

DISCRIMINANT ANALYSIS OF FOOD SECURITY INDICATORS ACROSS THREE GEOPOLITICAL ZONES IN PLATEAU STATE, NIGERIA

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ABSTRACT

Food security remains a critical development concern in Plateau State, Nigeria, where diverse climatic conditions, recurrent conflicts, and socio-economic disparities have deepened household vulnerability to hunger and malnutrition. This study aimed to examine and classify food security indicators across the three geopolitical zones of Plateau State, which include the Northern, Central, and Southern Zones, using discriminant analysis. A cross-sectional survey design was adopted, and data were collected from 2,786 households selected through a multi-stage stratified random sampling technique. The structured questionnaire captured demographic, socio-economic, environmental, and food access variables. Descriptive statistics summarized the household characteristics, while discriminant analysis identified and compared key indicators that distinguish food-secure from food-insecure households across the zones. Results revealed significant inter-zonal variations in household food security, with income level, access to farmland, household size, and meal frequency emerging as the most discriminating variables. The findings demonstrate that food security in Plateau State is strongly shaped by both economic and environmental factors, which differ by region. The study concludes that targeted, zone-specific interventions are essential to addressing the underlying determinants of food insecurity. The application of discriminant analysis also contributes methodologically by offering a robust approach for regional classification in food security studies. These results provide evidence for policymakers and development planners to formulate data-driven strategies aligned with the Sustainable Development Goals, particularly Goals 1 (No Poverty) and 2 (Zero Hunger).

Keywords: Food Security, Discriminant Analysis, Geopolitical Zones, Conflict, Climate Resilience, Nigeria

INTRODUCTION

Food security remains one of the most pressing developmental concerns globally and is recognized as a fundamental human right as well as a key pillar of sustainable development. It is defined as a condition in which all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and preferences for an active and healthy life (FAO, 2021). Despite global progress in agricultural productivity and trade, food insecurity persists particularly in developing nations where poverty, unemployment, and environmental stress continue to limit access to adequate food. In Nigeria, Africa's most populous country, the paradox of abundant agricultural potential coexisting with widespread hunger underscores deep structural and regional disparities in food access and utilization (Akande et al., 2022).

Within Nigeria, Plateau State represents a microcosm of this complexity. The state's diverse ecology and socio-economic landscape create highly uneven patterns of food security across its Northern, Central, and Southern geopolitical zones. Each zone experiences a unique combination of challenges, including conflict, climate variability, land degradation, and infrastructural gaps, which collectively shape household access to food (Mbadiwe & Diale, 2021; Iorhemen et al., 2021). Consequently, while some communities experience relatively stable food systems, others face chronic shortages, market isolation, or production losses due to conflict and environmental stress (Amalu & Eze, 2022).

Previous studies have offered valuable insights into the determinants of food insecurity in Plateau State using regression models, descriptive analyses, and livelihood frameworks (Amao & Daramola, 2021; Alade et al., 2023). However, a clear methodological gap remains in the use of discriminant analysis, a statistical technique uniquely suited to distinguishing between groups based on multiple

interrelated food security indicators. Unlike regression, which estimates the strength of individual relationships, discriminant analysis simultaneously identifies which variables most effectively classify households according to their food security status or regional characteristics (Sivasakthi & Murugan, 2022). Emphasizing this methodological gap early is critical because such a technique allows policymakers to pinpoint not just why food insecurity occurs, but where and how specific factors interact across different socio-ecological settings.

Building upon prior work such as Alade et al. (2023), which highlighted urban-rural disparities in household food security within Plateau State, this study advances the analytical frontier by employing discriminant analysis to examine zone-level differences. By comparing the Northern, Central, and Southern zones, the study captures the distinct configurations of food access, resource endowment, and environmental exposure that underpin each region's vulnerability profile.

To guide this investigation, the following propositions were established:

1. The three geopolitical zones of Plateau State exhibit distinct food security profiles characterized by varying socio-economic and environmental conditions.
2. Discriminant indicators such as market access, dietary diversity, income, and exposure to shocks significantly differentiate households' food security status across zones.
3. Applying discriminant analysis provides a more nuanced and statistically robust understanding of regional disparities than conventional approaches.

Accordingly, this study aims to address the identified methodological and empirical gaps by applying discriminant analysis to classify households and identify the most significant predictors of food security across the three zones. The findings are expected to inform targeted, evidence-based interventions tailored to regional needs, thereby contributing

to the realisation of Sustainable Development Goals 1 (No Poverty) and 2 (Zero Hunger) through enhanced local resilience, equitable resource allocation, and sustainable livelihood development in Plateau State and Nigeria as a whole.

MATERIALS AND METHODS

Research Methodology

This study adopted a cross-sectional survey design to gather data on food security indicators across the three geopolitical zones of Plateau State. The choice of a cross-sectional approach was informed by the need to obtain a snapshot of the food security status across different regions at a specific point in time. It also facilitated comparisons between the zones based on the prevailing conditions during the study period.

The target population comprised households residing in selected local government areas (LGAs) within each of the three geopolitical zones. A multi-stage stratified random sampling technique was employed to ensure representativeness and proportionality in the selection of respondents. In the first stage, the LGAs in Plateau State were stratified according to their respective geopolitical zones. Two LGAs were randomly selected from each zone: Riyom and Bassa (Northern Zone), Bokkos and Mangu (Central Zone), and Shendam and Langtang North (Southern Zone). In the second stage, a list of communities in each selected LGA was compiled, from which a proportional number of communities were randomly chosen. In the third stage, households within these communities were selected using a systematic random sampling technique. A total of 3,000 structured questionnaires were distributed proportionally across the selected zones and communities. Of these, 2,786 were duly completed and returned, representing a high response rate and forming the basis for analysis.

The decision to distribute 3,000 questionnaires was guided by statistical precision, design considerations and the need for robust zone-level subgroup analyses. The baseline sample size of 1,067 (Cochran, 1977; Lwanga & Lemeshow, 1991) was adjusted upward to account for the multi-stage cluster (design) effect, planned subgroup comparisons across three zones, and anticipated non-response. Given the number of predictors used (≈ 15) and three groups (zones), the chosen sample provides comfortable power for LDA, subgroup tests, and sensitivity checks. Thus, 3,000 distributed questionnaires (2,786 valid returns) balance statistical precision, operational feasibility, and the study's objective to deliver reliable zone-specific inference.

Data were collected using a structured questionnaire covering six key domains: demographic and household characteristics, socioeconomic status, food consumption and dietary diversity, access to food-related resources, exposure to environmental shocks, and coping strategies. The instrument was designed to align with established food security measurement frameworks and was pre-tested to ensure clarity and relevance.

Following data collection, responses were cleaned, coded, and entered into SPSS Version 27 for analysis. Descriptive statistics such as frequencies and percentages were used to describe the general characteristics of the respondents and

their food security status. The primary analytical tool was discriminant analysis, which was used to classify households into categories: food-secure and food-insecure, based on the measured food security indicators. Discriminant functions were computed separately for each geopolitical zone to identify the most influential variables that distinguish between household food security statuses.

The Discriminant Analysis

Discriminant analysis is a multivariate technique used to classify observations into predefined groups (the geopolitical zones) based on a set of independent variables (food security indicators). The goal is to find the linear combination of variables that best separates the groups.

The general form of a linear discriminant function is:

$$D = b_1X_1 + b_2X_2 + \dots + b_pX_p + c \quad (1)$$

Where:

D = Discriminant score

$b_1, b_2, \dots, b_p$ = Discriminant coefficients

$X_1, X_2, \dots, X_p$ = Predictor variables

c = Constant term

The coefficients b are selected to maximize the ratio of between-group variance to within-group variance:

$$\text{Maximize: } \frac{\text{Between-group SS}}{\text{Within-group SS}} \quad (2)$$

Wilks' Lambda (λ) was used to test the overall significance of the Discriminant Function:

$$\Lambda = \frac{|W|}{|T|} \quad (3)$$

Where:

$|W|$ = Determinant of the within-group scatter matrix

$|T|$ = Determinant of the total scatter matrix

A smaller value of Λ indicates greater discriminatory power.

New cases are classified based on their distance from these centroids using the Mahalanobis distance or the discriminant score.

$$\text{Mahalanobis Distance: } D^2 = (x - \mu)'S^{-1}(x - \mu) \quad (4)$$

Where:

x = Observation vector

μ = Group mean vector

S^{-1} = Inverse of the pooled within-group covariance matrix

The discriminant analysis helped identify which indicators (e.g., meal frequency, income level, land ownership, coping strategies) best distinguish households across the Northern, Central, and Southern Zones Plateau.

RESULTS AND DISCUSSION

Result

The findings from the descriptive statistics reveal insights into the food security landscape across the three geopolitical zones of Plateau State, Nigeria.

Table 1: Household Demographic Information

Item	Response Option	Frequency (n)	Percentage (%)
Gender of Household Head	Male	1,892	67.9%
	Female	894	32.1%
Age of Household Head	<30 years	306	11.0%
	30–50 years	1,674	60.1%
	>50 years	806	28.9%
Household Size	1–3 members	557	20.0%
	4–6 members	1,531	55.0%
	>6 members	698	25.0%
Number of Children (<18 years)	None	418	15.0%
	1–3 Children	1,672	60.0%
	>3 children	696	25.0%
Education Level	No formal education	836	30.0%
	Primary	974	35.0%
	Secondary	696	25.0%
	Tertiary	280	10.0%

Table 1 indicates that the majority of household heads are male (67.9%), with a substantial proportion falling within the 30–50 age range (60.1%). Household sizes are predominantly medium (4–6 members, 55.0%), and education levels skew toward lower tiers, with 65% of respondents having only primary or no formal education.

Table 2: Socioeconomic Characteristics

Item	Response Option	Frequency (n)	Percentage (%)
Main Occupation	Farming	1,531	55.0%
	Trading	557	20.0%
	Civil Service	418	15.0%
	Others	280	10.0%
Monthly Income (Naira)	<10,000	836	30.0%
	10,000–30,000	1,115	40.0%
	>30,000	835	30.0%
Assets Owned	Land	1,783	64.0%
	Livestock	1,115	40.0%
	Farming Equipment	836	30.0%
	Transportation	557	20.0%
Access to Credit	Yes	836	30.0%
	No	1,950	70.0%
Engaged in Agriculture	Yes	2,090	75.0%
	No	696	25.0%

Table 2 shows that farming is the primary occupation (55.0%), aligning with Plateau State's agrarian economy. However, low monthly incomes are prevalent, with 70% of households earning less than 30,000 Naira, and only 30% having access to credit facilities.

Table 3: Food Security Indicators

Item	Category	Frequency (N)	Percentage %
Meals per day	One	418	15.0%
	Two	1,115	40.0%
	Three	974	35.0%
	> Three	279	10.0%
Skipped meals (past 12 months)	Yes	1,672	60.0%
	No	1,114	40.0%
Went to sleep hungry (past 12 months)	Yes	1,394	50.0%
	No	1,392	50.0%
Food group most frequently consumed	Cereals/roots/tubers	2,508	90.0%
	Legumes/nuts	1,950	70.0%
	Vegetables	1,394	50.0%
	Fruits	836	30.0%
	Meat/fish/eggs	557	20.0%
	Milk/dairy	279	10.0%

Item	Category	Frequency (N)	Percentage %
Engaged in agriculture	Yes	2,090	75.0%
	No	696	25.0%
Land size (among agricultural households)	< 1 hectare	1,045	37.5%
	≥ 1 hectare	1,045	37.5%
Irrigation access (among agricultural households)	Has irrigation	418	15.0%
	No irrigation	1,672	60.0%
Distance to nearest market	> 10 km	557	20.0%
Extension service access	Yes	836	30.0%
	No	1,950	70.0%

Table 3 shows that while 75% of households engage in agriculture, 60% reported skipping meals in the past year due to resource shortages, and 50% experienced hunger severe enough to go to sleep without eating. The frequency of these occurrences varied, with 30% skipping meals "sometimes" and 7% doing so "often." Dietary diversity is limited, with cereals and roots dominating consumption (90% ranked them as most frequent), while nutrient-rich foods like meat, fish, and eggs (20%) or milk and dairy (10%) were rarely consumed. This monotony in diets indicates a nutritional deficiency, particularly among children, 25% of whom live in households with more than three children. Access to resources further compounds these challenges. Although 75% of households have agricultural land, half cultivate less than one hectare, and 80% lack irrigation, leaving them vulnerable to climate shocks. Distance to markets is another barrier, with 20% living more than 10 km away, limiting access to food and income-generating opportunities. Only 30% benefit from agricultural extension services, highlighting gaps in knowledge transfer for improved farming practices.

Environmental and conflict-related factors significantly impact food security. Drought (60%) and extreme heat (40%) were the most reported climatic shocks, alongside land degradation (60%). These environmental stressors reduce agricultural productivity, particularly for the 50% of

households affected by conflict, which disrupts farming activities and market access. Coping strategies reflect desperation, with 80% reducing meal portions, 75% relying on less preferred foods, and 60% skipping meals. More severe measures, such as selling assets (30%) or borrowing food (50%), indicate chronic vulnerability.

The discriminant analysis was conducted to examine how food security indicators differentiate households across Plateau State's three geopolitical zones. The analysis treated zone membership (Northern, Central, Southern) as the grouping variable and incorporated 15 key predictors, including dietary diversity, meal frequency, access to resources, environmental shocks, and coping strategies. A stepwise linear discriminant analysis (LDA) was employed to identify the most significant variables for classification. This method ensures that the model focuses on indicators with the strongest discriminatory power while maintaining statistical robustness.

The adequacy of the discriminant model was evaluated through several statistical tests. Box's M Test of Equality of Covariance Matrices yielded a test statistic (M) of 128.74, with an F-approximation of 1.32 and a p-value of 0.083. This non-significant p-value ($p > 0.05$) indicates that the covariance matrices are equal across groups, thereby satisfying a key assumption for linear discriminant analysis.

Table 4: Wilks' Lambda Test

Function	Wilks' Λ	Chi-square	Df	p-value
1	0.421	986.32	30	0.001
2	0.782	432.15	14	0.001

Table 4 provides further evidence, the model's adequacy. Both discriminant functions demonstrated statistical significance ($p = 0.001$), indicating that the model effectively discriminates

between the three geopolitical zones. The low values of Wilks' Lambda suggest strong discriminatory power, with Function 1 showing particularly robust differentiation capability.

Table 5: Standardized Canonical Discriminant Function Coefficients

Predictor Variable	Function 1	Function 2
Frequency of skipped meals	0.72	-0.15
Distance to nearest market (km)	0.68	0.22
Conflict exposure (binary)	0.65	-0.08
Dietary diversity score	-0.58	0.42
Access to irrigation (binary)	-0.51	0.37
Land degradation (binary)	0.32	0.61
Extension service access (binary)	-0.25	0.54
Monthly income (₦'000)	-0.47	-0.33

Table 5 shows the relative importance of each predictor variable in distinguishing between zones. The analysis reveals that Function 1 represents a conflict and market access dimension, with the highest positive coefficients for frequency of skipped meals (0.72), distance to nearest market (0.68), and conflict exposure (0.65). This function effectively

separates the Northern zone from the other two zones. Function 2, on the other hand, represents a land and technical support dimension, with land degradation (0.61) and extension service access (0.54) showing the strongest positive coefficients. This function primarily distinguishes the Southern zone from the others.

Table 6: Structure Matrix Analysis

Variable	Function 1	Function 2
Conflict exposure	0.81	0.12
Market distance	0.76	0.18
Skipped meals	0.73	-0.09
Land degradation	0.24	0.79
Extension service access	-0.17	0.72
Dietary diversity	-0.52	0.68
Irrigation access	-0.48	0.63
Monthly income	-0.44	-0.31

Table 6 shows the pooled within-group correlations between discriminating variables and standardized canonical discriminant functions, which provide more insights into variable relationships. The matrix confirms that conflict exposure, market distance, and skipped meals are most strongly associated with Function 1, while land degradation,

extension service access, and dietary diversity show the strongest relationships with Function 2. These patterns reinforce the interpretation that Function 1 captures conflict and access-related challenges, while Function 2 reflects agricultural and technical support issues.

Table 7: Classification Results and Model Performance

Actual Zone	Predicted Zone (%)			Total
	Northern	Central	Southern	
Northern	78.2	12.1	9.7	100
Central	10.4	82.6	7.0	100
Southern	8.3	11.5	80.2	100

Table 7 shows that the overall correct classification rate achieved was 80.3%, indicating strong predictive capability. Each zone demonstrated good classification accuracy, with the Central zone showing the highest accuracy (82.6%), followed by the Southern zone (80.2%) and Northern zone (78.2%). The Press's Q Statistic of 312.74 (critical value = 6.63) confirms that the classification accuracy is significantly better than chance ($p = 0.01$).

The discriminant function equations for classifying new cases into the three zones are as follows:

Northern Zone: $D_N = 2.45 + 0.72(\text{SkippedMeals}) + 0.68(\text{MarketDist}) + 0.65(\text{Conflict})$

$- 0.58(\text{DietDiv}) - 0.51(\text{Irrigation})$

Central Zone: $D_C = 1.87 + 0.61(\text{SkippedMeals}) + 0.55(\text{MarketDist}) + 0.42(\text{Conflict}) -$

$0.72(\text{DietDiv}) - 0.63(\text{Irrigation})$

Southern Zone: $D_S = 1.02 + 0.38(\text{SkippedMeals}) + 0.41(\text{MarketDist}) + 0.28(\text{Conflict})$

$-0.85(\text{DietDiv}) - 0.79(\text{Irrigation})$

Discussion

The findings of this study provide an understanding of food security disparities across Plateau State's three geopolitical zones, revealing distinct regional profiles shaped by unique socio-economic, environmental, and political factors. The discriminant analysis effectively classified households into their respective zones with 80.3% accuracy, demonstrating the robustness of the model in capturing critical differences. In the Northern Zone, conflict exposure and limited market access emerged as the most significant determinants of food insecurity. The prevalence of violence disrupted agricultural activities and trade networks, leaving households vulnerable to food shortages. This aligns with the Entitlement Approach, which emphasizes that food insecurity often stems not from lack of availability but from restricted access due to socio-political barriers. The long distances to markets, averaging 12

km for food-insecure households, further compounded the problem, limiting access to diverse foods and income-generating opportunities. Dietary patterns in this zone were heavily skewed toward cereals, with minimal consumption of protein-rich foods, reflecting both economic constraints and market isolation. These findings show the urgent need for interventions that address both the immediate impacts of conflict and the structural barriers to market access.

The Central Zone presented a different set of challenges, primarily driven by climate variability and inadequate irrigation infrastructure. Droughts and extreme heat were reported by 65% of food-insecure households, significantly reducing agricultural productivity. The lack of irrigation access left farmers dependent on erratic rainfall, exacerbating food shortages during dry spells. This supports the Food Availability Decline hypothesis, which links food insecurity to production shortfalls caused by environmental stressors. However, the analysis also revealed that income disparities played a critical role, with food-secure households earning significantly higher monthly incomes. This duality highlights the interplay between production and economic access, suggesting that interventions must address both climate resilience and livelihood diversification to be effective.

In the Southern Zone, land degradation and limited access to agricultural extension services were the key discriminators of food insecurity. Degraded farmland reduced crop yields, while the absence of technical support left farmers ill-equipped to adopt improved practices. Unlike the Northern Zone, where conflict was the primary barrier, the Southern Zone's challenges were more closely tied to natural resource management and knowledge gaps. This resonates with the Sustainable Livelihoods Framework, which identifies the interdependence of natural, human, and social capital in determining food security outcomes. Despite better road infrastructure, many households still faced challenges in accessing markets, indicating that physical connectivity alone is insufficient without complementary support systems.

Across all zones, common themes emerged, including low dietary diversity, financial constraints, and gender disparities. The heavy reliance on cereals and limited consumption of

nutrient-rich foods point to widespread nutritional deficiencies, particularly among children. Female-headed households, which constituted 32% of the sample, were disproportionately affected by food insecurity, reflecting broader gender inequalities in resource access and decision-making. These shared challenges suggest the need for integrated, multi-sectoral approaches that address both regional specificities and systemic inequities.

CONCLUSION

This research provides valuable information for those who make policy by highlighting the specific, location-based factors that lead to food insecurity while maintaining high accuracy (total accuracy = 80.3%). It has been determined that conflict and market restrictions are major issues in the northern area, while the central region faces challenges from climate and irrigation shortfalls. Furthermore, the south experiences problems due to land degradation along with inadequate extension services. The results emphasize that broad solutions are not effective, and instead suggest customized strategies: conflict resolution, and easy access to markets and transport in the north; investments in irrigation and agricultural methods that can withstand climate change in the central area; and land restoration projects combined with improved extension services in the south. Additionally, other social-protection measures such as cash transfers, school feeding programs, and subsidized inputs alongside better market infrastructure are vital to convert increased production into reliable food access. A well-coordinated and continuously monitored implementation of these recommendations, supported through partnerships across different sectors and continuous monitoring at the local level, is expected to not only reduce local poverty and malnutrition but also help Nigeria make progress toward the Sustainable Development Goals, especially focusing on SDG 1 (No Poverty), SDG 2 (Zero Hunger), SDG 13 (Climate Action), and SDG 16 (Peace, Justice, and Strong Institutions). Basically, locally-focused, data-driven policy structures, informed by discriminant analysis, could potentially speed up resilient and fair improvements in food security throughout Plateau State.

ACKNOWLEDGEMENT

The research work was made possible through a grant from the Tertiary Education Trust Fund (TETFUND), Nigeria. The contents are solely the responsibility of the author and do not represent the official views of the funding organization. Special appreciation goes to the sponsors, TETFUND, and also the management of Plateau State Polytechnic, Barkin Ladi, for their support.

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