

Tracking Household Resilience with Panel Data: Implications for Agri-Food Systems in Nigeria

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Abstract

This paper examines the dynamics of household resilience and its implications for food security within Nigeria's agri-food systems using four waves of nationally representative LSMS-ISA panel data. Against a backdrop of recurrent economic shocks, climate variability, and market instability, the study moves beyond static analyses by tracking resilience trajectories over time. Employing transition matrices, Markov chain analysis, an Ordered Probit model, and a dynamic Generalized Method of Moments (GMM) framework, the findings reveal that resilience significantly improves food security outcomes but remains uneven, persistent, and strongly path-dependent. Many households are trapped in low-resilience states, with frequent reversals following shocks. Substantial regional heterogeneity emerges, with stronger resilience–food security linkages observed in conflict-affected and structurally vulnerable zones, highlighting the critical role of local institutional and livelihood contexts. By providing novel panel-based evidence linking resilience mobility to agri-food system performance, the study shows that food security outcomes reflect cumulative welfare dynamics rather than contemporaneous shocks alone. The results underscore the need for integrated, resilience-centered policies that combine social protection, climate adaptation, market stabilization, and inclusive rural development to foster shock-responsive and sustainable agri-food systems.

Keywords: Household resilience; Food security; Agri-food systems; Panel data analysis; Nigeria.

1. Introduction and Conceptual Framework

Food insecurity remains one of the most persistent global development challenges, with Sub-Saharan Africa shouldering a disproportionate share of the world's undernourished population despite periods of economic growth (FAO *et al.*, 2022). Structural weaknesses in livelihoods, markets, and agri-food systems, combined with rapid population growth, poverty, climate variability, and recurrent conflict, expose households to shocks and strain the ability of food systems to meet rising demand (World Bank, 2020).

Nigeria is central to this challenge. As Africa's most populous country and a major agricultural producer, its food security outcomes have regional implications. Yet widespread insecurity persists, driven by macroeconomic

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instability, inflation, climate shocks, and protracted conflict, particularly in northern regions, which erode purchasing power and deepen household vulnerability (World Bank, 2020; FAO *et al.*, 2022). Farm households are particularly exposed because agriculture dominates rural livelihoods but remains highly sensitive to climatic variability, price volatility, and policy distortions (Pingali *et al.*, 2005; Olayide & Tetteh, 2019). Shocks affecting households ripple across production, markets, and the broader agri-food system.

Resilience has emerged as a critical lens in food policy and development research. Household resilience refers to the capacity to anticipate, absorb, adapt to, and recover from shocks without undermining long-term welfare. This capacity is shaped by interactions among shock exposure, assets, livelihood strategies, and institutional environments (Alinovi *et al.*, 2010; Barrett & Constan, 2014; Béné *et al.*, 2016; Holling, 1973; Folke, 2006). In agri-food systems, resilient households support stable food production, access, and utilization, whereas persistent vulnerability creates systemic risks (Tendall *et al.*, 2015).

Evidence from Sub-Saharan Africa highlights livelihood diversification, asset ownership, education, financial inclusion, and social protection as key resilience drivers (Asfaw *et al.*, 2016; D’Errico *et al.*, 2018; Ansah *et al.*, 2019). However, much of the existing research relies on cross-sectional data, providing static snapshots that obscure resilience persistence, mobility, and backsliding following shocks (Agwu *et al.*, 2018; Lawal, 2020). Emerging panel studies show that resilience is neither automatic nor permanent, particularly in contexts characterized by structural constraints and weak institutions (Barrett & Carter, 2013; Mulat & Negussie, 2010).

This study addresses these gaps using four waves of nationally representative LSMS-ISA panel data for Nigeria. It tracks household resilience trajectories over time and examines how resilience dynamics shape food security outcomes across regions. Specifically, the study (i) analyzes the evolution and persistence of household resilience under recurrent shocks and (ii) estimates the causal effect of resilience on food security. By linking micro-level household dynamics to agri-food system performance, the paper provides new evidence to inform resilience-centered agricultural and food policies in Nigeria and comparable developing-country contexts.

2. Data and Methodology

2.1 Data Source

The analysis uses four waves of the Nigeria Living Standards Measurement Study Integrated Surveys on Agriculture (LSMS ISA): 2010/2011, 2012/2013, 2015/2016, and 2018/2019 (NBS, 2020). The dataset provides nationally representative panel data on household demographics, livelihoods, shocks, assets, and consumption, enabling longitudinal tracking over nearly a decade.

2.2 Methods of Data Analysis

Both descriptive and inferential techniques were employed for data analysis. Descriptive statistics (means and percentages) were used alongside inferential methods, including Principal Component Analysis, Food Security, Economic Shock and Resilience indices, the Ordered Probit Model, and the Generalized Method of Moments.

2.2.1 Food Security Index (FSI): The following equation displays the household food security index, which was used to determine the food security status of farm households, in accordance with Omonona and Agoi (2007).

$$FSI = \frac{\text{Per capita food expenditure for the } i^{th} \text{ household}}{\frac{2}{3} \text{ mean per capita expenditure of all households}} \quad (1)$$

Where, FSI = Food Security Index; $FSI \geq 1$ is food secure i^{th} household; $FSI < 1$ is interpreted as food insecure i^{th} household.

2.2.2 Economic Shock Index (ESI): Economic shocks experienced by households were measured using twenty-one indicators, which were aggregated into a composite shock index using the Z-score standardization technique to capture both the intensity and distribution of shocks across households. The formula is expressed as follows:

$$Z_i = \frac{x_i - \bar{x}}{SD} \quad (2)$$

Where, Z_i = standard score for the observation, x_i = original value of the i_{th} observation, \bar{x} = mean of the observed value of x , SD = Standard deviation of x variable.

Additionally, the Composite Standard Score (CSS) was used to aggregate the findings of the standard score that was obtained. Thus, formula for CSS was expressed as:

$$CSS = \frac{\sum Z_{ij}}{N} \quad (3)$$

Where, CSS = Composite Standard Score, Z_{ij} = Z-score of variable j in the i_{th} observation, N = number of variables.

The shocks were categorized into three groups: high, medium, and low (using the HRI score-based categorization method; USAID, 2011) based on the composite Z-score value.

Economic Shocks variables include: Death or disability of an adult working member of the household, Death of someone who sends remittances to the household, Job loss, Departure of income earning member of the household, Nonfarm business failure, Theft of crops, cash, livestock or other property, Poor rains that caused harvest failure, Flooding that caused harvest failure, Pest invasion that caused harvest failure or storage loss, Loss of land, Increase in price of output, Fall in the price of output, Increase in price of major food items consumed (GHS, 2010 - 2018).

2.2.3. Resilience Index Construction

Household resilience was measured using a multidimensional index encompassing absorptive, adaptive, and transformative capacities, constructed following the TANGO International (2018) framework. Indicators were selected from established resilience literature (Frankenberger *et al.*, 2013; FAO, 2016; D'Errico & Di Giuseppe, 2018; TANGO, 2018). Principal Component Analysis (PCA) was applied to generate composite indices and address dimensionality and multicollinearity. Indicators were normalized to a 0–1 scale and aggregated using equal weights, with standardization ensuring consistent direction and proportional contribution across measures. Indicators standardized values were computed as:

$$Z_a = \frac{S_r - S_{min}}{S_{max} - S_{min}} \quad (4)$$

$$M_a = \frac{\sum_{a=1}^n I_{ai}}{n} \quad (5)$$

$$RI_a = \frac{\sum_{i=1}^3 W_{mi} M_{ai}}{\sum_{i=1}^3 W_{mi}} \quad (6)$$

Where, RI_a = Resilience Index for each zone, M_{ai} = the number of indicators of the major component, W_{mi} = weight of major component i .

$$RI_a = f(ABC_a, ADC_a, TC_a) \quad (7)$$

$$RI_a = \frac{W_{abc} ABC_a + W_{adc} ADC_a + W_{tc} TC_a}{ABC_a, ADC_a, TC_a} \quad (8)$$

Where, RI_a = Resilience index for household a , ABC_a = Absorptive capacity for household a , ADC_a = Adaptive capacity for household a , and TC_a = Transformative capacity for household a .

$$RI_a = f(ISN_a, CS_a, R_a, A_a, I_a, SDS_a, EI_a, LD_a, FS_a, CNR_a, BSI_a, FSN_a, SC_a) \quad (9)$$

Accordingly, ISN , CS , R , A , and I indicators was considered as part of absorptive capacity along with other indicators; SDS , EI , LD , and FS was captured under adaptive capacity indicators together with others; FSN , CNR , BSI , and SC were covered by the transformational capacity (TANGO, 2018).

In which: ISN = Informal safety net; CS = cash savings; R = Remittances; I = Insurance; A = assets; SDS = Socio-demographic status; EI = Exposure to information; LD = Livelihood diversification; FS = Financial services; CNR = Communal natural resources; BSI = Basic services and infrastructure; FSN = Formal safety net; SC = Social cohesion.

2.2.3.1. Classification of Household Resilience Index (HRI) Scores

The total HRI score categorizes households into three groups—low (highly vulnerable), average, and high resilience, capturing variations across indicators to reflect overall resilience (USAID, 2011).

Table 1: Classification of Household Resilience Index (HRI)

HRI Indicators	Scores	Categories	
ABC (ISN, CS, R, A, and I), ADC (SDS, EI, LD, and FS) and TC (FSN, CNR, BSI and SC)	0 – 0.3	Low resilience	Low Resilience
	0.31 – 0.6	Medium resilience	High Resilience
	0.61 – 1	Most resilient	

2.3. Resilience Dynamics and Drivers

Household resilience transitions were analyzed using a combination of Markov models and an Ordered Probit Model (OPM). Markov transition matrices tracked households' mobility across resilience states over time, estimating probabilities of persistence, upward transitions, or backsliding (Azariadis & Stachurski, 2004; D'Errico & Di Giuseppe, 2018). Transition probabilities (P_{ij}) were defined as the likelihood of moving from state i to j , with the matrix:

$$P = \begin{bmatrix} P_{LL} & P_{LH} \\ P_{HL} & P_{HH} \end{bmatrix} \quad (10)$$

Where P_{LL} and P_{HH} measure persistence in low and high resilience, and P_{LH} and P_{HL} capture upward or downward mobility.

To identify drivers of resilience, the OPM was applied, categorizing households by frequency of reaching the highest resilience level over four years. The latent resilience score y^* was modeled as a function of household characteristics x with coefficients λ and normally distributed errors ε :

$$y^* = x\lambda + \varepsilon$$

Observed outcomes correspond to ordered resilience categories, and marginal effects were calculated to interpret how predictors influence the probability of each level (Greene, 2003; Washington et al., 2003). This integrated approach captures both the dynamics and determinants of household resilience over time.

The independent variables x_{it} :

X_1 = Dependency ratio (ratio); X_2 = Household Size (number of persons); X_3 = Gender (Female = 0, Male = 1); X_4 = Age (Years), $X_5 = \text{Age}^2$; X_6 = Annual income (Naira); X_7 = Non-Food Expenditure (Naira); X_8 = Food Expenditure (Naira); X_9 = Main occupation of household head (Farming = 1, Otherwise = 0); X_{10} = Marital status of household head (married = 1, Otherwise = 0); X_{11} = Education of Household Head (Yes = 1, Otherwise = 0).

2.5. Generalized Method of Moments (GMM)

A dynamic panel Generalized Method of Moments (GMM) model (Arellano & Bond, 1991) was employed to estimate the relationship between farm household resilience and food security while addressing endogeneity arising from shock–recovery dynamics and interdependent resilience capacities. The approach controls for unobserved heterogeneity in short panel data. Economic shocks were treated as exogenous, while potentially endogenous variables were instrumented using household location and social network membership. The model additionally incorporates zonal effects, time fixed effects, and key household characteristics.

$$FSI_{it} = \gamma_0 + \gamma_1 FSI_{it-1} + \gamma_2 RI_{it} + \gamma_3 ESI_{it} + \gamma_4 X_{it} + \mu_i + \vartheta_t + \varepsilon_{it} \quad (11)$$

Eq. (17) is revised in initial differences to remove the part related to the zone-specific effect. Thus, zonal-specific effects are taken into consideration in Eq. (18);

$$\Delta FSI_{it} = \gamma_1 + 1\Delta FSI_{it-1} + \gamma_2\Delta RI_{it} + \gamma_3\Delta ESI_{it} + \gamma_4X_{it} + \varepsilon_{it} \quad (12)$$

Where, γ_i (where $i = 1, \dots, 4$) are the corresponding coefficients while γ_0 is the constant. FSI_{it} = Food Security Index; RI_{it} = Resilience Index; and X_{it} = other explanatory variables for household i at time t . ϑ_t is the time-specific constant, μ_i indicates the effect peculiar to a country, while ε_i stands for the error term. The food security index, or FSI_{it-1} is the food security index lagged by 1. $\Delta FSI_{it} = FSI_{it} - FSI_{it-1}$.

The independent variables X_{it} :

X_1 = Resilience (Index); X_2 = Household Size (Number of persons); X_3 = Gender (male = 1, Otherwise = 0); X_4 = Age (years); X_5 = Non-Food Expenditure (Naira); X_6 = Dependency ratio (ratio); X_7 = Non-Farm income (Naira); X_8 = Economic Shock Index (Index).

3.0. Results and Discussion

3.1. Household Resilience, Food Security, and Shock Exposure: Key Trends

Table 2 indicates that resilience within Nigeria's agri-food systems is dynamic but structurally fragile. Household food expenditure increased from ₦3,997 to ₦7,516 across survey waves, reflecting rising food price inflation and market volatility that weaken households' absorptive capacity (FAO, 2023; World Bank, 2022). Despite agricultural participation, many farm households remain vulnerable to food price shocks, supporting the argument by Headey and Fan (2010) that rural producers are often net food buyers.

Household characteristics further shape resilience outcomes. Household size remained stable at approximately six members (NBS, 2020), yet larger households face higher consumption burdens and limited savings, reducing their ability to cope with repeated shocks (Adepoju and Obayelu, 2013; Barrett and Conostas, 2014). The average household head age of about 50 years also reflects an aging farming population, which may slow technology adoption and weaken adaptive responses to climate and market changes (Wossen *et al.*, 2017; Doss and Morris, 2021).

Food security patterns reinforce these vulnerabilities. Figure 1 shows that food insecurity increased to 53 percent by 2018, leaving nearly half of farming households vulnerable amid climate variability, conflict exposure, and institutional constraints (FAO, 2020; Ulimwengu and Workneh, 2020; Ajibola *et al.*, 2021). Resilience trends mirror this trajectory. The resilience index declined to 0.137 in 2012 following macroeconomic instability and the food crisis period, before rising steadily to 0.265 in 2018 as households adopted livelihood diversification strategies and benefited from policy support and adaptive responses (Dercon, 2011; FAO, 2020). This improvement at the household level contrasts with broader national fragility trends (Imandojemu, 2022), highlighting the role of local adaptation and social capital in sustaining recovery (Béné *et al.*, 2016).

Exposure to economic shocks remained persistently high but fluctuating over time. Figure 2 shows that 99.4 percent of households experienced severe shocks in 2012, declining to 46.7 percent in 2015 before increasing again to 54.7 percent in 2018, with an overall average of 68.6 percent. These patterns reflect recurring price volatility, rainfall variability, and weak safety nets that characterize Nigeria's rural economy (World Bank, 2014; 2020; Muhammad Lawal *et al.*, 2012). Regional analysis reveals substantial spatial disparities in resilience capacity. Figure 3 indicates that resilience improved across all geopolitical zones by 2018, with later survey waves recording higher average resilience levels than earlier periods. The South West consistently exhibited relatively stronger resilience outcomes,

while the North Central briefly recorded the highest levels in 2015. In contrast, the North East and North West maintained persistently low resilience scores, suggesting chronic vulnerability linked to climate variability and violent conflict that disrupt agricultural livelihoods and weaken institutional capacity (Uche *et al.*, 2021; Ayanlade and Radeny, 2020). The World Bank (2014; 2020) similarly identifies Northern Nigeria as a fragility hotspot characterized by insecurity, infrastructure deficits, and limited-service delivery. Higher resilience in the South West and North Central regions likely reflects better infrastructure, stronger market access, and more stable socio-political environments (Mohammed *et al.*, 2019).

Overall, the evidence shows that resilience among Nigerian farm households evolves through recurring cycles of shocks and partial recovery shaped by household characteristics, regional conditions, and policy environments. Improving food security therefore requires moving beyond production expansion toward resilience-oriented policies that strengthen shock absorption, enhance adaptive capacity, and improve institutional and market integration across regions.

Table 2: Descriptive Statistics of Key Socio-economic Variables over the Years in Nigeria

	2010 (Wave 1)			2012 (Wave 2)			2015 (Wave 3)			2018 (Wave 4)		
	Food Exp. (N)	Household Size (No.)	Age (Years)	Food Exp. (N)	Household Size (Per.)	Age (Years)	Food Exp. (N)	Household Size (No.)	Age (Years)	Food Exp. (N)	Household Size (Per.)	Age (Years)
Min.	0.0	1.00	15.00	0.00	1.00	18.00	0.00	1.00	20.00	0.00	1.00	17.00
Max.	45240.0	31.0	110.00	99880.00	31.00	110.00	57725.00	34.00	103.00	84080.00	33.00	130.00
Mean	3997.1	5.6	49.71	4005.22	6.34	52.08	4718.04	7.16	53.58	7516.06	6.09	49.99
Std. Dev.	3577.2	3.1	15.45	3558.60	3.28	15.16	3963.40	3.56	14.38	7125.19	3.63	15.41



Figure 1: Food Security Status of Farming Households over the Years in Nigeria

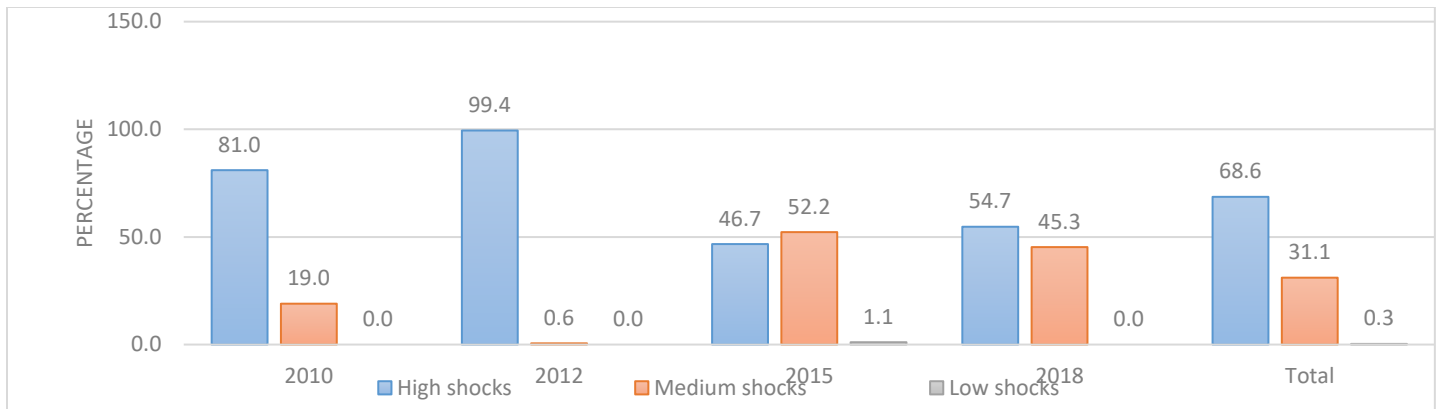


Figure 2: Level of Economic Shocks Experienced by Farming Households over the Years in Nigeria

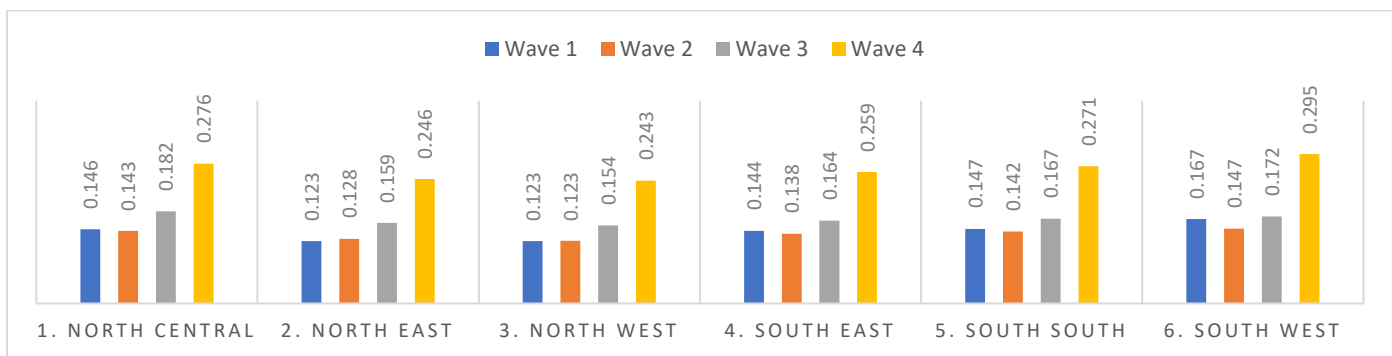


Figure 3: Mean Resilience Index over the years per zone in Nigeria

3.2 Household Mobility across Resilience Categories in Nigeria

Panel-based transition analysis reveals *limited mobility and persistent vulnerability* within Nigeria's agri-food systems. The resilience transition matrices (table 3) show that most farm households remained trapped in low resilience between 2010 and 2018, underscoring structural barriers to sustained adaptive capacity. At baseline, 99.6% of households were classified as low resilience, and only 0.4% transitioned upward by 2012. Although mobility improved modestly over time, just 20.1% had moved into higher resilience by 2018, leaving nearly four out of five households persistently vulnerable. Equally concerning, many previously resilient households experienced downward mobility, indicating that resilience gains were often temporary rather than sustained.

These patterns confirm that resilience is dynamic but fragile. Consistent with Alinovi *et al.* (2010), repeated economic, climatic, and conflict-related shocks erode resilience, conditions that closely characterize rural Nigeria. Frequent backsliding also reflects structural deficits in agricultural systems, including limited asset accumulation, weak market integration, and inadequate institutional support (Udmale *et al.*, 2020). As Barrett and Constan (2014) argue, without transformative interventions addressing underlying vulnerabilities, households remain trapped in cycles where short-term improvements cannot endure.

Markov transition estimates (table 4) reinforce this persistence. Low-resilience households faced an 80% probability of remaining trapped, while high-resilience households had only a 55% chance of maintaining their status, revealing substantial risk of reversal. Long-run equilibrium projections suggest that roughly 69% of households will remain in low resilience without structural change, highlighting strong path dependence driven by unequal access to assets, education, markets, and social protection (D'Errico & Pietrelli, 2017).

The 45% probability of downward transition among high-resilience households illustrates “reversible resilience,” where gains are easily eroded by recurrent shocks (Cissé & Barrett, 2018). Overall, resilience in Nigeria’s agri-food systems emerges as structurally constrained and path-dependent, underscoring the need to shift from short-term coping measures toward transformative strategies centered on climate-smart agriculture, inclusive rural finance, expanded social protection, and stronger market integration.

3.3 Drivers of Household Resilience Variation in Nigeria

Table 5 presents ordered probit estimates identifying the key drivers of household resilience across four survey waves (2010–2018). The model is statistically robust ($\text{Prob} > \text{Chi}^2 = 0.000$; $\text{Chi}^2 = 1964.44$) and explains 23.6% of variation in resilience outcomes, highlighting factors that influence households’ movement into higher resilience categories rather than remaining persistently vulnerable.

Determinants of higher resilience are strongly linked to socioeconomic capacity. Male-headed households, higher education levels, older household heads, and greater income and expenditure significantly increase the likelihood of achieving resilience repeatedly over time. Male-headed households reduce the probability of remaining least resilient by 7.6–15.4%, reflecting gendered disparities in access to productive assets and adaptive resources (Shah *et al.*, 2013; Haque *et al.*, 2012; Kartiki, 2011). Older household heads also demonstrate stronger resilience, likely due to accumulated experience and indigenous knowledge in managing shocks (Nyong *et al.*, 2007; Teklewold *et al.*, 2013). Higher food consumption and expenditure increase resilience probabilities by 11.5%, supporting evidence that improved consumption capacity and dietary diversity reinforce long-term food security (Alinovi *et al.*, 2010; Ciani & Romano, 2013). Access to income, remittances, and banking services further strengthens resilience, underscoring the role of livelihood diversification and financial inclusion (Hund & Do, 2023).

Drivers of vulnerability reflect structural constraints. Larger household size, higher dependency ratios, female-headed households, and reliance on farming as the primary livelihood significantly increase the likelihood of remaining least resilient. High dependency burdens reduce per capita resources and weaken shock absorption capacity (Gebrel & Rahut, 2021; Hartwig & Nguyen, 2022), while dependence on farming income alone exposes households to climatic and market risks (d’Errico & Di Giuseppe, 2018).

Overall, the results reveal a dual dynamic: structural disadvantages trap households in low resilience, whereas education, income diversification, and financial access enable upward mobility. Strengthening resilience therefore requires policies that simultaneously address demographic pressures and expand capacity-enhancing investments in gender equity, human capital, financial inclusion, and diversified livelihoods.

1.4 Dynamic Linkages Between Household Resilience and Food Security in Nigeria

The one-step Generalized Method of Moments (GMM) estimates (table 6) provide clear evidence that the relationship between household resilience and food security in Nigeria is *dynamic, regionally uneven, and strongly path-dependent*. At the national level, resilience exerts a positive but modest influence on food security, with statistically significant effects concentrated in the North East and South-South zones. This indicates that resilience improves food outcomes but operates within broader structural constraints, including conflict exposure, climate variability, and institutional limitations that shape regional food access (FAO, 2022; Béné *et al.*, 2016; Barrett & Constan, 2014).

Food security outcomes display strong inter-temporal persistence. Significant autoregressive effects across the North Central, North East, and North West regions show that past food security conditions strongly determine current outcomes, supporting dynamic poverty and resilience theories emphasizing path dependence (Dercon, 2004; Carter

& Barrett, 2006). In contrast, negative persistence in the South East and South-South suggests instability, where earlier improvements fail to translate into sustained welfare gains. This pattern reflects income volatility and repeated exposure to market and environmental shocks that undermine long-term food security (Headey & Fan, 2010; Thomas & Turk, 2023).

Household characteristics play a critical role in transmitting resilience into food security outcomes. Male-headed households are significantly more food secure nationally, likely reflecting gender disparities in access to land, assets, and credit (Doss *et al.*, 2018). Conversely, larger household size, higher dependency ratios, older household heads, and rising non-food expenditures consistently reduce food security, highlighting how demographic and consumption pressures weaken adaptive capacity (Babatunde *et al.*, 2010; Barrett & Conostas, 2014).

Regional heterogeneity further underscores the importance of context. Resilience strongly enhances food security in the conflict-affected North East and the resource-dependent South-South, while demographic pressures remain binding constraints across most zones. Importantly, non-farm income diversification does not uniformly improve food security, suggesting that diversification alone is insufficient without stable employment opportunities and functioning markets, consistent with broader empirical evidence (Ellis, 2000; D'Errico & Di Giuseppe, 2018).

Overall, the GMM results demonstrate that food security in Nigeria's agri-food systems is not simply a response to current shocks but a cumulative process shaped by past conditions, household structure, and regional vulnerabilities. Welfare trajectories evolve through dynamic feedbacks among shocks, assets, and adaptive capacity (Barrett & Conostas, 2014; Cissé & Barrett, 2018). Sustained improvements therefore require place-specific resilience strategies combining economic stabilization, demographic-sensitive policies, and long-term investments in adaptive capacity and institutional support (Béné *et al.*, 2016; FAO, 2020).

Collectively, the findings show that household resilience is a developmental process shaped by persistent structural constraints, reinforcing the need for transformative rather than short-term policy interventions.

4.0. Conclusion and Policy Implications

This study provides robust panel evidence that household resilience in Nigeria's agri-food systems is *dynamic, uneven, and highly path-dependent*. Key findings include:

- **Persistent vulnerabilities:** Farm households remain exposed to food price inflation, demographic pressures, aging agricultural populations, and recurrent economic and climatic shocks.
- **Fragile resilience gains:** Although some households temporarily improve resilience, transition and Markov analyses show limited upward mobility and frequent backsliding.
- **Inter-temporal persistence:** Past shocks and structural conditions strongly shape current food security, suggesting households trapped in vulnerability need structural interventions.
- **Heterogeneous effects:** Resilience's impact on food security varies across regions, influenced by conflict exposure, institutional capacity, and livelihood patterns.
- **Household determinants:** Gender, education, income, household size, and dependency burdens are key channels through which resilience affects food security.

Policy Implications:

1. **Shift from reactive to long-term strategies:** Move beyond short-term shock responses to sustained resilience-building in agri-food systems.
2. **Strengthen absorptive capacity:** Expand agricultural insurance, targeted safety nets, and access to affordable credit.

Table 3: Household Mobility across Resilience Categories in Nigeria

		Wave 1 (2010)		
		Low Resilience (%)	High Resilience (%)	Total (%)
Wave 2 (2012)	Low Resilience	99.6	0.4	100
	High Resilience	75.6	24.4	100
Total		99.2	0.8	100
		Wave 1(2010)		
		Low Resilience (%)	High Resilience (%)	Total (%)
Wave 3 (2015)	Low Resilience	98.8	1.2	100
	High Resilience	75.3	24.7	100
Total		98.4	1.6	100
		Wave 1 (2010)		
		Low Resilience (%)	High Resilience (%)	Total (%)
Wave 4 (2018)	Low Resilience	79.9	20.1	100
	High Resilience	55.0	45.0	100
Total		79.5	20.4	100
		Wave 2 (2012)		
		Low Resilience (%)	High Resilience (%)	Total (%)
Wave 3 (2015)	Low Resilience	79.8	20.2	100
	High Resilience	45.5	54.5	100
Total		98.4	1.6	283 (20.4)
		Wave 2 (2012)		
		Low Resilience (%)	High Resilience (%)	Total (%)
Wave 4 (2018)	Low Resilience	79.8	20.2	100
	High Resilience	45.5	54.5	100
Total		79.5	20.4	100
		Wave 3 (2015)		
		Low Resilience (%)	High Resilience (%)	Total (%)
Wave 4 (2018)	Low Resilience	80.3	19.7	100
	High Resilience	30.4	69.5	100
Total		79.5	20.4	100

Table 4: Markov Processes for Transitory Resilience in Nigeria (Pooled - National)

	Initial probabilities (n = 0)		n = 2		Steady-state probabilities (n = ∞)	
	Low Resilience	High Resilience	Low Resilience	High Resilience	Low Resilience	High Resilience
Low Resilience	0.798	0.202	0.803	0.197	0.694	0.309
High Resilience	0.455	0.545	0.304	0.695	0.694	0.309
P (n)	0.688	0.3316	0.693	0.311	0.694	0.309

Table 5: Ordered Probit Estimates of Drivers of Households' Variation in Resilience Over the years in Nigeria

Variable	Coefficient	Standard Er	Resilience Once		Resilience Twice		Resilience Thrice		Always Resilient	
			Marginal Ef	Standard E	Marginal Ef	Standard Er	Marginal Ef	Standard E	Marginal E	Standard Er
Dep.Ratio	-.205***	.019	-.006*	.006	-.021***	.004	-.073***	.005	-.082***	.009
Household Size	-.168***	.008	-.023***	.003	-.022***	.002	-.031***	.002	-.032***	.003
Gender	.755 ***	.084	.076***	.017	.072***	.008	.114***	.013	.154***	.023
Marital Status	-.303 ***	.077	-.057**	.027	-.058**	.017	-.067**	.022	-.006	.036
Education	.326**	.109	.053***	.027	.029*	.014	.064**	.019	.016	.047
Age Square	.000**	.000	-8.63e-06	.000	-.000**	.000	-.000	.000	-.000*	.000
Age	.047***	.010	.001	.003	.006***	.002	.004	.003	.011*	.005
NF.Expenditure	.609***	.029	.075***	.009	.077***	.005	.114***	.007	.104***	.015
F.Expenditure	.227***	.033	.011*	.010	.020***	.006	.032***	.008	.045**	.014
Income	.010*	.005	-.001	.002	.003**	.001	-.001	.001	-.002	.002
M.Occupation	-.573***	.048	-.100***	.015	-.073***	.009	-.087***	.012	-.128***	.023
/Cut 1	9.959									
/Cut 2	10.737									
/Cut 3	11.311									
/Cut 4	12.476									
LR chi2(11)	1964.44									
Log Likelihood	-3175.843									
Pseudo R ²	.2362									
Prob > chi ²	0.000									
N	4,123									

*** $P < 0.01$, ** $P < 0.05$, * $P < 0.1$

3. **Enhance adaptive capacity:** Promote savings, livelihood diversification, financial inclusion, and rural employment opportunities.
4. **Support transformative capacity:** Invest in education, rural infrastructure, and institutional reforms to break persistent vulnerability traps.
5. **Tailor interventions regionally:** Design place-based strategies that reflect local realities, particularly in conflict-affected or resource-dependent areas.
6. **Coordinate policies:** Ensure institutional alignment across agriculture, social protection, and climate adaptation frameworks.

Policy Takeaway: Resilience is not a fixed household trait but a developmental process shaped by shocks, assets, and institutions. Sustainable food security in Nigeria requires long-term, coordinated investments that transform rural livelihoods, not just stabilize them.

Table 6: Generalized Methods of Moments (GMM) on Dynamic Linkages Between Household Resilience and Food Security in Nigeria

One-step estimates with robust standard errors							
Food Security							
	POOLED NATIONAL	NORTH CENTRAL	NORTH EAST	NORTH WEST	SOUTH EAST	SOUTH SOUTH	SOUTH WEST
FSI_{it-1}	.092 (.075)	.092* (.047)	.479** (.158)	.196** (.075)	-.400* (.166)	-.153* (.084)	.103 (.178)
Resilience	0.222 (.224)	0.053 (.333)	0.002 (.676)	.009 (.467)	0.016 (.517)	0.068 (.448)	0.564 (.595)
Household Size	-0.003 (.009)	-.516 (.025)	2.218** (.018)	.499 (.015)	.584 (.037)	.754* (.023)	-.514 (.033)
Gender	0.989 (.206)	0.121 (.237)	0.001 (.141)	0.286 (.385)	0.258 (.415)	0.092 (.258)	0.387 (.134)
Age	-.073*** (.005)	-.103*** (.007)	-.025 (.011)	-.075*** (.006)	-.069* (.009)	-.075** (.007)	-.096** (.011)
Log Non Food Expenditure	0.000 (.019)	0.000 (.043)	0.166 (.043)	0.000 (.027)	0.060 (.059)	0.001 (.049)	0.004 (.056)
Dependency Ratio	.715** (.008)	1.232*** (.022)	.293* (.031)	.189 (.012)	.057 (.026)	1.361*** (.024)	1.337*** (.016)
Log Non-Farm Income	0.001 (.012)	0.000 (.017)	0.038 (.024)	0.624 (.017)	0.892 (.030)	0.000 (.032)	0.000 (.038)
Economic Shock Index	-.016** (.003)	-.024*** (.008)	-.009 (.0293)	-.001 (.026)	-.004 (.111)	-.022** (.0950)	-.057** (.0671)
Constant	0.001 (.031)	0.000 (.035)	0.410 (.062)	0.869 (.031)	0.697 (.057)	0.002 (.046)	0.00 (.069)
Wald chi2(8)	-.059** (.019)	.024 (.043)	-.074* (.043)	-.109*** (.027)	-.091 (.059)	.019 (.049)	-.093* (.056)
Prob > chi2	0.002 (.008)	0.582 (.022)	0.084 (.031)	0.000 (.012)	0.127 (.026)	0.703 (.024)	0.094 (.016)
	0.079 (.012)	0.058 (.017)	0.335 (.024)	0.913 (.017)	0.587 (.030)	0.204 (.032)	0.465 (.038)
	-.034** (.003)	-.009 (.017)	-.025 (.024)	-.039* (.017)	-.048 (.030)	.002 (.032)	-.016 (.038)
	.031 (.019)	.109** (.035)	-.208** (.062)	.015 (.031)	.059 (.057)	-.056 (.046)	.254*** (.069)
	0.111 (.026)	0.002 (.032)	0.001 (.053)	0.619 (.049)	0.298 (.054)	0.228 (.064)	0.000 (.063)
	0.508	0.881	0.507	0.474	0.352	0.458	0.873
Wald chi2(8)	983.87	426.29	798.30	254.07	286.85	507.04	332.38
Prob > chi2			0.000				

*** $P < 0.01$, ** $P < 0.05$, * $P < 0.1$. Standard errors in parenthesis

References

- Alinovi L, Mane E, Romano D. Measuring household resilience to food insecurity: application to Palestinian households. *Agricultural survey methods*. 2010 Apr 16:341-68.
- Barrett CB, Carter MR. The economics of poverty traps and persistent poverty: Empirical and policy implications. *The Journal of Development Studies*. 2013 Jul 1;49(7):976-90.
- Barrett CB, Constan MA. Toward a theory of resilience for international development applications. *Proceedings of the National Academy of Sciences*. 2014 Oct 7;111(40):14625-30.
- Béné C, Headey D, Haddad L, von Grebmer K. Is resilience a useful concept in the context of food security and nutrition programmes? Some conceptual and practical considerations: C. Béné et al. *Food security*. 2016 Feb;8(1):123-38.
- D'Errico M, Smith L. Comparison of FAO and TANGO measures of household resilience and resilience capacity. Working paper; 2019.
- Béné C, Frankenberger TR, Nelson S, Constan MA, Collins G, Langworthy M, Fox K. Food system resilience measurement: principles, framework and caveats: Béné, Frankenberger, Nelson, Constan, Collins, Langworthy and Fox. *Food Security*. 2023 Dec;15(6):1437-58.
- Omonona BT, Agoi GA. An analysis of food security situation among Nigerian urban households: Evidence from Lagos State, Nigeria.
- Arellano M, Bond S. Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *The review of economic studies*. 1991 Apr 1;58(2):277-97.