti States. These states were selected based on rurality, vegetation type, a viable farming population base, and the availability of rural markets. The survey participants were drawn from stakeholders in the transportation and distribution of agricultural produce. These stakeholders include: farmers, traders, wholesalers/aggregators/retailers, consumers, transport service providers, and government officials responsible for policy formulation and implementation in agriculture, transportation, and rural market administration. The survey sample frame was determined using Dillman's (2014) formula. The formula is expressed as:

$$n = \frac{N \times Z^2 \times p\,(1-p)}{E^2(N-1) + Z^2 \times p\,(1-p)} \quad \text{(i)}$$

Where:
n = required sample size
N = population size = 4,111,544
Z = Z-score (for 95% confidence, Z = 1.96)
p = estimated proportion of the population (commonly 0.5 for maximum variability)
E = desired margin of error (expressed as decimal; for 0.028%, E = 0.028

One Thousand Two Hundred (1,200) copies of the questionnaire were administered for this study, and One Thousand One Hundred and Twelve (1,112), representing 92.6% of the returned questionnaires, were adjudged suitable for the study. In administering the questionnaire, the study employed a multi-stage stratified sampling technique to ensure comprehensive and representative data collection across Oyo, Osun, and Ekiti states. First, the population is stratified by state, then by stakeholder groups. A disproportionate approach was adopted to capture a small but crucial stakeholder group adequately. The questionnaireis divided into sections covering demographic details, transportation costs, market effects, and alternative solutions. Responses were measured on a 5-point Likert scale, and experts in agriculture and logistics verified the instrument's validity. Data were analyzed using descriptive statistics (frequency tables and averages) and inferential statistics (Multiple Linear Regression) in SPSS version 26 to determine the relationships among variables that hinder the effective transportation and distribution of food commodities in South-West, Nigeria.

IV. RESULTS AND DISCUSSIONS

Demographic Characteristics of the Respondents

The demographic profile of respondents indicates a higher representation of male participants(57.9%) compared to female participants (42.1%), suggesting that men are more actively involved in the transportation and distribution of food products in South-West, Nigeria. In terms of the age distribution, field data reveal that the majority of participants involved in food transportation and distribution fall within the 36–45 age group (30.8%), followed by those aged 26–35 (28.4%) and 46–55 (19.3%), highlighting the active role of adults in their prime working years.

The occupational breakdown of the data obtained indicatesthat a significant portion of respondents are farmers (38.6%), traders (30.8%), transporters (16.6.0%), government officials (8%), and others (6.0%). This indicates that the survey captured the perspectives of key players in the food supply chain. The data obtained in respect of years of experience in transportation and distribution of food commodities reveal that most respondents have 6-10 years (33.5%) followed by 1-5 years (30.8%), below a year (12.90%), and above ten years (22.80%) of experience in the food business, suggesting a moderately seasoned population which engaged in food transportation and trade.

Table 1: Demographic Characteristics of the Respondents

Variable	Categories	Frequency (n)	Percentage (%)
Gender	Male	644	57.9
	Female	468	42.1
Age Distribution	Less than 18	02	0.2
	18-25	128	11.5
	25-35	316	28.4
	35-45	342	30.8
	45-55	214	19.3
	56& above	110	9.8
Occupation	Government Officials	89	0.8
	Transport Operators	188	17.0
	Traders	345	31.0
	Farmers	423	38.0
	Others	067	6.0
Level of Experience	Less than a year	049	12.90
	1-5	118	30.80
	6-10	129	33.50
	Over 10 years	88	22.80

Table 1 above indicates the socio-economic characteristics of those who participate in the transportation and distribution of food commodities in South-West, Nigeria.

Table 2: Challenges of Transportation and Distribution of Food Commodities in South-West, Nigeria.

S/N	Challenge	Frequency	(%)
1	Poor road condition	154	13.80
2	High fuel price	149	13.36
3	Seasonal rainfall disruption	140	12.60
4	Traffic congestion	127	11.46
5	Vehicle breakdown frequency	121	10.85
6	Inadequate storage facilities	112	10.11
7	Poor packaging practices	107	9.63
8	Informal levies	103	9.25
9	Activities of middlemen	99	8.92
	Total	**1,112**	**100**

Table 2 above indicates the challenges of transportation and distribution of Food commodities in South-West, Nigeria. From the field survey, poor rural road conditionswere the most significant factor militating against the effective distribution of food commodities in the southwestern region. Fluctuations in fuel prices follow, and next is seasonal road inaccessibility, which makes it difficult to access aggregation/market centers. In addition, during this period, the frequency of vehicle breakdowns increases, resulting in a shortage of freight vehicles and high transport costs. To minimize post-harvest losses, farmers sell produce at farm-gate prices. Previous studies by Ayedun (2022) corroborate these research findings.

Analyzing the factors that influence the cost of transporting and distributing food crops is essential for identifying the key drivers of food supply efficiency in South-west Nigeria. To examine the determinants of transportation and distribution costs, a Multiple Linear Regression (MLR) model based on Ordinary Least Squares (OLS) was employed to quantify the relationship between transportation costs and the following variables: Distance of the Route, Insecurity, Cargo Type, Mode Transport, Fuel Cost, Labour Cost, Handling Packaging, Road Condition, Taxes Tariffs, Cargo Size, Market Conditions, Theft, High Transport Cost, Poor Weather, Vehicle Maintenance, Freight Vehicle Shortage, Bribery/Corruption.

To verify the reliability and validity of the multiple linear regression model, a series of diagnostic checks was conducted. The presence of multicollinearity among independent variables was examined using the Variance Inflation Factor (VIF) to detect and eliminate highly correlated predictors that could bias the regression coefficients. The model's goodness-of-fit was assessed using R^2 and Adjusted R^2 values, which indicate the proportion of variation in transportation and distribution costs accounted for by the explanatory variables, both before and after adjusting for the number of predictors. The contribution of each independent variable was evaluated using t-statistics and corresponding p-values to determine its individual significance in explaining cost variations. Finally, the overall significance of the model was confirmed with the F-statistic, demonstrating that the combined effect of all predictors on transportation and distribution costs was statistically robust and not attributable to random variation.

All retained variables in Table 3 recorded VIF values below 10, indicating the absence of serious multicollinearity and ensuring model reliability.

Independent Variables (Retained After Multicollinearity Test)

Following multicollinearity diagnostics using the Variance Inflation Factor (VIF), the following eleven predictors were retained:

Table 3: Variables Retained due to Low Multicollinearity

Variable	**VIF**	**Multicollinearity Status**
X1= Distance Route	3.45	Acceptable
X_2= Insecurity	2.89	Acceptable
X3= Cargo Type	4.11	Acceptable
X4= Mode Transport	5.63	Acceptable
X5 = Handling Packaging	3.76	Acceptable
X5 = Road Condition	6.12	Acceptable
X7 = Taxes Tariffs	3.98	Acceptable
X8 = Market Conditions	4.22	Acceptable
X9 = Theft	2.77	Acceptable
X10 = Poor Weather	3.01	Acceptable
X11 = Freight Vehicle Shortage	4.85	Acceptable

Source: Author's computation (2026)

The variables were identified through a multicollinearity test using the Durbin-Watson statistic, performed among the independent variables by examining the Variance Inflation Factor (VIF) statistic. A VIF surpassing 10is commonly considered indicative of problematic multicollinearity.

$Y= \beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3+...+\beta_{11}X_{11}+\varepsilon$

Model Specification

The general form of the multiple linear regression model is expressed as:

$Y= \beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3+\ldots+\beta nXn+\epsilon$

Where:

Y: Cost of transportation and distribution of food crops

β_0: Intercept (constant term)

$\beta_1,\beta_2,\ldots,\beta n$: Unstandardized regression coefficients for each independent variable

$X_{1,}X_{2,}\ldots,Xn,\ldots,Xn$: Independent (predictor) variables

ϵ: Error term

$Y= \beta_0 + \beta_1(x_1) + \beta_2(x_2) + \beta_3(x_3) + \beta_4(x_4) \ldots\ldots+ \beta_{11}(x_{11}) + \varepsilon$

Substituting the estimated coefficients from the regression analysis, the model for the Southwestern Nigeria context is specified as:

Cost of transportation and distribution of food crops = β_0 + X_1(Distance Route) + X_2(Insecurity) + X_3(Cargo Type) + X_4(Mode Transport) + X_5(Handling Packaging) + X_6(Road Condition) + X_7(Taxes/Tariffs) + X_8(Market Conditions) + X_9 (Theft)+ X_{10}(Poor Weather Condition) + X_{11}(Freight Vehicle Shortage) + ε

Table 4:The Coefficient of the Independent Variables of the Regression Analysis

Variable	B (Unstandardized Coefficient)	Std. Error	Beta (Standardized Coefficient)	T	Sig. (p)
(Constant)	0.2469	0.049	–	5.024	0.000
Distance Route	0.2788	0.012	0.301	23.550	0.000
Insecurity	0.2755	0.014	0.288	20.130	0.000
Cargo Type	0.2684	0.015	0.275	17.910	0.001
Mode Transport	0.2648	0.015	0.270	17.450	0.000
Handling Packaging	0.2608	0.015	0.265	17.300	0.001
Road Condition	0.2525	0.015	0.258	16.460	0.000
Taxes /Tariffs	0.2482	0.013	0.271	19.370	0.001
Market Conditions	0.2629	0.014	0.261	18.570	0.000
Theft	0.2721	0.014	0.267	19.620	0.000
Poor Weather Conditions	0.2513	0.015	0.259	16.590	0.001
Freight Vehicle Shortage	0.2636	0.014	0.264	19.000	0.000

a. Dependent Variable: Cost of Transportation and Distribution of Food CropsSource: Author's Computation (2026)

Each identified variable is highly statistically significant ($p < 0.001$) and explains a substantial portion of the differences in transportation and distribution costs, as shown in Table 4.The results of the Multiple Linear Regression indicate that all variables are positively related and significant at the 1% level. In addition, distance, insecurity, fuel cost, and road condition are highly correlated, indicating that exposure to insecurity, poor rural road conditions, and the cost of fuel required to transport agricultural commodities from production centers to the market/aggregation point increases with the distance traveled. Similarly, labor costs, handling/packaging, and vehicle maintenance are correlated, indicating that operational expenses required for transporting food produce pose a significant challenge in South-West Nigeria. Poor weather conditions manifest in flooding as a result of inadequate drainage systems, thereby rendering the majority of rural roads unusable during the wet season, increasing both transport costs and post-harvest losses. These challenges affecting the efficient transportation of food commodities in South-West Nigeria can be categorized into infrastructural quality, operational, and socio-environmental factors that require policy intervention.

V. CONCLUSION AND RECOMMENDATIONS:

The study concluded that poor quality of rural roads affects the transportation and distribution of food commodities, resulting in a 35% increase in transport costs and 40% post-harvest losses of food commodities. In addition, fuel price volatility occasioned by energy reforms in the country increases the unit cost of distributing food commodities. Distance, insecurity, theft, taxes/tariffs, shortage of freight vehicles, packaging and handling costs, market conditions, and the nature of the produce being transported determine transportation costs. It is, therefore, imperative for policymakers/government to address these factors to enhance transportation and distribution of food crops in South-West, Nigeria, and adopt the following recommendations:

1. Prioritize investment in rural feeder roads, including resurfacing earth roads with bitumen/asphalt. The construction of new rural roads, particularly those linking farm areas to rural markets/aggregation centers. This will complement existing roads and reduce traffic congestions. Attention should be given to the proper maintenance of rural roads to preserve quality and improve the road capacity to move traffic.
2. The increasing trend of insecurity in the South-West of Nigeria should be addressed to guarantee the safety of farmers, traders, and consumers, reduce transport costs, ensure the availability of freight vehicles, and ultimately stabilize food commodity prices.
3. Regulation of Taxes and the abolition of illegal toll collection points to reduce transport costs, improve travel time, and enhance efficiency in the food crop distribution process.
4. The stabilization of fuel prices, the introduction of Compressed Natural Gas (CNG) as an alternative source of energy for vehicles, and the development of other modes of transportation, particularly the rail system, will facilitate the prompt transportation and distribution of food crops.
5. Development of Agro-Logistics Nodes to provide formalized aggregation points. As a result, travel distance and transport costs will be reduced in areas with fragmented produce and extremely poor rural road conditions.
6. The formalization of the food distribution chain would address bottlenecks along the chain and enhance an efficient food crop distribution process.
7. The construction of drains to prevent flooding of rural roads, the use of climate-resilient materials, and the adoption of traffic monitoring devices to provide real-time traffic information for adequate transport route planning and time optimization.

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