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Gendered Spatial Vulnerability to Food Insecurity in Nigeria: Developing and Applying a Food Security Vulnerability Index

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Abstract

This study develops a Food Security Vulnerability Index (FSV) to examine regional disparities in women's vulnerability to food insecurity in Nigeria. Using the 2018/2019 Nigeria General Household Survey (GHS) data, Principal Component Analysis (PCA) was used to construct a composite index scaled from 0 to 1 and classified into five categories ranging from very low to very high vulnerability. The analysis covered 4,401 households, with descriptive statistics complemented by Moran's I to test for spatial autocorrelation. Results show that the mean FSV score was 0.302 (SD 0.172), with most households concentrated in very low (35.54%) and low (35.17%) vulnerability classes, while 22.86% fell in the moderate class, 6.23% in the high class, and 0.20% in the very high class. Female-headed households consistently displayed greater vulnerability than male-headed households, with 23.17% and 6.92% falling into moderate and high categories compared to 22.52% and 5.48% for men. Regional disparities were marked, as households in the South-South, South East, and South West exhibited higher vulnerability scores, with up to 46.33% in moderate and 15.73% in high categories, while the North East and North West recorded relatively lower vulnerability, partly due to external support interventions. Moran's I confirmed significant spatial clustering, rejecting the null hypothesis of no regional difference in women's vulnerability. The findings underscore that food insecurity in Nigeria is both gendered and spatially constituted, demanding spatially targeted, gender-sensitive policy responses.

Keywords: food security, gender, inequality, spatial, vulnerability index

1: Introduction

Food insecurity exhibits a multidimensional character, which manifests not only as economic deprivation and food availability but also as systemic social and other vulnerabilities (Badewa & Dinbabo, 2022; Ikebuaku & Dinbabo, 2023). It remains one of the world's development challenges and a priority for many countries. Underdevelopment in many regions of the world, such as sub-

Saharan Africa, creates structural barriers, as they can be detrimental to food security and make specific groups of people, especially women, more susceptible to food insecurity (Anjum & Aziz, 2025; Campbell et al., 2016; Moon, 2024; Rahman et al., 2024). For example, there are gendered land tenure regimes, where customary and patrilineal land rights deprive women of formal control of land and collateral (reducing investment and access to credit) (Adeniyi & Dinbabo, 2020; Boakye, Nwabufo, & Dinbabo, 2021; Agarwal, 2018; FAO, 2018). Once more, there are known policy and market biases that refer to urban-centred infrastructure and service provision, which curtail rural women's formal control over land and collateral (Lipton-style urban bias) and restrict income diversification and resilience (World Bank, 2023). We employ a nuanced spatial vulnerability index that captures both the spatial disparities in gendered risk exposure and sensitivity across Nigeria, a country with significant regional differences, socio-cultural diversity, and unequal exposure to climate risk, to illustrate this proposition. This index was developed using Principal Component Analysis (PCA) technique, which is not just a data-reduction tool but also a well-established method of driving a composite index that captures multidimensional concepts such as food security (Lever et al., 2017; Greenacre et al., 2022)

Spatial heterogeneity is among the defining characteristics of vulnerability. Local food systems, from how food is grown to how it is sold, are greatly shaped by land use patterns, the availability of infrastructure, and variabilities in ecological zones. In Nigeria, these spatial factors, combined with systemic social inequalities, exacerbate food insecurity among women (Wang et al., 2023). For instance, women constitute more than 60% of the agricultural labour force, yet they own less than 20% of farmland (NBS, 2019). In addition to this inequality in access to productive assets, production norms are also particularly restrictive in northern Nigeria, where women's access to markets and mobility are limited, further reducing their resilience (Akinola & Adetunji, 2024; Barasa et al., 2023).

The mainstreaming of gender as a driver of vulnerability is another fundamental aspect of this study, where vulnerability is not seen as homogeneous but as something constrained by structural inequities, history, and cultures. Women have limited access to land, credit, and decision-making opportunities worldwide (Gupta et al., 2024; Sithole & Dinbabo, 2016). Food security outcomes are directly linked to these structural barriers. This means that there are gender-specific experiences in Nigeria, where women have poor inheritance rights, lower employment, higher dependence, and lower education, which is associated with higher food insecurity (Kabeer & Sulaiman, 2023; Ikebuaku & Dinbabo, 2023; Sithole, Tevera, & Dinbabo, 2022). Hence, the provision of disaggregated data and adoption of a spatial lens in this study is largely driven by these gendered constraints, which in turn lead to the lived realities of most women's population.

The study employs the principal component analysis (PCA) methodological framework to develop a Food Security Vulnerability Index (FSV), in conjunction with spatial statistical tools such as Moran's I, for assessing the dynamics of clustering and addressing multidimensional and spatial challenges (Zhang et al., 2025). It utilises household data from the Nigerian General Household Survey (GHS), encompassing food consumption behaviour, demographic factors, and institutional support (Oluwole et al., 2023; Fenton et al., 2024). This multi-faceted analysis enables the detection of spatial vulnerability clusters and how vulnerability is manifested by gender within those clusters (Santa-Ramirez et al., 2023).

With the construction and analyses of a spatially explicit, gender-sensitive vulnerability index, this paper aims to contribute to targeted policy interventions for the most acute and chronic manifestations of food insecurity (Nkosi et al., 2025). By demonstrating that credible food security strategies cannot be based solely on aggregate national numbers but must incorporate

geographical dimensions and the intersections of vulnerability. This is important as it contributes to the broader literature, particularly in contexts where women are significant actors in agriculture and household nutrition, yet remain chronically disadvantaged (Kabeer & Sulaiman, 2023; Gupta et al., 2024). The implications from Nigeria underscore the need for gender-disaggregated spatial indices to be incorporated into food security programs and resilience-building efforts.

2: Methodology

Principal Component Analysis (PCA) is a multivariate statistical method used to reduce the dimensionality of high-dimensional data by transforming a large set of variables into a smaller one while preserving as much of the information as possible (Greenacre et al., 2022; Jolliffe & Cadima, 2016). The justification for this approach is that it attempts to explain the most significant amount of variance in the original dataset with a smaller number of composite indicators (Lever et al., 2017).

Assuming PCA model in standard form such that we let $Z_{k,i}$ represent standardized value of variable k for household (z-core), $\alpha_{j,k}$ is the eigenvector or loadings of k on principal component j, $PC_{j,i}$ is the score of component j for household i, and ω_j stands for the assigned weight to component j. Then Principal Component equation will be specified as follows:

$$PC_{j,i} = \sum_{k=1}^{K} \alpha_{j,k} Z_{k,i} \qquad for\ j = 1, \ldots, J \tag{1.1}$$

Aggregated index in 1.1 yields the Food Security Vulnerability (FSV) specified in 1.2 below:

$$FSV_i = \sum_{j=1}^{J} \omega_j PC_{j,i} \tag{1.2}$$

It has been proven that using the first few components that explain the majority of the total variance are obtained after computing the eigenvalues and eigenvectors of the covariance (or correlation) matrix of the data (Abdi & Williams, 2010). For developing the index, the index I can be constructed as a weighted sum of the standardised variables by substituting equation 1.1 into 1.2 as follows:

$$FSV_i = \sum_{j=1}^{J} \omega_j \left(\sum_{k=1}^{K} \alpha_{j,k} Z_{k,i} \right) = \sum_{k=1}^{K} \left(\sum_{j=1}^{J} \omega_j \alpha_{j,k} \right) Z_{k,i} \tag{1.3}$$

This helps to reflect composite influences of variables related to food security indicators obtained from the Nigerian General Household Survey (GHS) on the index (Loades et al., 2021).

The Kaiser-Meyer-Olkin (KMO) measure was adopted to assess and serve as a prerequisite of sampling adequacy before conducting PCA. The KMO measure reflects how well the variables correlate with each other compared to the variance among the variables that might be due to common variance. Estimated values close to 1.0 suggest that the correlation structure is rather compact, and thus a factor analysis (or PCA) should yield separate and reliable components. Values between 0.59 and 0.90 are generally considered acceptable values to confirm that the PCA outcome will indeed be strong (Brown, 2019; Hair et al., 2014).

2.1: Data Preprocessing

A quality data preprocessing remains the backbone of an effective index from PCA-based construction (Shlens, 2014). The process includes three (3) basic steps, which include data cleaning, variable normalisation and standardisation, and assessing the suitability of PCA. Based on the dataset received from the Nigerian GHS, which covers food security topics in addition to a range of socioeconomic variables, we begin with careful screening of inconsistent entries and missing data, and variable transformation to preserve the integrity of the data. To keep the data ready, the selected variables needed to be standardised based on the range of different measurement scales for the indicators. A z-score transformation was applied, transforming every variable *to* maintain comparability across varying measurement units as:

$$Z = \frac{X - \underline{X}}{\sigma_X}, \tag{1.4}$$

where $\underline{X}$ is the sample mean and σ_X is the corresponding standard deviation. When we use PCA, the scale of each variable can influence the overall analysis of the PCA, so we use standardization so that all the variable scales have the same weight in the output of PCA, and the difference in scales does not inappropriately tilt the structure of responses on the factors (Ilin & Raiko, 2010).

2.2: Weighting and Aggregation Methods

The final adopted and standardised set of indicators is then subject to PCA to extract the principal components (Ringnér, 2008). Weights for every variable are constructed using the PCA eigenvectors (loadings). For example, if the proportion of total variance explained by the first principal component Z_i is large, the index can be constructed mostly on the first component. This can then be formally treated with the weighting scheme:

$$\hat{I} = \sum_{\mathrm{j}=1}^{p} \alpha_{ij} \, . \, Z_j, \tag{1.5}$$

where α_{ij} is the loading for variable j in the major component. The final aggregation into a single index is therefore a reflection of both the relative importance of each variable shown in the loading (see Figure 4.1) and the proportion of variance accounted for by the component (Malkamäki, 2019; Karamizadeh et al., 2013). These empirical-derived weights are typically further normalized here to allow for bounded scaling of the index so that the data are comparable across spatial units for interpretive purposes.

2.3: Spatial Analysis

At this stage, the Global Spatial Autocorrelation was employed using Moran's index approach. The statistic checks for a systematic or purely random pattern in the observed values of a spatial dataset (food security vulnerability among women) across space (Bivand et al., 2013). Moran's I is a measure of global spatial autocorrelation such that:

$$\mathrm{I} = \frac{N}{S_0} \, . \, \frac{\sum_{i=1}^{N} \sum_{j=1}^{N} w_{ij}(x_i - \bar{x})\left(x_j - \bar{x}\right)}{\sum_{j=1}^{N}(x_i - \bar{x})^2}, \tag{1.6}$$

where:
N represents the number of spatial units,
w_{ij} stands for the spatial weight between units i and j,
x_i and x_j are the corresponding generated index in units i and j,
$\underline{x}$ represents the mean of the index values, and

$S_0 = \sum_{i=1}^{N} \sum_{j=1}^{N} w_{ij}$ is the sum of total spatial weights.

Positive Moran's I values suggest clustering of similar index values (i.e., areas of high vulnerability cluster around each other) as opposed to negative values, which suggests spatial dispersion. This statistic is frequently employed in permutation-based significance testing of Moran's I under the null hypothesis of spatial randomness. This modelled analysis determines whether the food insecurity of women can be considered systematic or random (Anselin, 2022).

3. Results and Discussion

Table 3.1: Descriptive Statistics (Frequency and Percentage). ***Source: Author's estimation using Nigerian GHS 2018. The entry has column frequencies and column percentages for both male and female.***

Variable	Option	Male		Female	
		Freq.	**%**	**Freq.**	**%**
Geo-political zone (Regions)					
	North Central	217	10.25	232	10.16
	North East	372	17.56	360	15.77
	North West	676	31.92	645	28.25
	South East	336	15.86	426	18.66
	South South	400	18.89	490	21.46
	South West	117	5.52	130	5.69
Employment					
	No	666	31.44	937	41.04
	Yes	1452	68.56	1346	58.96
Inheritance law[1]					
	Equal right for both female and male	142	6.70	159	6.96
	Consider female right, but not equals male	779	36.78	753	32.98
	No female right	1197	56.52	1371	60.05
Marital status					
	Married (monogamous)	711	33.57	738	32.33
	Married (polygamous)	213	10.06	428	18.75
	Informal/loose union	8	0.38	12	0.53
	Divorced	17	0.80	21	0.92
	Separated	10	0.47	31	1.36
	Widowed	34	1.61	259	11.34
	Never married	1125	53.12	794	34.78
Land ownership					
	No	47	2.22	87	3.81
	Yes	2071	97.78	2196	96.19
Credit access					
	No	2085	98.44	2227	97.55
	Yes	33	1.56	56	2.45
Agro-ecological zone					
	Tropic-warm/semiarid	966	45.61	937	41.04
	Tropic-warm/subhumid	832	39.28	978	42.84

[1] Inheritance law stands for "Prevailing inheritance laws and custom in Nigeria". It is a categorical variable generated based on information from secondary data sources and customary practice in Nigeria as there is no federal law on inheritance right with respect to gender. Ilaw = 0 if female and male have equal inheritance right; 1 if custom guarantee female right but not equal to male; 2 if custom does not guarantee female inheritance right to landed property

	Tropic-warm/humid	319	15.06	367	16.08
	Tropic-cool/subhumid	1	0.05	1	0.04
Receive remittance					
	No	1836	86.69	1854	81.21
	Yes	282	13.31	429	18.79
Adopt coping strategy for economic shock					
	No	1262	59.58	1379	60.40
	Yes	856	40.42	904	39.60
Education level					
	None	204	9.63	502	21.99
	Informal	239	11.28	256	11.21
	Nursery	4	0.19	1	0.04
	Primary	559	26.39	583	25.54
	Secondary	895	42.26	786	34.43
	Tertiary	217	10.25	155	6.79

From the results, 68.56% of males are employed, while only 58.96% of females are employed. This indicates a gender employment gap of nearly 10 percentage points in favour of males. Conversely, 41.04% of females are not employed, compared to only 31.44% of males. This marked a difference in unemployment or non-participation in labour activities between the sexes. This employment imbalance, as noted by Anthias (2013) and FAO (2017), indicates the structural barriers women face in accessing economic opportunities, and it has far-reaching implications for household welfare and food security. Several socio-cultural and institutional factors underpin this employment gap. In many parts of Nigeria, particularly in the northern region, restrictive gender norms limit women's mobility, decision-making autonomy, and access to productive resources, all of which constrain their labour force participation. In addition, women's domestic and caregiving roles often go unrecognised in labour statistics, despite constituting unpaid and essential economic activities (Ashagidigbi et al., 2022).

With regard to inheritance rights, there is no great gender difference that favours men in having full inheritance rights. Only 6.96% of women come from backgrounds where prevailing customary laws uphold equal inheritance rights for both males and females, compared to 32.98% from locations where female rights may be permitted but not considered equal to men's rights to landed property. More than half of the women (60.05%) are from areas where custom and tradition do not support female right of inheritance, validating earlier studies' claim of females' marginalisation in access to productive resources (Brons et al., 2007; Muhammad & Abubakar, 2020). As expected, 56.52% of men come from backgrounds where there is no customary recognition of women's right to inheritance of landed property. Against this background, only 6.7% of men have a background where women are privileged to inherit landed property.

In terms of land ownership, the data shows that a slightly higher percentage of men (97.78%) own or have access to land, compared to 96.19% of women. While this gap is narrow, it is crucial in a largely agrarian society where land is the primary asset for production, income, and food. Even where women report ownership, the quality, size, and control over land use may be limited. Land tenure insecurity for women, often due to patrilineal inheritance systems, polygamous marriages, or male-dominated community leadership structures, hinders their ability to use land as collateral, attract extension services, or invest in long-term improvements. Land ownership remains a symbolic and functional pillar of empowerment, and the slight gender gap in ownership likely underestimates deeper inequities in land control (FAO, 2018; Benra & Nahuelhual, 2019).

When it comes to access to credit, both men and women are overwhelmingly excluded, but women are slightly more likely to report access. Only 2.45% of women had accessed credit, compared to 1.56% of men. While this may appear counterintuitive given traditional narratives

of financial exclusion, it suggests that women are more likely to seek microfinance, community savings groups, or informal lending opportunities, particularly for small-scale trading or household consumption. However, the overall inaccessibility of credit (over 97% for both sexes) highlights a systemic constraint that limits the ability to invest in productivity-enhancing technologies, recover from shocks, or smooth consumption during lean periods. This aligns with Mitra et al. (2016), who found that most households do not rely on access to formal credit as a coping strategy in times of shock. For women, this constraint is often compounded by the lack of collateral, such as land, and limited financial literacy.

In terms of adopting coping strategies during economic shocks, the data show a remarkable similarity between genders, although women slightly edge out men in terms of not adopting coping strategies (Ajefu, 2023; Dinbabo & Mazani, 2025; Toluyemi, 2025; Mazani & Dinbabo, 2025). About 60.40% of females reported not adopting any strategy, compared to 59.58% of males (USAID, 2025). Conversely, 40.42% of males adopted strategies, while only 39.60% of females did. This difference, though marginal, may suggest that men have slightly more agency or resources to implement adaptive responses such as diversifying income sources, selling assets, or modifying food consumption (Quinton, 2021; Elum et al., 2025). For women, the slightly lower adoption may reflect limited control over household decision-making, restricted access to information, or fewer material assets that can be leveraged in times of distress (IDRC, 2025; Kusi-Mensah et al., 2025).

The distribution of educational attainment shows that inequality is particularly pronounced at both the lowest and highest ends of the educational spectrum, with women being significantly overrepresented among those with no education and underrepresented among those with tertiary education (Egenti & Dinbabo, 2025; Omoniyi & Nnadi, 2020; Adepoju et al., 2022). These trends reflect deep-rooted structural, cultural, and economic barriers that continue to limit educational opportunities for women and girls across many regions in Nigeria. At the lowest level of educational attainment (having no formal education), females constitute a disproportionately higher share. A striking 21.99% of females report no formal education, compared to only 9.63% of males. This more than two-fold gap reveals the historical and ongoing exclusion of girls from basic educational opportunities. In many rural or traditional communities, especially in northern Nigeria, early marriage, domestic responsibilities, poverty, and conservative norms often prevent girls from enrolling in or completing school (Agas, 2025; World Bank, 2025; Egenti & Dinbabo, 2022). The long-term consequences of these are: women with no education are more likely to be economically dependent, less informed about health and nutrition, less participation in civic life, more vulnerable to poverty and food insecurity, as observed by Beuchelt and Badstue (2013) and UNESCO (2023).

3.2 Principal Component Analyses

The Principal Component Analysis (PCA) of food security indicators allows the researcher to identify the core patterns underlying food insecurity and to reduce the complexity of the sample data while preserving the most significant variance in household responses.

Table 3.2: Description of variables (Food security). *Source: Nigerian Generalised Household Survey 2018/2019*

Variable	Definition
worried_ef	HH worried about not having enough food to eat in the last 30 days
eat_healthy	HH were unable to eat healthy and nutritious/preferred foods in the last 30 days
ate_few	HH ate only a few kinds of foods in the last 30 days
skip_meal	HH had to skip a meal in the last 30 days
ate_less	HH ate less than you thought you should in the last 30 days
food_fishied	HH ran out of food in the last 30 days

hungry	HH were hungry but did not eat in the last 30 days
nofood_ahd	HH went without eating for a whole day in the last 30 days
restrict_cons	HH restricted consumption in order for children to eat in the last 30 days
borrowfood	HH borrowed food, or relied on help from a friend/relative in the last 30 days
meal_perday	HH total number of meals taken per day by all age groups

Table 3.2 contains key questions on food security behaviour in the sampled households. The index generated with the above variables forms a part of the comprehensive FSV index in this study. A correlation matrix of the variables is presented in Table 3.3, indicating the degree of overlap among the inputs of the PCA method. There is a relatively high correlation coefficient with many well above 0.5, suggesting a substantial overlap of information among the variables. This made PCA very effective in reducing dimensionality through the transformation of correlations into a few uncorrelated variables, known as principal components. Under high correlation among the input variables, the first few principal components of the PCA are expected to capture a significant share of the total variance in the data, indicating a strong linear relationship among the variables of interest. The influence of observed high correlation on Table 3.3 is visualised in Figure 3.1, where the first two principal components have eigenvalues above 1 and explain over 60% of the total variance in the 11 original variables. The figure equally displays the loadings of the first two principal components, showing contributions of each to either of the components.

Table 3.3: Matrix of correlations (Food security). ***Source: Researcher's estimate from GHS 2018/2019***

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) worried_ef	1.000										
(2) eat_healthy	0.664	1.000									
(3) ate_few	0.703	0.751	1.000								
(4) skip_meal	0.626	0.516	0.624	1.000							
(5) ate_less	0.719	0.629	0.718	0.696	1.000						
(6) food_fishied	0.628	0.510	0.592	0.659	0.687	1.000					
(7) hungry	0.557	0.464	0.527	0.624	0.597	0.683	1.000				
(8) nofood_ahd	0.239	0.195	0.220	0.295	0.251	0.331	0.386	1.000			
(9) restrict_cons	0.518	0.471	0.490	0.548	0.559	0.544	0.493	0.290	1.000		
(10) borrowfood	0.268	0.215	0.257	0.253	0.259	0.311	0.294	0.359	0.229	1.000	
(11) meal_perday	-0.193	-0.102	-0.151	-0.179	-0.167	-0.170	-0.161	-0.072	-0.037	-0.093	1.000

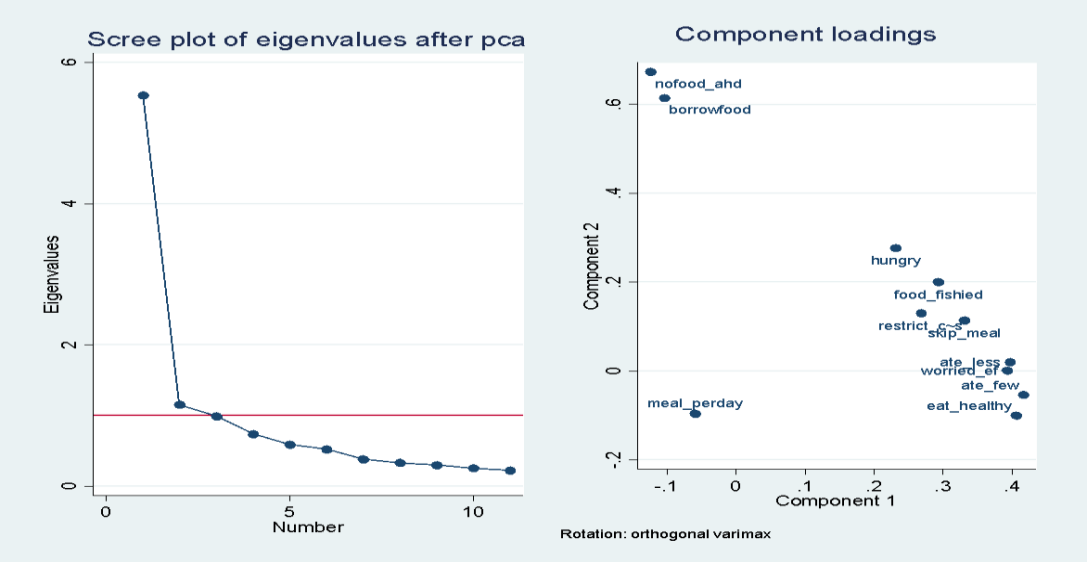


Figure 3.1: Principal eigenvalues and component loadings (Food security).*Source: Researcher's estimate from GHS 2018/2019*

Table 3.4 presents the numerical information depicted in Figure 3.1, illustrating two principal components that together account for 60.8% of the total variance in food insecurity indicators. Component 1 (50.3%) captures what we may term "core food access and consumption stress", and it is heavily loaded with variables reflecting the psychological, qualitative, and quantitative dimensions of food insecurity. High factor loadings in this component include: ate_less (0.366), worried_ef (0.354), ate_few (0.352), skip_meal (0.347), food_fishied (0.351), and eat_healthy (0.323). These variables reflect households' concerns about food availability, inability to consume nutritious meals, limited food choices, and reduced food intake or skipped meals. The consistency of these loadings suggests that this component reflects the daily experience of chronic food insecurity, where households are struggling with persistent anxiety about food, poor dietary quality, and insufficient food quantity (IMF, 2023). Moreover, the positive loading of "hungry" (0.329) on Component 1 reinforces this interpretation: households report being hungry but not eating, likely due to a lack of food or resources. This component illustrates how psychological and behavioural aspects of hunger intersect to produce a profound sense of deprivation, particularly among vulnerable populations such as women, children, and the elderly (Amare et al., 2021; Bofa et al., 2024). Importantly, this component serves as a reliable index of sustained food insecurity, useful for classifying households according to severity and guiding intervention strategies (Ajiboye, 2025).

Component 2, which explains 10.5% of the total variance, captures a somewhat different dimension of food insecurity (acute food crises and household coping mechanisms). This is evidenced by strong loadings from nofood_ahd (0.660), borrow food (0.599), and to a lesser extent hungry (0.149) similar to Ibukun & Adebayo (2021). These indicators are less about daily deprivation and more about extreme responses to food shortages, such as fasting for an entire day or borrowing food from others (IMF, 2023). These experiences likely represent short-term, high-intensity food insecurity, where a household exhausts all its internal resources and turns to external help or experiences severe hunger. The variable restrict_cons (0.001) has a near-zero loading here, indicating it plays a more neutral role in distinguishing this dimension (Muziri et al., 2020). Component 2 also reflects a social aspect of food insecurity, as borrowing food implies reliance on social networks and informal safety nets. In regions or communities where institutional support is limited, these coping strategies become essential lifelines (Bofa et al., 2024). However, they may not be sustainable, and high dependency on them could indicate a precarious food security situation (IMF, 2023). Thus, while Component 1 identifies households facing regular, prolonged food stress, Component 2 shows those at the edge of collapse, relying on desperate or socially dependent responses to hunger (Ajiboye, 2025).

Table 3.4: Factor loadings for illustrating the interpretation of Figure 3.1

Factor	Comp1	Comp2
worried_ef	0.354	-0.169
eat_healthy	0.323	-0.266
ate_few	0.352	-0.228
skip_meal	0.347	-0.041
ate_less	0.366	-0.154
food_fishied	0.351	0.053
hungry	0.329	0.149
nofood_ahd	0.180	0.660
restrict_cons	0.298	0.001
borrowfood	0.173	0.599
meal_perday	-0.095	-0.061
Eigenvalue	**5.537**	**1.154**

Explained variance (%)	**50.3**	**10.5**

We reported only factor loadings with Eigenvalues ≥ 1

As shown in Table 3.4, meal_perday has a negative loading on both components (-0.095 for Component 1 and -0.061 for Component 2), indicating an inverse relationship: as food insecurity increases, the number of meals consumed per day decreases (Amare et al., 2021; IMF, 2023). While the loading is relatively small, its direction aligns logically with expectations and supports the validity of the PCA structure (Muziri et al., 2020). Households that report more symptoms of food insecurity tend to consume fewer meals. This serves as an objective indicator reinforcing the subjective and behavioural data from other variables (Bofa et al., 2024). The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy in Table 3.5 shows the reliability of the PCA (Ajiboye, 2025). With an overall KMO score of 0.925 and individual item scores all well above the 0.5 threshold, this indicates that the selected variables are highly suitable for PCA (Ibukun & Adebayo, 2021). Variables like restrict_cons (KMO = 0.957), skip_meal (0.944), and worried_ef (0.946) have exceptionally high scores, confirming that the indicators are not only statistically reliable but well-correlated and measure cohesive constructs of food insecurity.

Table 3.5: Kaiser-Meyer-Olkin measure of sampling adequacy (KMO test). ***Source: Researcher's estimate from GHS 2018/2019***

Variable	KMO
worried_ef	0.946
eat_healthy	0.893
ate_few	0.901
skip_meal	0.944
ate_less	0.936
food_fishied	0.932
hungry	0.929
nofood_ahd	0.862
restrict_cons	0.957
borrowfood	0.891
meal_perday	0.865
Overall	**0.925**

3.3 Food Security Vulnerability Index

Table 3.6 presents the results of the Food Security Vulnerability Index (FSV). This shows the quantitative assessment of the severity and distribution of food insecurity among households in Nigeria. Developed using multiple indicators related to food access and consumption stress identified through Principal Component Analysis, the index assigns each household a score between 0 and 1, where higher scores indicate greater vulnerability to food insecurity (FAO, 2025). Based on the results from 4,401 households, the food security vulnerability index yields an average FSV score of 0.302 with a standard deviation of 0.172. This score ranged from the minimum value of 0.025 to the maximum value of 0.905. The wide range and high standard deviation indicate disparities in food security, which are shaped by regional, socioeconomic, gender-based, and environmental factors (WFP, 2025).

The study categorises the index into five vulnerability classes for clarity. Very low (< 0.2), Low (0.2-0.39), Moderate (0.4-0.59), High (0.6-0.79), and Very high (≥ 0.8). These categories enable a sound and actionable interpretation of the index, allowing for the identification of households requiring immediate support versus those at risk of deterioration if left unassisted. The majority of households fall into the "very low" (35.54%) and "low" (35.17%) categories, showing that about 70.7% of the sample experiences relatively stable food security conditions, though "low"

vulnerability still implies fragility and potential risk in the face of shocks such as inflation, drought, or loss of income.

Table 3.6: FSV Summary Statistics. *Source: Researcher's estimate from GHS 2018/2019*

Variable	Obs	Mean	Std. Dev.	Min	Max	
FSV	4401	.302	.172	.025	.905	
FSV classification	***very low***	***low***	***moderate***	***high***	***very high***	
Value	<0.2	0.2 - 0.39	0.4 - 0.59	0.6 - 0.79	≥0.8	
	Male		***Female***		***Total***	
	Freq.	(%)	Freq.	(%)	Freq.	(%)
very low	780	36.83	784	34.34	1564	35.54
Low	740	34.94	808	35.39	1548	35.17
Moderate	477	22.52	529	23.17	1006	22.86
High	116	5.48	158	6.92	274	6.23
very high	5	0.24	4	0.18	9	0.20

The "moderate" category, representing 22.86% of households, indicates that nearly a quarter of the population is already experiencing noticeable food stress and may tip into high vulnerability under relatively small economic or environmental shocks (Ajiboye, 2025). These households are likely reducing meal sizes, consuming less preferred foods, or relying on borrowing as coping strategies, as seen in earlier PCA results. More alarmingly, a non-negligible portion of households falls into the "high" (6.23%) and "very high" (0.20%) vulnerability categories. While small in percentage terms, these represent a deep level of food insecurity, where hunger, meal skipping, and extended periods without food are regular occurrences. These households are likely experiencing crisis-level food shortages and are the most urgent targets for social protection interventions, food aid, and climate adaptation support (WFP, 2025).

A gendered breakdown of the FSV reveals that female-headed or female-respondent households are slightly more concentrated in the higher vulnerability bands. For instance, 6.92% of females are in the "high" vulnerability category compared to 5.48% of males, and while the "very high" category shows a near-equal distribution (0.24% for males, 0.18% for females), it is notable that women are overrepresented in the "moderate" and "high" groups, which together account for 30.09% of all female respondents (as compared to the 28% for males) (Akanle, 2015a; Agarwal, 2018). Conversely, a higher proportion of men fall into the "very low" category (36.83%) than women (34.34%). This gender imbalance explains the structural and systemic disadvantages women face in relation to food security (Akanle, 2015a; Agarwal, 2018). As shown in other parts of the study such as lower employment rates, lower educational attainment, higher dependency ratios, and higher rates of widowhood, women often bear a greater burden of caregiving, have limited access to resources, and face gendered barriers to coping strategies. These factors cumulatively increase their vulnerability in the face of shocks like food price hikes, climate stress, or household income loss.

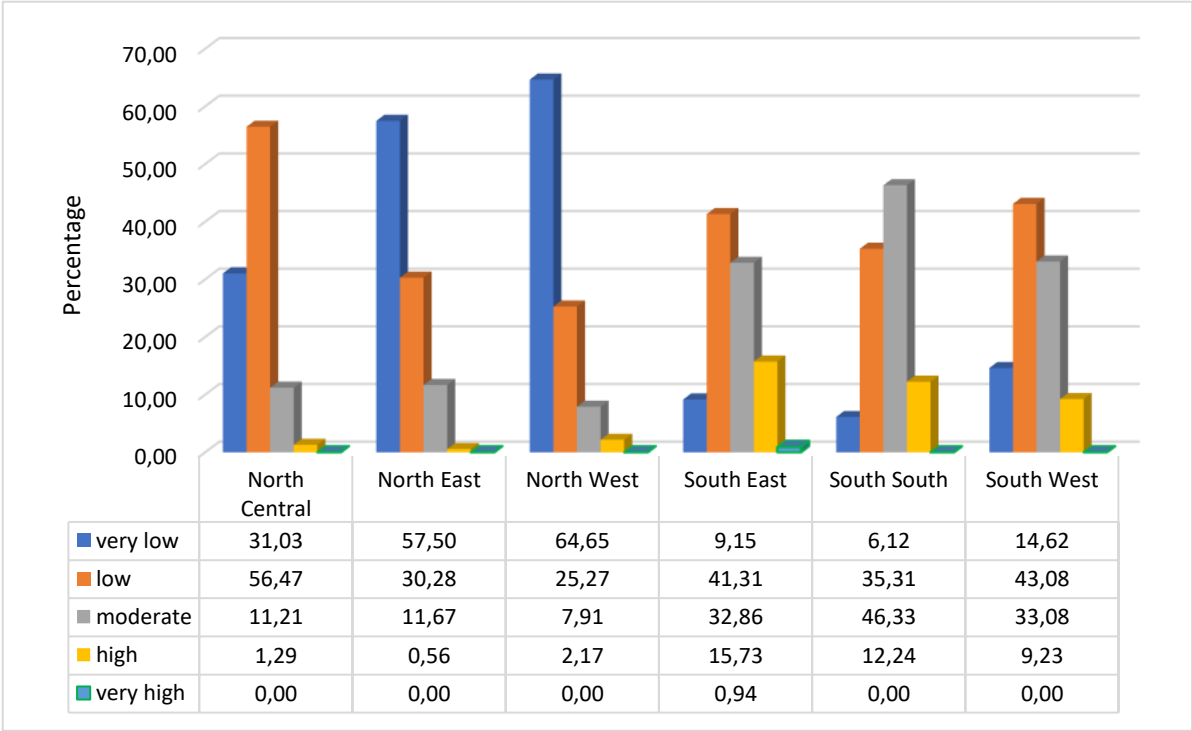
The results from Figure 3.2 and the spatial regression model (Table 3.7) reveal clear and significant regional disparities in the levels of food insecurity experienced by women, showing that gendered vulnerability to food insecurity in Nigeria is not only pronounced but also spatially uneven (Ajiboye, 2025).

3.4 Presentation of the Spatial Vulnerability Index

The Spatial Vulnerability Index (SVI) represented in this study through the Food Security Vulnerability Index (FSV), serves as a core analytical tool for examining regional disparities in vulnerability to food insecurity among women across Nigeria (Bryan et al., 2024; Chukwuma et al., 2024). The SVI is categorised into five levels of vulnerability: very low, low, moderate, high, and very high, allowing for intuitive interpretation and mapping of vulnerability across regions (Imo et al., 2024).

In the northern regions, particularly the Northwest (64.65%) and Northeast (57.5%), the majority of women fall into the very low vulnerability category. This suggests that women in these regions, contrary to some general assumptions about widespread deprivation in the North, are relatively less food insecure when compared to their counterparts in other parts of the country (Odey et al., 2022; Ajiboye, 2025). This pattern may be influenced by a number of localised factors, such as communal sharing systems, agro-pastoral economies that provide subsistence security, seasonal migration patterns that allow households to supplement food supplies, and regional food aid programs, which may temporarily suppress food insecurity metrics without addressing deeper gender-based disadvantages (Bryan et al., 2024). Moreover, cultural constraints might limit the accurate reporting of food insecurity by women in these regions, potentially underestimating actual conditions (Fabiyi et al., 2007).

In contrast, the southern zones (South-South, South East, and South West) show significantly higher levels of food security vulnerability among women. For instance, in the South-South, a striking 46.33% of women are classified as moderately vulnerable, while 12.24% fall into the high vulnerability category. In the South East, the situation is even more concerning, with 32.86% of women categorised as moderately vulnerable, 15.73% as highly vulnerable, and a small but notable 0.94% in the very high vulnerability bracket, the only region where this level is reported (Elum et al., 2025). These figures indicate persistent and concentrated food insecurity in the southern part of the country, despite these regions traditionally being considered more economically developed and urbanised (Akanle, 2015a; Ibukun & Adebayo, 2021). The prevalence of oil exploration in the South-South, for example, may not translate into widespread food access due to incessant environmental pollution, especially for women who are often marginalised in formal land ownership, labour markets, and political representation (Odey et al., 2022).



	North Central	North East	North West	South East	South South	South West
very low	31,03	57,50	64,65	9,15	6,12	14,62
low	56,47	30,28	25,27	41,31	35,31	43,08
moderate	11,21	11,67	7,91	32,86	46,33	33,08
high	1,29	0,56	2,17	15,73	12,24	9,23
very high	0,00	0,00	0,00	0,94	0,00	0,00

Figure 3.2: Regional Distribution of FSV among Women in Nigeria 2018. ***Source: Author's estimation using Nigerian GHS 2018/2019.***

We ascertain the existence of spatial dependence or correlation of food security vulnerability among women across the regions, we estimated and presented the Moran's statistic-an index that measures the randomness or otherwise of the outcome variable (FSV) using spatial lag (weights) of the error term (Nicholas et al., 2024). The result identifies areas with clustering (I > 0) or dispersion (I < 0) of FSV of a region compared to other adjoining regions. First, we estimated a simple linear regression of socioeconomic (income) and institutional (support) variables on FSV, and then estimated the index based on an Inverse distance matrix of the household's coordinates (Adamu et al., 2024). The result is presented below in Table 3.7.

Table 3.7: Linear regression and Moran test of spatial dependence (y = FSV)

Variable (fsv)	**Coef.**
Income	-3.90e-09
	(9.26e-09)
Institutional support	-0.105***
	(0.019)
Constant	0.312***
	(0.004)
Number of obs.	*2283*
R-squared	*0.013*
F-stat$_{(2,2280)}$	*14.90****
AIC	*-1548.79*
Moran Statistic	
Spatial lag of error term (W)	Inverse distance matrix
Chi2(1)	1,352.12***

*Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1*

Null hypotheses: Error terms are random (exhibit i.i.d. properties).

The simple regression result shows that receipt of institutional support is both negative and significant, suggesting its effectiveness in reversing food security vulnerability among women

(Rahman et al., 2025). Although households' income is expected to have a negative relation with food insecurity, its impact is negligible due to low average income and large household size (Muhammad & Abubakar, 2020; Orjiakor et al., 2023). The result statistically validates the presence of spatial dependence in these patterns, given the Moran's I test Chi-square value of 1,352.12 with $p < 0.01$ (Ayalew et al., 2024). Hence, decisively rejects the null hypothesis of spatial randomness and upholds strong evidence of positive geographical clustering of FSV among women in the study (Wubetie et al., 2024). This finding confirms that food insecurity vulnerability among women is not randomly distributed across Nigeria but follows a spatial structure, where regions with high or low FSV scores are likely to be surrounded by areas with similar characteristics (Akhter et al., 2024). Such clustering may be driven by socio-cultural norms (e.g., inheritance rights), or institutional constraints (e.g., access to credit or public services), reinforcing the idea that geography plays a central role in shaping food security outcomes (Rahman et al., 2025).

In brief, the spatial presentation of the FSV underscores the pressing need for regionally differentiated and gender-responsive food security interventions (Ayalew et al., 2024; Boakye, Nwabufo, and Dinbabo, 2021). The index not only quantifies vulnerability but also maps it, visualises it, and makes it actionable for policymakers and development practitioners. By identifying geographic "hotspots" where women are particularly at risk, such as the Southeast and South-South regions, the SVI provides a powerful evidence base for directing resources, targeting social protection schemes, and deploying community-based resilience programs (World Food Programme, 2025). In contrast, the areas such as the North West, where there is less vulnerability, should be closely examined to reveal the resilience factors upon which nation-wide intervention can be informed. Thus, the Spatial Vulnerability Index, as derived through the FSV in this study, provides a rich, sound, and policy-relevant tool for analysing gendered food insecurity in Nigeria. It exposes critical regional disparities that might otherwise be masked in national aggregates and brings attention to the intersection of place, gender, and deprivation. The index confirms that a woman's place of residence in Nigeria significantly influences her ability to secure food for herself and her household, and that any attempt to address food insecurity must begin by understanding and responding to these spatial dynamics (Rahman et al., 2025).

4 Conclusion

The study provides a detailed and gender-sensitive analysis of food insecurity using a spatially disaggregated Food Security Vulnerability Index (FSV). The spatial analysis, with particular emphasis on women, shows that food (in)security is not merely a function of exposure to environmental shocks or the income level of households but is rather entangled with structural inequalities which are geographic and gendered in nature. Key findings of the study point out a few major things. For instance, even though a relatively large share of Nigerian households belong to low or very low vulnerability classes, close to 30% of households, particularly those headed by (or mostly composed of) women, suffer from moderate to high food insecurity.

Second, the analysis provides compelling evidence of the key role of gender in shaping vulnerability outcomes. Even though women play a key role in the food production process and care for household members, they are structurally marginalised by being unequally employed as much as men, not owning as much land, not accessing banking and credit as well and having lower educational attainment compared to men. These limitations constrain their resilience to climate and economic shocks. The fact that female respondents are more likely to have higher dependent ratios as revealed According to the data, this further indicates that women bear a greater burden of caregiving responsibilities and, consequently, a higher risk of facing food insecurity during crises.

Third, PCA provided a parsimonious and sturdy way to measure vulnerability, which evaluated both the chronic and acute aspects of food insecurity. This was done by deriving a proxy based on a combination of behavioural indicators (e.g. skipping meals or going hungry) to generate a composite index effective at mapping household vulnerability at the regional level. The study further conducted an analysis of spatial clustering using Moran's *I*. The results show that the distribution of food insecurity among women is neither random nor uniform, but rather positively spatially clustered, highlighting how food insecurity is manifested in specific regions through the complex interactions of ecological, social, and institutional processes.

Based on these findings, the study offers several critical policy implications. Interventions need to be region-specific and gender-sensitive, as women face distinct challenges in different regions of the country. Potential interventions could include increased access to land and credit for women, female literacy programs, vocational training, and infrastructure development in areas of high vulnerability. In addition, institutionalising the use of more granular, disaggregated data in food security assessments could help to avoid leaving the lowest-income households behind. This chapter concludes by emphasising the importance of incorporating spatial and gendered considerations into the analysis and policy on food security. It identifies clusters of vulnerability and socio-demographic drivers thereof, offering a valuable evidence base for food security strategies that will ultimately be more equitable and effective. As such, it is clear that tackling food insecurity in Nigeria, particularly among women, cannot rely simply on technical fixes, but also demands transformational shifts in social norms, institutions and governance structures that reinforce inequality.

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